

Aspects of palaeo-terrace formation and stream sediment petrography of the Orange and Vaal River confluence in the Douglas area

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ABSTRACT

The mineralogy and geochemistry of a representative number of stream sediments in combination with geomorphologic mapping of the Orange/Vaal River terraces is used to assess the provenance of the sediments and the diamond-bearing potential of the terrace material in the confluence area around Douglas, Northern Cape.

Utilizing sediment profile descriptions, grain size analyses, heavy mineral separation and identification techniques we were able to distinguish sediment provenance groups at different sites in the Orange/Vaal confluence area near Douglas. First assessment of the rock fragment/mineral spectrum reveals Ventersdorp volcanics material as well as Karoo material to be predominant provenances of these sediments, and to a lesser extent glacial material derived from Dwyka series to be the source of sediments; based on the frequency of diggings, the possible diamond-bearing potential appears to be by far higher in the terraces of the lower Vaal River and along the Orange River downstream Douglas than along the Orange River section between Hopetown and Douglas. Looking specifically at the heavy minerals further studies will attempt to correlate the terraces. Also, relative ages will be determined by looking at the post-depositional alteration or weathering. First quantification of the (heavy) mineral content displays a large contribution of quartz, epidote, magnetite, and amphibole grains from Karoo sediment and volcanics, whereas altered granite and pegmatite fragments of unknown origin form the lesser part of the sediment spectrum. At Bucklands, on both sides of the confluence point, relatively large estimated gravel thicknesses (>5m) are overlain by several cycles of up to 3 m thick mud to silty sediments with occasional larger pebble to gravel occurrence, both part of the Rietputs and Riverton Formations.

Orange and Vaal River sediments are sorted selectively by hydraulic processes causing the sorting of according to size, shape and density, concentrating heavy minerals in trap sites such as potholes, along bars, and in areas of turbulent water flow. Therefore river bars and slip-off slopes in an area of moderate relief appear to be prime loci of heavy mineral deposition.

Principally it can be concluded that the Orange River section between Hopetown and Douglas shows less pronounced younger gravel terrace formation due to a relatively low erosion basis and a stronger incision into the Ventersdorp bedrocks; the lower Vaal River and the Orange River downstream Douglas however have a more pronounced terrace formation due to a higher erosion basis caused by bedrock morphology.

Key words: Orange, Vaal River, terraces, sediment petrography, provenance.

INTRODUCTION

From a sediment-petrographic point of view, the Orange and Vaal River sediments, did not receive considerable attention lately since the work of Helgren in 1979. Not only was the area important in terms of its alluvial diamonds, but with the understanding of river morphology and terrace development the question of material provenance arose. The importance lies in the ability to budget the material contribution of various source areas to the different river terraces during the geomorphic evolution of Southern Africa from the Miocene and on through the Quaternary (Burbank et al., 1996). However, not all sections of the Orange River

received equal attention (Holmes, 1979). This study has identified one such under-studied area. The study attempts to characterize the sediment mineralogy qualitatively and quantitatively and thereby reconstruct the geomorphic development of that part of the Orange River in the vicinity of Douglas, defining the composition of terraces.

The alluvial sediments visited and sampled are part of the Rietputs Formation A to C which has a quaternary age and generally is composed of clasts of Ventersdorp Supergroup, as well as quartzites, BIFs, and cherts from the Transvaal Supergroup. The Riverton Formation appears to comprise the most recent alluvial sediments on top of Rietputs C gravels.

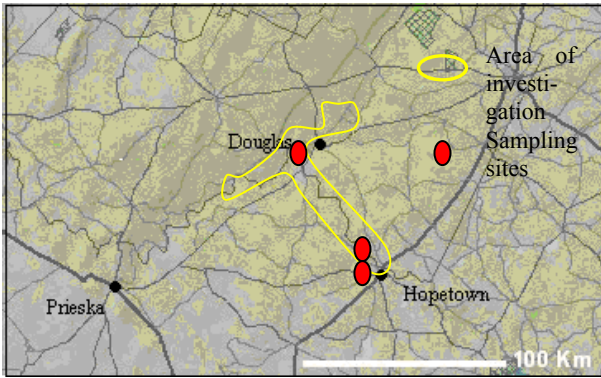


Figure 1. Orientation map of area of investigation.

METHOD AND RESULTS

Investigation started with a remote sensing overview (Google Earth, satellite images, geological and topographic maps) for orientation purposes and to focus on key sampling sites. Preliminary field survey was undertaken to determine occurrence and distribution of terraces in the Douglas area. In the field survey, visual conclusions concerning the type of sediment were made, GPS waypoints and elevations were taken, and grab samples were taken with a shovel and a geological hammer on various locations of both river terraces. These sites are representative of the sedimentary deposits in the study area. The visited locations were near Hopetown and Douglas along the Orange and Vaal Rivers. On vertical profiles systematic sampling took place in 3 m intervals. Samples were described macroscopically and digital photographs were taken for reference purposes.

In the lab samples were washed, screened to various grain size fractions, in order to determine grain size distribution curves for each type of sediment.

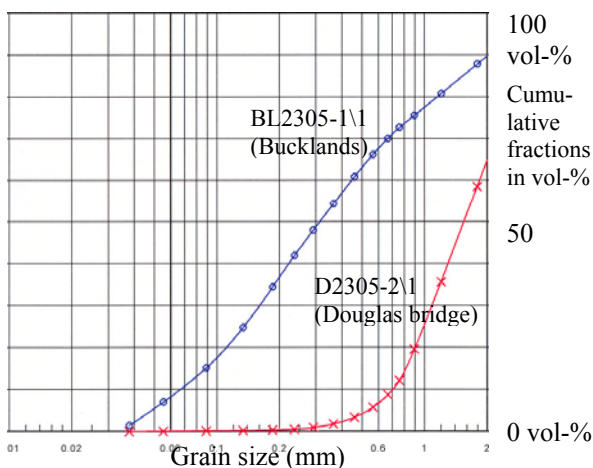


Figure 2. Grain size distribution curve of representative sediment samples. Bucklands (blue circles) shows even spectrum from coarse clay to coarse sand with a fine sand maximum, whereas Douglas town

sample (red crosses) has its maximum in the coarse sand to pebble fractions.

Grain sizes of sediments are a function of transportation process and helps determine the distance from the source. Naming of different fragments is done with the Wentworth grade scale and for the samples inspected classification would vary from clay, fine-, middle- to coarse grain sizes. Weighed sand samples are passed through downwards decreasing diameter sieves with known mesh sizes. Weight of retained sample in each sieve was than measured. Cumulative curves were derived for both samples and differences in sorting were immediately obvious. Better sorted material will be closer to the vertical with fine and coarse grained members at the end of the curve. For sample D2305-2/1 sediments consist of 10% clay, 35% fine grained, 30% middle grained and 25% coarse grained and for sample BL2305-1/1 35% fine clay, 5% middle grained and 60% coarse grained materials. The curves for the samples are very different: BL2305-1/1 has a steeper slope than D2305-2/1, which indicates that its sediments are better sorted.

Hydraulic effects cause selective sorting of sediments according to size, shape and density (Slingerland, 1984). Sediment sections of Orange and Vaal River show different grain size distributions which is an indication for various river flow velocities. Particles that are bigger would need faster flow rates to be transported far from source and are normally well rounded. This may also indicate more than one transport cycle.

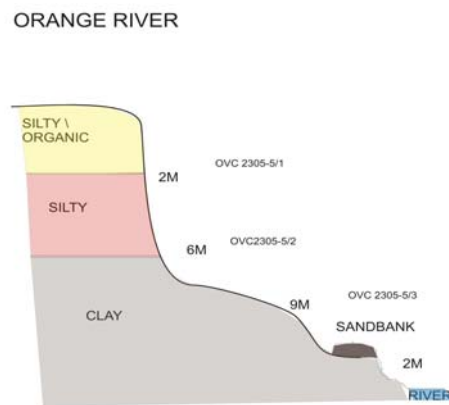


Figure 3. Terrace profile at the Vaal/Orange confluence on the Orange River side showing different soil types

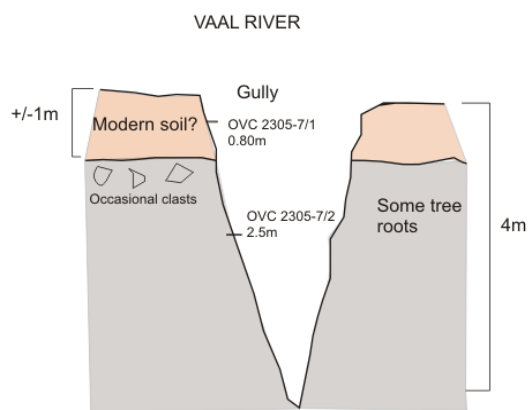


Figure 4. Terrace profile at the confluence on the Vaal River side, showing different soil types.

Heavy minerals are high-density mineral constituents of siliciclastic sediments, which are very useful to determine provenance, source areas, tracing sediment transport paths and for locating potential economic deposits.

Heavy mineral content was looked at but is still an ongoing investigation, using a photo-binocular SX2000 of Olympus. Fractions <500µm were examined for the sediment samples (Mange and Maurer, 1989). Table 1 shows results from heavy mineral analysis. Those tend to concentrate in smaller sediment fractions <210µm. In these fractions we find epidote, tourmaline, rutile and magnetite but samples are still very quartz dominated.

Sample number	Rock fragment & mineral content	Dominant content	Source areas
BL2305-1\1 >500µm	Quartz, Karoo siltstone, Granite, Pegmatite, Amphibole, Biotite, Epidote	Quartz dominated (variety of silicate minerals)	Ventersdorpe Sgr, Karoo Sgr, Transvaal Sgr.
D2305-2\1 >500µm	Magnetite, Quartz, Feldspar, Amphibole, Metal components anthropogenic, Epidote, Fe-(hydr)oxides	Quartz dominated (variety of silicate minerals)	Ventersdorpe Sgr, Karoo Sgr, Transvaal Sgr.

Table 1. First results of heavy mineral analysis

Structures found in the sediments in this area were horizontally deposited layers of sediments of variable grain size, which is typical for a river terrace. Weathering in some parts make it difficult to visually distinguish between the terraces. There is also a lot of agricultural activity in most of this area obscuring sedimentary structures.

CONCLUSIONS

From the sediment data generated so far it is apparent that on the different sides of the Vaal-Orange River confluence the transportation rates varied considerably reflected by the variable degree of sorting between different sediment sample locations. A high degree of sorting for example in the Bucklands samples appears to reflect a longer transport distance before deposition. The on-going mineral/rock fragment analysis in these sediments indicates contribution of Ventersdorp volcanics material as well as Karoo material, and to a lesser extent glacial material derived from Dwyka series as source of the sediments. The characterization of the river terrace geometry and the quality of the heavy mineral spectrum may give an indication of the diamond-bearing potential of the respective river sections (Burbank et al., 1996); both are object of the current investigation.

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