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Eastern limb of the Bushveld Complex, South Africa: Geology and Geomorphology of a Uniquely Layered Ultramafic-mafic Intrusion

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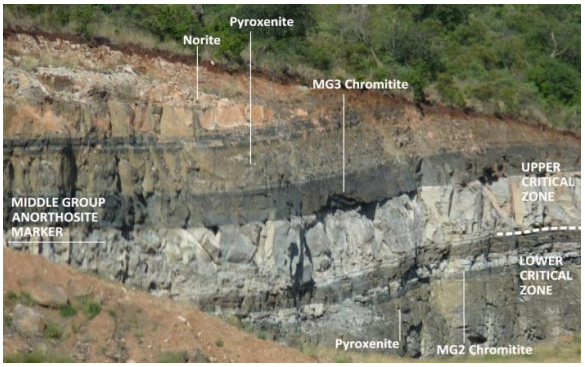
The 2,055 Ma Bushveld Complex contains the largest layered igneous complex on Earth. The Eastern Limb crops out spectacularly in a rugged landscape of linear and arcuate ridges associated with an embayment in the interior plateau of north-eastern South Africa. This embayment has been caused by the superimposed drainage of the Olifants and Steelpoort River systems which have etched out individual rock layers and units within the layered intrusion by erosion during regional uplift. The mountain ranges are remote wilderness areas, but the valleys and plateaus are densely populated. Human habitation dates to the Iron Age (1,600-1,000 AD) and includes the site of Thaba Mosega in the Tsate Valley, where King Sekhukhune united vulnerable communities into the formidable Pedi Empire. The area supports numerous mines with a modern infrastructure and is well suited to geotourism. The opportunity to examine ultramafic-mafic rocks, such as chromitite, orthopyroxenite, harzburgite, norite and anorthosite in outcrops that are almost pristine is unparalleled.

The ultramafic-mafic rocks were intruded beneath the Rooiberg Felsites (the oldest component of the complex) into underlying metasedimentary rocks of the mid-Proterozoic Transvaal Supergroup. They were subsequently capped by thick sheets of granite. The resistant metasedimentary floor-rocks have been uplifted and tilted in response to vertical tectonics induced by the emplacement of ultramafic magmas and now form a conspicuous range of mountains. Doming associated with the floor rocks has produced a highly irregular basal contact to the intrusion and some are so large as to penetrate through the entire layered intrusion and into the granite. A prominent geomorphologic feature within the embayment is the rugged Bushveld Escarpment. Some 180 km in length and situated between the Great Escarpment and the interior plateau it is ascribed to the resistant nature of gabbroic rocks within the intrusion.



Classic layering of chromitite-pyroxenite-anorthosite in the Critical Zone

A distinctive feature of the layered intrusion is the intercalation of rock layers with remarkably different compositions. The layered intrusion resembles a sheeted sill complex rather than a shallow magma chamber (magmas sourced from staging chambers) with repeated replenishment by discrete magma-lineages. Each succeeding zone is

more extensive than the underlying one. The economically important ***Critical Zone*** reveals spectacular layering, including chromitite layers that range in thickness from one or two grains to over 2 m. Two of the chromitite layers, the MG2 and MG3 straddle an important contact as they separate the orthopyroxenite-dominated lower part from the noritic-dominated upper part (photograph). The 2 m-thick layer of anorthosite, sandwiched between these layers is a regional feature. The world-famous platiniferous Merensky Reef occurs as part of a 2-3 m-thick layer of feldspathic orthopyroxenite located near the top of the Critical Zone and includes thin stringers of chromitite. The ***Upper Zone*** although dominated by thick sequences of monotonous ferrogabbro contains numerous layers of massive Ti-magnetite. The 2 m-wide Main Magnetite Layer (which is contiguous along strike for over 150 km) is the world's main source of vanadium ore. An intriguing feature of the intrusion is the prevalence of discordant bodies, many of which crosscut the layering perpendicularly. They include the enigmatic platinum-rich pipe-like orebodies, Mooihoek the discovery site of economic mineralization, and Onverwacht the oldest mine which revealed grades of almost 2,000 g/t Pt in hand-sized lumps of chromitite, xenoliths derived from the layered wall rocks.