

Volcanism, sedimentation, and development of life in a Mesoarchaeoan intracratonic setting: the Dominion Group, South Africa

*Andrea Agangi^{1,2}, Axel Hofmann², Dora Paprika², Andrey Bekker^{2,3}, Frantz Ossa-Ossa^{2,4}

1. Akita University, 2. University of Johannesburg, 3. University of California, 4. University of Tuebingen

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. As such, it represents one of the oldest examples of volcanism and sedimentation on stable continental crust. Deposition of the Dominion Group is interpreted to have occurred largely subaerially in a failed rift. In contrast to other Palaeo- to Mesoarchaeoan successions of the Kaapvaal craton, the Dominion Group is little deformed and was metamorphosed at greenschist facies grade, allowing excellent preservation of rock textures and chemical composition. The succession includes a thin basal conglomerate that marks a major, craton-scale nonconformity, and is overlain by sandstone. Volcanic rocks include intercalated massive to amygdaloidal mafic lavas of tholeiitic affinity, felsic lavas, and ignimbrites with high Fe/Mg.

In the area around the town of Ottosdal, the Dominion Group is represented by felsic volcanic rocks with intercalated, thin sedimentary layers that crop out discontinuously for several km along the strike. The presence of shallow, porphyritic intrusions that developed peperitic contacts with the sediments and the intense alteration developed in sediments underlying (but not in overlying) volcanic rocks indicate deposition of these sediments in a volcanically and hydrothermally active environment, such as volcanic lakes. These sediments are composed of carbonaceous and variably sulfidic shale and minor arenite and have a distinctive aluminium-rich composition (Al_2O_3 up to 36 wt.%) and very low contents of alkaline elements, Ca, and Fe (Na_2O content from below detection limit to 0.3 wt%; $\text{Fe}_2\text{O}_3 = 0.1$ to 1.6 wt%). The main mineral components of these sediments are pyrophyllite, diaspore, K-mica, rutile, and pyrite. No carbonate was found.

The total organic carbon content is up to 1.5 wt%, and bulk-sample isotope analyses indicate strongly ¹³C-depleted composition ($\delta^{13}\text{C}_{\text{VPDB}} = -45$ to -29%). These isotopic values are diagnostic of biogenic carbon fixation and the lowest, best-preserved values are indicative of methanogenesis and methanotrophy in a redox and chemically stratified shallow basin. Modern examples of volcanic environments hosting methane-producing Archaea, even under low pH and high temperature conditions, are known from Kamchatka, Russia and Argentina.

Our results indicate that restricted and ephemeral lakes that developed in Mesoarchaeoan volcanic environments shortly after the large-scale emergence of the Kaapvaal craton fostered life and were likely niches for life diversification. This ancient environment might be a better Mars analogue than modern caldera environments on Earth where the impact of advanced biosphere is more pronounced.

Keywords: Archaeoan, Terrestrial life, Alteration