AN ORIGIN OF LIFE AT TERRESTRIAL HOT SPRINGS: SUPPORT FROM EARLY EARTH AND IMPLICATIONS FOR THE SEARCH FOR LIFE ON MARS. M. J. Van Kranendonk[1,2], T. Djokic[1,2], K.A. Campbell[3], D. Deamer[4], B. Damer[4], M.R. Walter[1], L. Steller[1,2], T. Ota[5], E. Nakamura[5], and S. Tadbiri[1,2], [1]Australian Centre for Astrobiology, School of Biological, Earth and Environmental Sciences, University of New South Wales Australia, Kensington, NSW 2052 Australia; m.vankranendonk@unsw.edu.au, [2]ARC Centre of Excellence for Core to Crust Fluid Systems, [3]School of Environment, University of Auckland, Auckland 1142 New Zealand, [4]Dept of Biomolecular Engineering, University of California at Santa Cruz, Santa Cruz CA, 95064 USA, [5]Institute for Planetary Materials, Okayama University, Misasa, Tottori 682-0193, Japan.

Introduction: The origin of life on Earth remains contentious but has profound implications for the search for life elsewhere in the solar system and beyond. One model for origin of life at alkaline hydrothermal vents in seawater [1] supports the search for life on the watery, ice-covered moons Enceladus and Europa. However, a model for origin of life at terrestrial hot springs [2-5] would preclude life detection missions to these moons, but support the search for life in analogous deposits on Mars [6].

Early Earth insights: Recent, ongoing investigations of the 3.48 Ga Dresser Formation, Pilbara, Western Australia have revealed that some of the earliest microbial life on Earth thrived in terrestrial hot springs within an active, low-eruptive volcanic caldera [7-9]. The supporting evidence includes diverse biosignatures preserved in and around geyserite, siliceous sinter, and the mineralised remnants of the hot spring pools themselves [9]. Terrestrial hot springs provide wet-dry cycles required for polymerization [4] and the fresh water K^+/Na^+ ratios found in all cells [3]. Critically, however, we have found that the Dresser hot spring setting also includes concentrations of many key elements (C, Zn, B, P, and N), and minerals (e.g., kaolinite) required for prebiotic chemistry [2,3] (Fig. 1). These were concentrated and created via intense epithermal (e.g., steam-heated acid-sulfate, or advanced argillic) alteration of previously seawater-modified (carbonate-altered) underlying basalts affected by a dense network of hydrothermal chert-organics±barite±pyrite veins [7,8,10].

Life on Mars?: An origin of life at terrestrial hot springs is highly relevant to the search for life on Mars. This setting precludes the requirement of a global ocean in early Mars history, for which the evidence is disputed. In contrast, ancient terrestrial hot spring deposits have been found in several places [6,11]. We now know that all terrestrial hot spring deposits on Earth throughout 3.5 billion years of geological time contain biosignatures preserved in siliceous materials, so siliceous hot spring deposits are the most likely place to search for signs of life on Mars.Such a strategy avoids the complications of searching for organic compounds that could have multiple sources including contamination, and instead focusses on cellular and macroscopic preservation [12].

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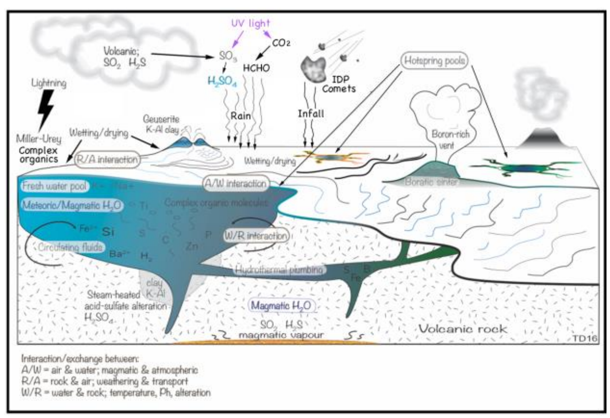

Fig. 1: Schematic diagram of the Dresser hot spring system and its concentrated elements: R/A = Rock/Air; A/W = Air/Water; W/R = Water/Rock.