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Review of engineering, hydrogeological and vadose zone hydrological aspects of the Lanseria Gneiss, Goudplaats-Hout River Gneiss and Nelspruit Suite Granite (South Africa)

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ABSTRACT

Three major basement granites of South Africa, viz. the Lanseria Gneiss of the Johannesburg Dome Granite, the Goudplaats-Hout River Gneiss and the Nelspruit Suite, are compared in terms of existing and new geotechnical and hydrogeological data. Typical weathering profiles based on landform and climate are deduced, denoting typical engineering and hydrogeological behaviour. Finally, the vadose zone behaviour of the basement granites are described with the aim on better understanding of the behaviour of these systems under variable saturation. Ephemeral hillslope wetlands, seepage lines and catenas are specifically addressed as associated hydrological influences, as well as the associated processes of translocation forming duplex soils and pedogenesis forming ferricrete. The final summarised findings depict low plasticity and expansiveness of granites with the most notable geotechnical influences being collapsibility, dispersive behaviour, seepage and difficult excavation. Hydrologically, secondary porosity prevails and younger structures or intrusions govern groundwater occurrence. The vadose zone comprises thick fractured rock to be included in modelling with the soil zone having saturated conductivity typically in the order of 1×10^{-4} to 1×10^{-5} m/d.

Contents

Abbreviations: ca., Circa (approximately); DWA, Department of Water Affairs (previously DWAF); DWAF, Department of Water Affairs and Forestry (now DWA); G-HRG, Goudplaats-Hour River Gneiss (Suite); JGD, Johannesburg Granite Dome; KNP, Kruger National Park; Ma, Million years; NGA, National Groundwater Archive; NGRS, Ngwenyeni Northern Granites Research Supersite, KNP; s.l., Sensu lato in the broad sense (as opposed to s.s.); s.s., Sensu stricto in the strict sense (as opposed to s.l.); SANParks, South African National Parks; SANS, South African National Standard; SEM, scanning electron microprobe; SGRS, Stevenson-Hamilton Southern Granites Research Supersite, KNP; USCS, Unified Soil Classification System; WRC, Water Research Commission; XRD, X-ray diffraction; XRF, X-ray fluorescence spectroscopy.

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1. Introduction

Numerous authors have evaluated basement aquifers in southern Africa (e.g. Botha and Van Rooy, 2001; Dippenaar et al., 2009; Holland and Witthüser, 2011; Titus et al., 2009; Witthüser et al., 2010). However, as a critical component of understanding the hydrological cycle, one needs to consider the behaviour of earth materials in *all* aspects of the hydrological cycle, which includes not only saturated conditions, but also the vadose zone, aquicludes and barriers. These all relate to the formation of the earth materials and are highly dependent on the mineralogy of the host rock, the tectonic influences causing subsequent deformation, weathering of the in situ rock, prevailing and historical climatic conditions, geomorphological processes governing landscape development, and the intrusion of younger lithologies.

Three distinct basement granite settings have been selected based on ten years' detailed investigation in these areas and the subsequent abundance of data specifically relevant to the phreatic hydrology (behaviour as aquifers), soil properties (and shallow vadose zone hydrology) and geochemistry. These areas are:

- Lanseria Gneiss of the JGD (Gauteng Province).
- Goudplaats-Hout River Gneiss (Limpopo Province).
- Nelspruit Suite (KNP, Mpumalanga Province).

The purpose of this paper is to review and collate the data from a variety of studies within these basement granite areas, with the emphasis on addressing bulk of the important variables as envisaged in the triangle of geomechanics and the triangle of engineering geology by Bock (2006) as shown in Fig. 1. The eventual aim is

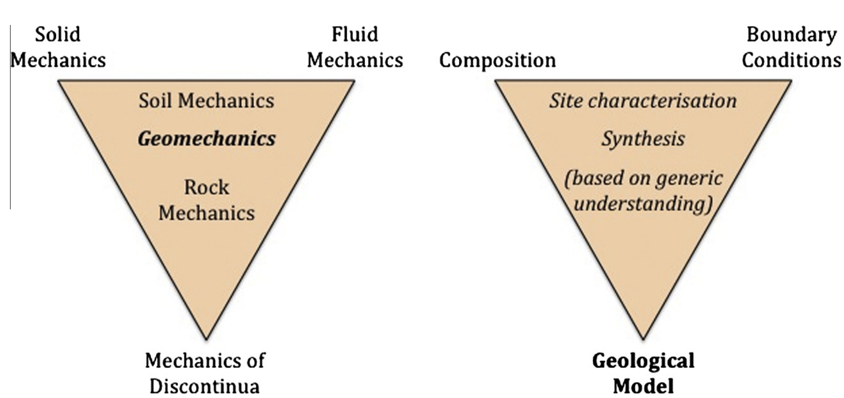

Fig. 1. The triangle of geomechanics (left) and the triangle of engineering geology (right) (Bock, 2006).