

Volcanism, sedimentation, and microbial activity in a ca. 3.0 Ga intracontinental setting

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The ca. 3 billion-years-old Dominion Group of the Kaapvaal craton, South Africa, is a >2 km thick volcano-sedimentary succession emplaced in an intracontinental setting shortly after craton consolidation. Deposition of the Dominion Group occurred largely subaerially in a failed rift. Despite its age, the Dominion Group is little deformed and metamorphosed, resulting in excellent preservation of rock textures and chemical signatures. The succession includes a thin, locally U-bearing clastic succession above a major, craton-wide nonconformity, and it is overlain by massive to amygdaloidal mafic lavas of tholeiitic affinity and felsic lavas and ignimbrites with ferroan composition.

Felsic volcanic rocks are locally intercalated with sedimentary units that crop out discontinuously for several km along strike. These largely turbidity current deposits are composed of carbonaceous and variably sulfidic shale and arenite and have a distinctive aluminous composition and very minor alkalis. The presence of shallow intrusions with peperitic contacts and intense alteration developed in volcanic rocks underlying (but not overlying) sediments indicate deposition in a volcanically and hydrothermally active environment.

Periodic subsidence events led to subaqueous deposition of fine-grained volcanoclastic to epiclastic sediments. The sub-wave base nature of the sediment and lack of facies variations both vertically over tens of metres and laterally over several kilometres suggests deposition in large lakes. The main mineral components of these sediments are pyrophyllite, diaspore, K-mica, rutile and pyrite, suggesting low pH aqueous conditions. The total organic carbon content is up to 1.5 wt.%, and $\delta^{13}\text{C}$ values vary between -45 and -29‰ VPDB. These isotopic values together with an abundance of diagenetic sulfides are suggestive of a microbial consortium of methanogenic and anaerobic methanotrophic archaea.

Restricted and ephemeral intracontinental water-bodies that developed in Mesoarchaeon active volcanic environment fostered life and represented niches for life diversification even under the low pH and hydrothermal conditions prevalent in this active volcanic setting on land.