THE CULTURABLE MICROBIAL COMMUNITY FROM THE HOT SPRINGS OF AN AFRICAN SODA LAKE. L.E. Davis¹, I.A. Crawford², J.M. Ward³, S. Hunter³, C.R. Cousins¹, A.P. Jones¹, G. Shields-Zhou¹. ¹Dept. Earth Sciences, University College London, Gower Street, London, WC1E 6BT, lottie.davis@ucl.ac.uk, ²Dept. Earth Sciences, Birkbeck College, Malet Street, London, WC1E 7HX. ³Dept. Structural and Molecular Biology, University College London, Gower Street, London, WC1E 6BT.

Introduction: Extreme environments on the Earth can provide insight into the conditions under which life can exist. As more data is accumulated on the geology of Mars and Enceladus, alkaline environments are becoming of increasing interest in terms of astrobiology. Where environments with a high pH were not previously considered as relevant to Mars, it is becoming clear that these planets and moons are more environmentally heterogeneous than previously thought [1].

Sediments on Mars in areas such as the Mwarth Vallis indicate a neutral to alkaline aqueous environment having prevailed for an extended period in the history of Mars [2]. Wet Chemistry data from the Phoenix Mars Lander reveals that in some localities, soil pH reaches 7.7 + 0.5 [3]. The sediments on Mars can be divided into three epochs based on their mineralogy. The oldest grouping, known as the Phyllosian is a period characterised by an extended period of neutral to alkaline, aqueous conditions and resulting in the deposition of phyllosilicates and carbonates. Later periods are characterized by more acidic conditions [4].

Terrestrial alkaline and saline environments have received much attention; Lake Magadi in the East African Rift Valley is one of the lesser studied localities. This soda lake has a high pH (8-11) and additionally contains up to 30% dissolved sodium chloride, as well as sodium carbonate and bicarbonate [5].

Along the African rift system there are a series of volcanoes and hot springs. These springs vary considerably in their temperature along the rift system [5] with a noticeable temperature gradient from a warmer north, to a cooler southern region.

The soda lakes— which could be considered hostile and inhospitable— in fact contain a rich diversity of life from microbes to flamingos, indicating that in even these hot and saline conditions life can flourish.

The purpose of this study is to identify the culturable alkali and halotolerant microorganisms which can be used in Martian survivability and biosignature studies.

Method: Samples were collected from Lake Magadi at the southern end of the East African Rift Valley in Kenya. Water, soil and biomass samples were taken from three different areas around the lake. Temperature and pH was measured at all sites in situ.

Water samples were analysed using Ion Chromatography and Inductively Coupled Plasma Atomic Emission Spectroscopy which provided the chemical analysis with which an analogous growth medium could be designed. In addition the growth media were augmented with either 1% peptone or 0.5% soluble starch. The sodium chloride content of the media was altered from <1% salt (low salt) to 6.8% and 15% (w/v).

Between 5 and 6 samples were chosen from each area to be cultured, these were chosen based on the temperature from which they sampled being around 80°C, 60°C or 37°C in order to gain a good variety of types of samples comparable between areas.

The water activity of the samples was ascertained using Novasina TH500 AW Sprint water activity meter at 25°C.

The samples were grown at temperatures which were analogous to the temperature from which they were collected. (37°C, 60°C, 80°C). The pH of the medium was altered to mimic the samples original environment, using a sodium carbonate buffer system.

Figure 1: Map of Lake Magadi, indicating spring localities (numbered) areas of trona and open water lagoons in the lake area (Adapted from [9]).
to maintain pH levels at higher temperatures. All selected samples have also been grown at 37°C.

Results and discussion: Area A, at the north of the lake (Figure 1), contains the hottest sample locality, with temperatures in the main spring flow in the region of 80.1°C-82.7°C, however, around the edge of the stream the temperatures dropped off to 58°C. South of the most northerly spring raised areas of pooling water were measured at temperatures of 38 °C and 44°C, however the main body of water still measured around 82°C, fed by springs along its length. The pH was fairly constant 9.50. Twenty samples were collected from this locality, eight of which were from 80°C sites.

Area B to the south west of A was cooler with temperatures being measured between 57.3 °C and 66 °C. This site seemed to have a much less of a temperature variation than site A. The pH varied between 9.07 and 9.31, but there seemed to be no connection between temperature and pH with 64.3 °C waters at different sites having a pH of 9.07 and 9.29. Twenty samples were collected from this site.

Site C was the geographically largest area and contained the most sampling sites and for this reason thirty eight samples plus two, one metre long cores were collected. Water temperature ranged from 35.7 °C to 44.6 °C and pH varied between 9.96 and 10.1. Samples were collected from the edge of the lagoon as well as from springs and pools. The cores were sampled ~three metres from the lagoon edge where the mud was soft enough for penetration. This was the only locality where the coring could be completed due to hard soil elsewhere.

There was very little variation in the water chemistry between the three areas despite the difference in temperature. Calcium and magnesium levels were below the detection limits, which is in line with previous studies [5]. Chlorine levels were between 5000 and 7000 ppm and sodium levels were in the region of 5000ppm. The salt content of the samples was considerably lower than expected in these saline lakes, and the results of the water activity analysis agreed with this. The water activity of all samples are between 0.977aw and 0.984aw. It seems likely that the high salt saturation described by others occurs in the central areas of the lake where trona formation occurs, rather than in the spring waters which feed the lake, that were sampled in this study.

The samples incubated at 37°C low sodium chloride and 6.8% sodium chloride plates showed significant growth within 24 hours of incubation. The 15% sodium chloride plates, showed growth after between 5 and 7 days incubation.

All low temperature samples (~37°C) grew when incubated at 37°C. Samples from the 60°C sites were plated and incubated at 60°C. However no growth was achieved even after 15 days on any plates except one colony which grew after 10 days on the low salt peptone plate. The same applied for the samples from area A, grown at 80°C. No growth was observed.

All samples from all areas were then incubated at 37°C and growth was observed on most plates. The only sample which failed to show any growth was the water sample from the hottest part of the stream in area A (measured at 82.7°C). This sample failed to grow on any media at 37°C or 80°C, under these culture conditions.

All samples plated onto peptone agar grew well at all salt contents, the soluble starch plates grew considerably slower.

Most samples showed some bacterial growth on at least one type of medium.

A definitive study of the cultured community will be completed using 16s DNA sequencing.