GEOLOGY, SOILS AND GROUNDWATER CONDITIONS IN THE KWANOBAMBA ROYAL RESIDENCE, eMAKHOSINI-OPHATHE HERITAGE PARK, ULUNDI AREA, KWAZULU-NATAL

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1. SCOPE OF WORK

Brousse-James & Associates have been contracted by the Zulu Royal Family to conduct a Basic Assessment for the building of the KwaNobamba Royal Residence in the eMakhosini-Ophathe Heritage Park, approximately 27 km from Ulundi. This residence will be built along the lines of a traditional homestead (*umuzi)*. The development requires environmental authorization in terms of activities specified in the National Environmental Management EIA regulations. Brousse-James and Associates are undertaking a Basic Assessment Process which requires baseline information on the biophysical environment. The Council for Geoscience will provide a description of the geology of the site, soil landtype conditions and groundwater environment.

2. GEOLOGY

The eastern margin of the Kaapvaal Craton underwent major development at ~3.2 Ga when voluminous granitoids were emplaced into the base of greenstone fragments, with the main focus of emplacement being in the Piet Retief area associated with the Anhalt Granitoid Suite (Robb et al. 2006). Although not differentiated, the granitoid basement in the eMakhosini area is suggested to form part of the Anhalt Granitoid Suite. Homogeneous fine-to medium-grained granodiorites are known to occur to the north of the study area within the White Umfolozi valley. The granodiorite is of batholithic proportions, being tabular in shape with a massive core and a weak fabric preserved near the granitoid/greenstone contact (Robb et al. 2006). Mineralogically the granodiorites are commonly phenocrystic, with K-feldspar porphyroclasts up to 10 cm in length identified in homogeneous medium-grained granodiorite along the White Umfolozi River (Figure 1a) the granodiorites comprise plagioclase, K-feldspar and quartz, with minor amounts of biotite and muscovite.

Besides the major granodioritic phase minor occurrences of heterogeneous grey tonalitic gneiss which predate the granodiorite are observed. Although Matthews et al. (1989) suggest that these gneisses are older than the Mvunyana granodiorite. Robb et al. (2006) indicate that their relationship is unknown. The gneisses are migmatitic with the felsic component being fine to medium-grained hornblende-bearing granitoid whilst the melanocratic component comprises fine- to medium-grained amphibolitic gneiss (Figure 1b).

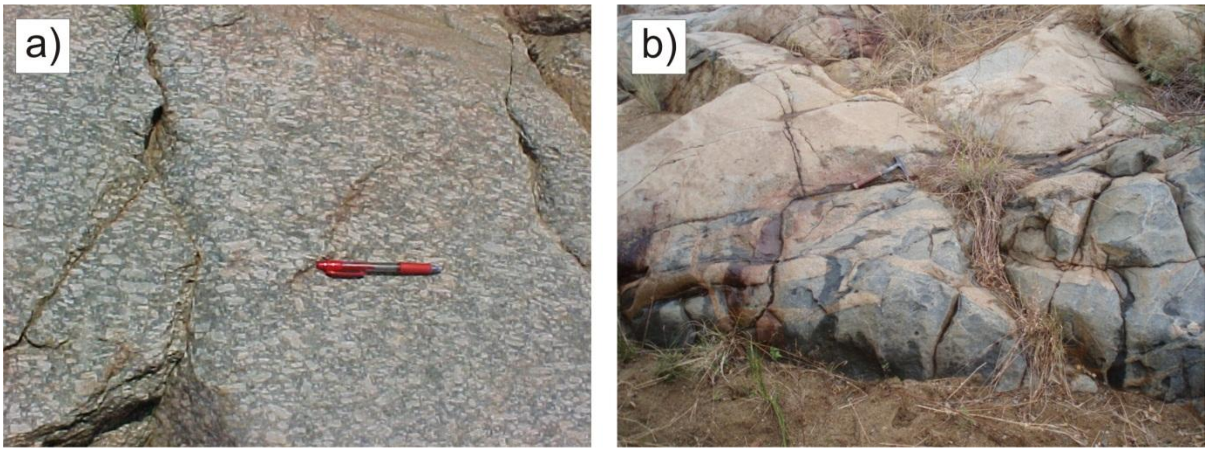

Figure 1: a) Phenocrystic k-feldspar granodiorite of the Anhalt Granitoid Suite along the White Umfolozi River. This granitoid forms the basement that is nonconformably overlain by the Pongola Supergroup. b) Intrusive contact between granodiorite (light colour) and tonalitic gneiss (dark grey) within the Nhlebela tributary. Both lithologies form part of the Anhalt Granitoid Suite.

Within the eMakhosini region, Klausen et al., (2010) identified two separate dyke swarms, a southern E trending population and a northern NE trending swarm, that occur primarily within the basement granitoids to the north and northeast of the study area. The E-trending swarm occurs predominantly in granitoid rocks in the vicinity and just to the north of the study area (Figure 2a). Intrusions consist of a number of sub-alkaline dykes of basaltic andesite composition (Klausen et al., 2010). The geochemical composition of these dykes combined with their relative absence within the Pongola Supergroup suggest that this swarm is possibly the ~2.95 Ga feeder system to the Nsuze Group volcanics in this region (Klausen et al., 2010).

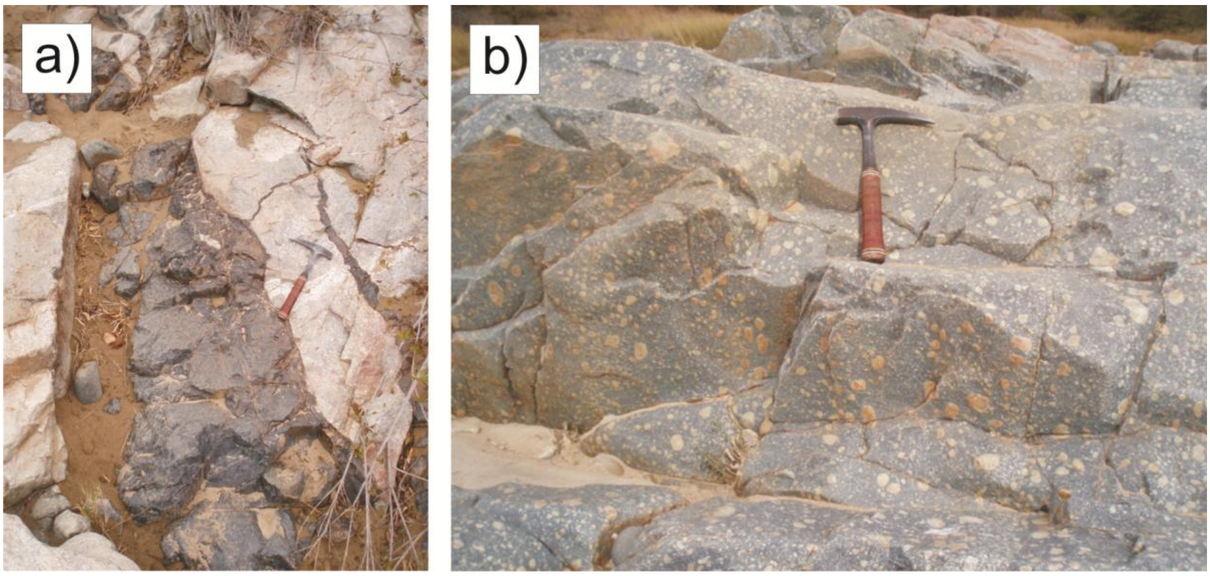

Figure 2: a) Basaltic dyke (black) intruding basement granite. b) Phenocrystic dyke hosting white-coloured feldspar phenocrysts.

The NE-trending swarm occurs predominantly northeast of the study area comprising tholeiitic, commonly phenocrystic, dykes of basaltic composition. Phenocrysts are primarily altered feldspar, which can be up to 20 mm in diameter (Figure 2b). These dykes intrude all lithologies in the Pongola Supergroup (Hicks, 2009) but are not evident cutting the Karoo Supergroup lithologies. The identification of clasts derived from phenocrystic dykes within Dwyka Group tillite that unconformably overlies the Pongola Supergroup in the White Umfolozi area indicates that these dykes pre-date the Karoo Supergroup and are unrelated to the predominantly north-trending Jurassic dolerite dykes and sills of the Karoo Igneous Province (Hicks, 2009).

The granitoids and surrounding lithologies within the eMakhosini region have been intruded by dykes and sills during numerous phases of volcanic activity, the largest of which coincided with the Jurassic-aged, Karoo Large Igneous Province. An extensive network of sills and dykes emplaced at shallow depths in sedimentary strata (Walker and Poldervaart, 1949; Chevallier & Woodford, 1999; Svensen et al., 2006) and is widely developed throughout the Karoo basin where it formed the intrusive feeder systems to the flood basalts of the Drakensberg Group. It is postulated by (Duncan et al., (1997) and Svensen et al., (2006) that the volcanic activity associated with the Karoo Igneous Province occurred within a short period at ~183 ±1 Ma.

Dykes and sills are commonly emplaced within sedimentary strata of the Karoo Supergroup, however a number of Jurassic sills and dykes intrude the basement granites within the study area. The dolerite exposures within the area range from extremely weathered to fresh, with weathered outcrops represented by yellow-brown, friable, medium- to coarse-crystalline rock. Remnants of onion-skin weathering and ophitic texture are still visible within the sills however 95% of the rock has been deeply weathered.

The Masotcheni Formation colluvial deposits mantle lower hillslopes in the region where up to 20m of stratified, texturally heterogeneous colluvium with interbedded clay-rich palaeosol profiles are exposed locally in stream banks (Botha, 1996). The colluvium is highly erodible and is preferentially incised by runoff to form dendritic donga systems (Rienks et al., 2000).

2.1 Potential environmental impacts of geology

The shallow soil depth and variable weathering of the granitoid or dolerite bedrock could impose mechanical excavation or even blasting for parts of the development foundations.

Use of the soil for berms or cut embankments should address the high erodibility of the weathered sandy soil or saprolite by ensuring low gradient slopes with adequate runoff control and permanent vegetation cover during rehabilitation.

3. SOIL LANDTYPES

The undulating, low relief landscape is formed by incision of the Nzololo/Mkhumbane tributary streams of the White Mfolozi River. The proposed umuzi site is on a low interfluve spur between east flowing high order tributary stream valleys. The soil land type has been characterised as Fa103a on the 2830 Richards Bay land type map (SIRI, 1986, 1988). The soils developed from the granitoid bedrock and intrusive diabase/dolerite dykes are mainly shallow lithosols (<0.5m) suggesting that the bedrock is moderately weathered and decomposed to low to medium clay content soils. Areas where the contact between the shallow soil and rock is abrupt have been classified as Mispah (Ms10) soils.

Shallow vadose zone groundwater flow over the granite bedrock has led to the formation of bleached, eluvial E-horizons in areas of Cartref (Cf 20/21, 30/31) profiles which have medium to coarse sand and low clay content. Seasonally perched water table has led to the formation of soft plinthic subsoil horizons in areas where more clay enriched Westleigh Form soils occur. The presence of ferromagnesian mineral rich diabase/dolerite dykes is indicated by red sandy Hutton Form soils.

Bottomlands are characterised by thicker alluvial soils (Va, Oa) and duplex Estcourt Form profiles where an eluvial sandy horizon overlies a clay-enriched prismacutanic B-horizon (Es34/35). The lower hillslopes are also areas where paleodrainage channels are infilled with texturally heterogeneous, stratified hillwash colluvium of the Masotcheni Formation.

The sediment yield map of South Africa (Rooseboom et al., 1992) classifies the Erodibility Index of the area as “High”.

3.1 Potential environmental impacts of soils

The development will require upgrading of access roads and installation of stormwater drainage channels and runoff attenuation structures. The erodible sandy soils must be protected by lining runoff channels to prevent rill and donga formation. Appropriate structures must be sited where runoff is diverted into natural channels to prevent splash erosion and incision of stream banks that can result in rapid donga formation and spread.

Excavation of foundations will encounter variably weathered bedrock at relatively shallow depth. The hardness of the granitoids could vary over short distances if spheroidal weathering profiles are encountered.

Differential weathering along intrusive dolerite and diabase dykes will result in changes in bedrock hardness conditions over short distances.

Disposal of sewage and domestic grey water through a septic sewage system will require infiltration testing to ensure that hard impermeable bedrock does not limit infiltration from the soakaway.

4. GROUNDWATER

The study area lies within the North Eastern Middelveld Hydrogeological Region outlined in the KwaZulu-Natal Groundwater Plan (DWAF, 2008) where little data is available on groundwater resources or development potential.

The granitoids and dolerite are generally massive rocks with very low primary porosity. Groundwater in the area is associated with secondary aquifers related to weathering or structures traversing the rocks.

The granitoid basement rocks are classified as “Weathered and Fractured” aquifer with moderate borehole yields expected (>0.5 to 3 l/s). The intrusive dolerites have been classified as poor yield aquifers (>0.1 to 0.5 l/s). Enhanced transmissivity of groundwater will be associated with preferentially weathered joint planes in spheroidal weathering profiles and along the contacts of intrusive dolerite dykes. Static water levels are controlled by the topography relative to the phreatic groundwater table.

In general the water quality is good with electrical conductivity of 0-70 mS/m recorded although total dissolved solid (TDS) levels are variable. The groundwater development potential is suitable for small scale reticulation (Martinelli and Associates, 1994).

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