MOUND SPRING COMPLEXES IN CENTRAL AUSTRALIA: AN ANALOG FOR MARTIAN GROUNDWATER FED OUTFLOW CHANNELS?

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Introduction: The arid inland of Australia contains a diversity of landscapes and landscape processes, often of great antiquity, extending back to the Mesozoic and Paleozoic. The potential of this landscape as a source of Mars analogs has, however, been little explored. The few examples studied so far include radiation-tolerant microbes in thermal springs [1] and hematite-silica hydrothermal alteration near Arkaroola in the Finders Ranges [2], and aeolian landforms at Gurra Gurra water hole the north east of Arkaroola [3]. Further Australian Mars analog studies were provided by the studies of Bourke and Zimbelman [5, 6] of the paleoflood record of the Todd and Hale Rivers in central Australia. To facilitate study of such analogues, Mars Society Australia has embarked on a project to construct a Mars Analog Research Station near Arkaroola [4]. The international scientific community will soon have the opportunity to participate in Mars analog studies in central Australia utilizing this facility. An area of considerable Mars analog potential is the mound spring complexes that occur at the margins of the Great Artesian Basin (GAB) [7] which underlies 22% of the Australian continent and covers 1.7 million km^2. The mound springs are formed when ground water flows to a topographic low, and subsurface strata dips up causing a hydrological head at the surface. Minerals precipitated at the spring discharge zone form low mesas or "mounds", the height of which are controlled by the hydrological head. This paper describes the Dalhousie Mound Spring Complex (DMC) in the northern part of South Australia (Figure 1), and its potential as a Mars analog.

Hydrogeology: The DMC consists of a cluster of more than 60 active springs formed by natural discharge from the GAB) [7]. Total measured discharge from the GAB is 1.74 GL per day, estimated unfocussed natural leakage through the aquaclude is thought be approximately equal to this figure. Some 54 ML per day are currently discharged by the DMC, 3% of the measured total. The discharged artesian waters [8] are of low to moderate salinity (700 - 9400 ppm), near neutral pH (6.8-7.3) and warm (20-46^{o}C). The elevated temperatures are due to passage of the groundwater through deeply buried (up to 3 km) aquifers in an region of high heat flow, rather than magmatic heating. The waters also contain high levels of dissolved iron and H_2S and <1 ppm dissolved oxygen. The water is carried in the Late Jurassic Algebuckina Sandstone beneath the aquaclude of the Bulldog Shale. It is brought near the surface by the mid-Cenozoic Dalhousie anticline and the ground water flow focused along a series of faults that breach the anticline's crest [9].

Geomorphology: The regional map [10] shows the DMC occurring in a topographic low rimmed by silcreted breakaways (mesas) of Paleogene Eyre Formation sediments. These have been sculpted by ground water sapping out of this unit. The main depression contains numerous active and extinct mounds, the largest (extinct) mounds being more than 5 km long and approximately 20 m high (Figure 2). The mounds are constructed of clays, carbonates, gypsum, and iron oxides. The larger size of the extinct mounds indicates a waning of discharge over time since the formation of the complex in the Early Neogene. Discharge from the DMC forms pools of varying size at the springs themselves and then flow north into a series of playas. Past larger groundwater flows, seepage from the Eyre Formation and intercepted runoff have eroded Spring Creek, an ephemeral braided drainage system up to 5 km wide that flows north, then east and finally south for a distance of approximately 100 km. The outflow is eventually lost in the red sief dunes of the Simpson Desert.

Biology: The biota of the spring system contains many endemic species. Most studies have focused on the fishes, invertebrates, and higher plants. Micro algae have received only preliminary attention [11], and other microorganisms none. Observations by the authors during a visit to the DMC and other mound springs of the GAB in 2001 revealed a diversity of microbial crusts on the mound spring and inter-spring surfaces, filamentous and thermophilic algae in the hot pools, and travertine deposits with possible microbial textures, suggesting the presence of diverse and complex microbial communities. The tufa samples from fossil springs are stained dark by amorphous organic matter they contain. Samples of the travertine deposit obtained from Strangways mound springs, to the North of DMC, were analyzed using X-ray diffraction and were composed of calcite (95.3%), gypsum (3.9%) and < 1% halite. In thin section, the samples consist of spongy fine grained calcite stained brown by amorphous organic matter. The calcite consists of small pellets, laminae, crusts, and calcified filaments strongly suggestive of microbial filaments (Fig. 3).

Analog value: The DMC and other mound springs in the region provide several potential Mars analogs. These include: mound morphology, valley morphology, hydrology, and the biota and ecology of springs. Other terrestrial analogs of Martian valley networks include the channeled scabland and box canyons [12], the first fed by catastrophic glacial dam bursts, the second by regional aquifer seepage. In contrast the DMC provides an example of a major groundwater landform system fed by a discrete geothermally heated groundwater source. This may provide a useful alternative analog for those Martian valley networks which are believed to be related to localized geothermal activity [13]. Given the intense interest in thermal spring as favorable environments for life on the early earth [14] and perhaps on Mars [15], the presence of a diverse microbial biota in the thermal springs, outflows and perhaps in the subsurface of the DMC warrants further research.

Figure 1: Location of the DMC in Australia with extent of GAB shaded. Modified from Smith [8].

Figure 2: A view over the DMC from the west. Foreground breakaways are of an extinct high-level mound spring travertine deposited on top of Bull Dog Shale. The Groundwater sapping gullies lead down to white playa lake, approximately 20 m lower in the landscape. The dark area in distance is a heavily vegetated cluster of active springs about 500 m in length.

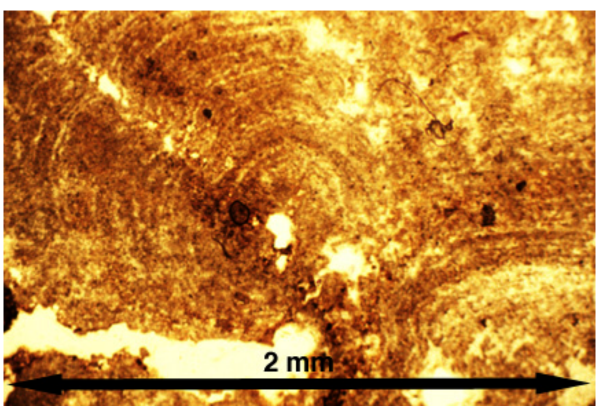

Figure 3. Photomicrograph of thin section of tufa from Strangeway mound spring.

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