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PROTEROZOIC BUSHVELD-VREDEFORT CATASTROPHE: POSSIBLE CAUSES AND CONSEQUENCES; W.E. Elston[1], D. Twist[2].

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Bushveld Complex and Vredefort Dome are unique features, formed in close proximity during the same time interval, ~2 Ga. Both show evidence of catastrophic events in the shallow marine environment of the otherwise stable Kaapvaal Craton. Explanation by multiple impacts of an asteroid, brecciated by an inter-asteroidal collision and disintegrating in Earth's gravity field (1, 2) is supported by pseudotachylite, shatter cones, coesite, and stishovite at Vredefort (3, 4, 5) but these shock phenomena have not been found in the Bushveld Complex (6). The Bushveld Complex was formerly interpreted as a lopolith (7), a view incompatible with gravity, electrical resistivity, magnetic, and seismic-reflection data (8, 9, 10, 11). It is outlined by five inward-dipping lobes of layered ultramafic-to-mafic plutonic rocks (Rustenburg Layered Suite, RLS) that partly coalesce to form a basin-like feature 400 km in diameter and 65,000 km^2 in area, equivalent to a small lunar mare. RLS and underlying sedimentary rocks (Transvaal Sequence) end abruptly below 11-13 km. The interior consists of one or more basement domes, which lends credence to the interpretation of the Vredefort dome as a deeply eroded Bushveld outlier (2). Between the inward-dipping Transvaal-RLS succession and the central dome there is a collar of disturbed pre-Bushveld rocks (11). By the impact interpretation, the central dome(s) correspond to uplifted floor(s) of one or more coalescing primary craters; shock features could be expected there but the domes do not crop out. The collar is inferred to include intensely folded and cataclasized rocks of the western Crocodile River-Rooiberg and eastern Marble Hall-Stavoren "fragments." Originally interpreted as roof pendants in a lopolith, the fragments were interpreted by Rhodes (2) as central peaks of separate impact craters. By the present impact interpretation, they are parts of the rim and flanks of a complexly modified and enlarged crater. This explains intense deformation below the level of shock metamorphism (13).

The Bushveld Complex is orders of magnitudes larger than other proposed terrestrial impact structures and differs from them in important ways. Its principal members, in order of age, are Rooiberg Felsite, RLS, and Lebowa Granite. Rooiberg Felsite (initial volume 200,000->300,000 km^3; 12), the largest mass of related volcanic-like rocks on Earth, may hold the key to its origin. Its volume is ~20% of the Bushveld Complex, far more than impactite meltrock of known astroblemes (< 5%; 14). No calderas or other eruptive centers are known. It could be explained by excavation of the Earth's crust to isotherms above the ambient-pressure solidus of granite (~30 km); added kinetic energy of impact would explain textural and mineralogical evidence for quenching from unusually high temperatures (skeletal clinopyroxene, swallow-tail plagioclase, quartz needles paramorph after primary tridymite, etc.). Repeated water influxes account for explosive volcanism (including ignimbrites and rheoignimbrites in the upper part), complicated stratigraphy with zones of accretionary lapilli, mudflows, and sedimentary interbeds (15). Basal exposures above the disturbed collar show that deformation of the sedimentary floor occurred between times of deposition of the Transvaal Sequence and emplacement of Rooiberg Felsite. Petrography and field relations show transitions from felsite to sedimentary rocks that were metamorphosed (sanidine facies; stability field of tridymite) or partly melted. Geochemical mixing models for major and trace elements show that the high-Mg group of felsites, confined to the lower part of the section (15), closely resemble mixed Transvaal sedimentary rocks. Other chemical varieties (low-Mg and high-Fe) have more complex characteristics. RLS intruded along the unconformity between Transvaal Sequence and Rooiberg Felsite; by the impact hypothesis it represents partial mantle melts induced by deep fracturing near the crater wall. Remaining siliceous melts equilibrated with crust to form anatectic granitic melts, mainly erupted as sheets of Lebowa Granite along RLS-Rooiberg contacts (16).

The Bushveld-Vredefort events occurred during the interval from neutral or reducing atmosphere to oxidizing atmosphere (uraninite-and pyrite-bearing pre-Bushveld sedimentary rocks; post-Bushveld redbeds of the Loskop Group (17). This transition is usually related to the evolution of photosynthesizing organisms (18). If the impact hypothesis for Bushveld-Vredefort can be confirmed, it may represent a global catastrophe sufficient to contribute to environmental changes favoring aerobic photosynthesizing eukaryotes over anaerobic prokaryotes.

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