

**USING COMPLEXITY ANALYSIS TO DISTINGUISH FIELD IMAGES OF STROMATOLOIDS FROM SURROUNDING ROCK MATRIX IN 3.45GA STRELLEY POOL CHERT, WESTERN AUSTRALIA.** M. Storrie-Lombardi<sup>1</sup> and A.J. Brown<sup>2</sup>, <sup>1</sup> Kinohi Institute, 530 South Lake Avenue, Pasadena, CA 91101 USA, email: mike@kinohi.org <sup>2</sup> Australian Centre for Astrobiology, Macquarie University, NSW 2109, Australia.

**Introduction:** The biogenicity of stromatolitic features in the Early Archaean Strelley Pool Chert have recently been the subject of some debate. If biogenic, these features would be a valuable source of evidence for Earth's earliest biosphere. If abiogenic, the features may still be able to provide information about distinguishing biogenic from abiogenic stromatoloids. A new method developed for the remote identification of stromatolites and subsequent quantification of their likely biogenicity is herein described. Initial results and future directions are presented. Further applications to planetary missions are outlined.

**Strelley Pool Chert:** The 3.45 Ga Strelley Pool Chert (SPC) was first described by Lowe [1]. The SPC succession is one of several volumetrically small volcanoclastic sedimentary units within the primarily volcanic Early Archaean Warrawoona Group [2]. Stromatoloids at the Trendall Locality have been described by Hoffman et al [3] and meter scale mapping and a geochemical study of the area have been conducted by Van Kranendonk [4, 5]. More recently a photo montage and geological map have been collated by Brown [6].

**Biogenicity of Stromatolitic Features:** Lindsey et al [7] have recently disputed the biogenicity of stromatolites at the Trendall Locality of the Strelley Pool Chert. They propose that the stromatoloidal carbonate and silicified carbonate layers of the Trendall locality were "generated by direct precipitation of carbonate from hydrothermal fluids in a relatively deep marine setting". They state that they "find no direct evidence of biogenic mediation" and point out one of their observations is that the structures are "conspicuously isopachous". This provides an opportunity to apply texturally based complexity analysis to assess the biogenicity of the stromatoloidal structures.

The term "stromatolite" will be used rather than "stromatoloid" [8] to describe the laminar features within the SPC within this paper, even though their biogenicity is still being determined.

**Complexity Analysis:** Storrie-Lombardi et al [9] recently described a method by which the biogenicity of stromatoloids may be judged using complexity analysis. The complexity of a digital file can be quantified using lossless compression algorithms which reduce file size by identifying redundant information. Decompression of the compressed file returns the original file unaltered. Both biological and physicochemical structures can exhibit "complexity". The ap-

parent redundancy of a complex systems varies with scale and may, in the most fundamental sense, originate in the "grain size" of the geochemical or biochemical processes altering the matrix. In that case, the differentiation of geological and biological complexity depends on the size of the fundamental unit of redundancy, e.g. a single cell versus a mineral crystal.

In previous work, we have implemented a matched-pair strategy for empirically estimating the relative compressibility of a target of interest by comparing it to the surrounding environmental matrix. We calculate the differential compressibility index,  $\delta_c$ , comparing the lossless compressibility of an image of a target area,  $C_t$ , to the compressibility of the surrounding matrix,  $C_m$ , where

$$\delta_c = \log[1+(C_t - C_m) / (C_t + C_m)].$$

The absolute value of  $\delta_c$  provides the magnitude of the difference in complexity independent of whether the target is more or less compressible than the surrounding matrix. The implementation of such a complexity probe is readily accomplished by comparing the percent compression of a stromatolite sample to its neighboring rock matrix. The two major sources of experimental error in this strategy are the degree of diagenesis (post-deposition alteration, usually by water-mediated geochemical weathering) in the stromatolite and the presence of biogenic modification to the rock matrix.

**Method:** As part of the collation of a photo-montage of the Trendall locality, photographs were assembled of all preserved stromatoloids within a 50m x 30m rectangle of the Trendall Locality. Stromatolite and rock matrix targets were identified in two of these photos and 5cm x 5cm image samples were obtained and compressed using the "gzip" computer code. The sedimentary rock matrix adjacent to the stromatolites is a carbonate rich in iron, comprised primarily of dolomite.

**Results:** Preliminary results of complexity analysis are outlined in Table 1.

	Mean	Sigma	n
Stromatolites	17.8%	2.5%	6
Rock Matrix	31.9%	10.2%	6
Relative Compression, $\delta_c$	0.14	0.07	6

**Table 1 – Complexity analysis of Strelley Pool Chert stromatolite and rock remote imaging samples.**

At this scale the stromatolite images exhibit minimal variance in compressibility ( $17.8 \pm 2.5\%$ ) and are significantly less compressible than the images of the surrounding rock matrix ( $31.9 \pm 10.2\%$ ,  $p < 0.009$ , student T-test). The  $\delta_c$  value computed implies variation of a target from the surrounding matrix more than two sigma removed from what would be expected from the variance attributable to a random, diffusion driven system.

**Application to future missions:** Analysis of stromatoloidal structures imaged by planetary orbital missions or mission landers will be problematic. This method provides a detection methodology for automated search campaigns and a first order analysis for the biogenicity of the structures, using the ability of the compressibility algorithm to capture the random nature of abiotic sediment or the regular nature of a biogenically controlled structure. A simple metric can be employed to analyse a large number of images of a massive outcrop quickly and without human intervention, allowing robotic assistance in the search for more interesting sections of a single outcrop or more promising outcrops of a particular formation.

**Future Research:** It is intended that further field work will be conducted in May-July 2004 in order to collect photographs of the Trendall locality and other promising sites within the Warrawoona Group. The imaging system employed to obtain photos analysed thus far have used the JPEG algorithm which performs some initial lossy compression of the image. Essentially, the camera throws out some of the information used in the complexity analysis. It is encouraging that the technique appears robust to this loss, since such a situation may occur in robotic searches. Future images will be obtained using the TIFF format.

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**Figure 1 - Carbonaceous Stromatoloids from the Trendall locality - note distinctive 'mickey mouse ears' structure at top right.**