The Paleoproterozoic Waterberg Group, South Africa : provenance and its relation to the timing of the Limpopo orogeny

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Abstract:

Four Paleoproterozoic formations of the Waterberg Group in South Africa are composed of coarse clastic detritus derived from erosion of the Limpopo Belt. Timing of the Limpopo orogeny, an event involving the collision of the Kaapvaal and Zimbabwe cratons, has long been a contentious issue. The results of point counting, major and trace element geochemistry, and U–Pb detrital zircon geochronology indicate that the Waterberg sedimentary formations in the study area were primarily sourced by siliceous (rifted margin) sedimentary and minor mafic volcanic rocks of the Archean Beit Bridge Complex, Limpopo Central Zone. The volumetrically predominant beige/brown sandstones in the four studied formations are quartzrich with average QFR ratios of 80:7:13 (Blouberg), 70:19:11 (Setlaole), 88:5:7 (Makgabeng), and 89:3:8 (Mogalakwena). Chert and arenite account for >90% of lithic fragments in all formations, with minor siliceous gneiss fragments. Although all formations are silica enriched, the Makgabeng dune samples produce extremely high SiO2 abundances (92–99 wt%), which are attributed to the presence of silica cement and quartz within rock fragments. Geochemically, the stratigraphically highest Mogalakwena Formation is unique with elevated Ti and Zr values, and intra-formational differences in REE patterns; the latter feature is consistent with a mixed provenance. Volumetrically minor green and purple sandstones in the Waterberg formations contain the greatest Cr, Ni, Ti, and V abundances, which supports localized derivation from a mafic or ultramafic source. Chemical index of alteration (CIA) values range from 57 to 89, which could indicate significant chemical weathering of the source rocks, but a plot of Th/Sc versus Zr/Sc illustrates that the sandstones have undergone recycling, which was probably responsible for enrichments in Al2O3 relative to Na2O3, CaO and K2O. Combinations of well rounded and subangular quartz grains support a recycled origin. Detrital zircons in the lowermost Blouberg Formation produced a wide array of ages ranging from ca. 3379 to 2043 Ma. The youngest peak at 2046 Ma is also the largest, and represents the maximum age of deposition for the formation. Additional peaks at 3281 Ma, 3330 Ma, and 3379 Ma are consistent with ages previously determined from the Beit Bridge Complex, whereas peaks at 2578 Ma and 2649 Ma coincide with ages determined from gneisses of the Limpopo Central Zone. Derivation of detritus from the Beit Bridge Complex is directly indicated by sedimentary and siliceous gneiss fragments in the sandstones, subrounded quartz grains suggestive of relatively short transport distances, green and purple sandstone drapes derived from mafic volcanic units, and paleocurrent patterns consistent with south to southwest flow directions. Therefore the timing of deposition of the Blouberg Formation (2046 Ma) equates to the end stages of the Limpopo orogeny. This negates previous suggestions that the Limpopo orogeny occurred only during the Neoarchean.

The sedimentology of the Waterberg Group in the Transvaal, South Africa: an overview

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The Palaeoproterozoic Waterberg Group consists chiefly of a succession of coarse siliciclastic rocks which shows two upward-fining sequences. The main depository evolved as a continental, faultbounded basin in the northern part of the Kaapvaal craton. The Main basin is bounded in the south by the Thabazimbi-Murchison fault zone and in the north by the southern part of the Melinda fault zone. The Swaershoek and lower Sterk River Formations at the base of the sequence are interpreted to have been deposited as fan deltas and were possibly reworked in a littoral palaeo-environment. The Alma and upper Sterk River Formations are interpreted as a series of alluvial fans forming a bajada along the scarp caused by the uplifted block on the southern side of the Murchison fault zone. The Skilpadkop and Setlaole Formations are considered to have been deposited on narrow braidplains. The Makgabeng Formation was deposited during the more stable period that followed and it is considered to represent a large dune field, which may have been coastal in nature towards the south. The upward-coarsening Aasvoëlkop Formation was deposited in a shallow through-flow lake, although fluvial deposition was more important towards the top of the formation. The Mogalakwena and Sandriviersberg Formations are interpreted as having been deposited by large braided rivers, forming an extensive braidplain which probably continued to the southwest, through Bostwana into the northern Cape Province, where it may be represented by the Fuller Member of the Volop Group. As sediment input from the north decreased, the sea transgressed over the braidplain and deposited the Cleremont Formation, which is interpreted as a littoral deposit or a tidally influenced shelf deposit. The Vaalwater Formation, which ended the Waterberg episode, formed within a littoral or a shallow siliciclastic sea palaeo-environment.

THE GEOLOGY OF THE WATERBERG GROUP IN THE SOUTHERN PORTION OF THE WATERBERG BASIN

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The Waterberg Group consists of a succession of coarse clastic sedimentary rocks and is 1700-1900 Ma old. The depository evolved as a continental, fault-bounded basin in the northern part of the Kaapvaal craton.

The Swaershoek and lower Sterkrivier Formations are interpreted to have been deposited as fan deltas. The Alma and upper Sterkrivier Formations are probably the deposits of alluvial fans. The Skilpadkop and Setlaole Formations were most likely deposited on narrow braidplains. The Makgabeng Formation was deposited as a large dunefield. The Aasvoelkop Formation is thought to have resulted from a through-flow lake.

The Mogalakwena and Sandriviersberg Formations are interpreted as the product of an extensive braidplain, and the Cleremont Formation is interpreted as a littoral or tidally-influenced shelf deposit. The Vaalwater Formation formed within a littoral or a shallow siliciclastic sea palaeoenvironment.

Placer, epigenetic hydrothermal, authigenic and possible syngenetic hydro-thermal (stratabound) mineralization occurs in the Waterberg Group.