SURVIVAL OF HALOPHILES AT SIMULATED MARS CONDITIONS

A.A. Berezhnoy[1], A.V. Bryanskaya[2], A.S. Rozanov[2], S.I. Baiborodin[2], A.K. Pavlov[3], S.E. Peltek[2]

[1] Sternberg Astronomical Institute, Moscow State University, Russia
[2] Institute of Cytology and Genetics, SB RAS, Novosibirsk, Russia
[3] Ioffe Physical-Technical Institute, St. Petersburg, Russia
Contact: ber@sai.msu.ru

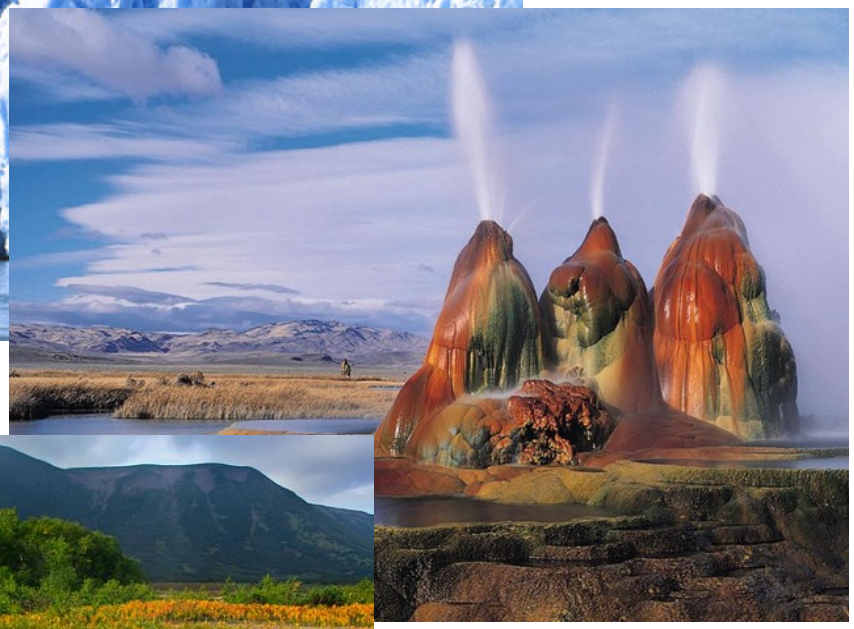
РОССИЙСКАЯ АКАДЕМИЯ НАУК
Физико-технический институт имени А.Ф. Иоффе

ИЦГ

МГУ имени М.В.Ломоносова 1755

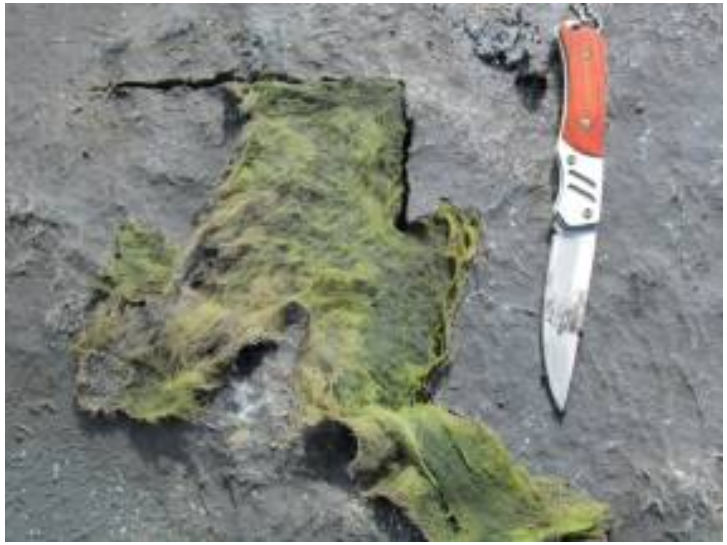
ГАИШ


RUSSIA
MONGOLIA
CHINA
JAPAN

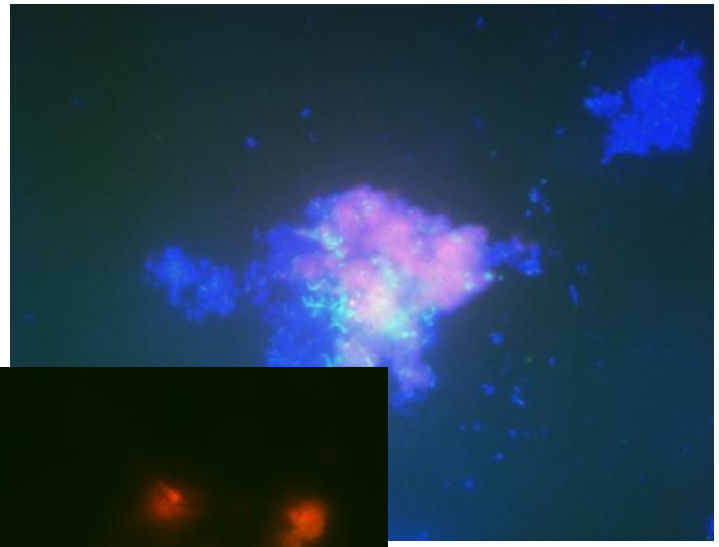


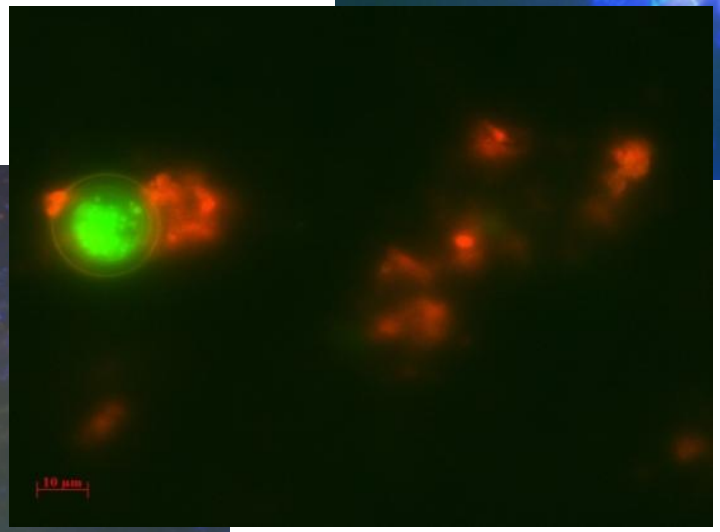
The salt lakes of the Altai region and Novosibirsk oblast

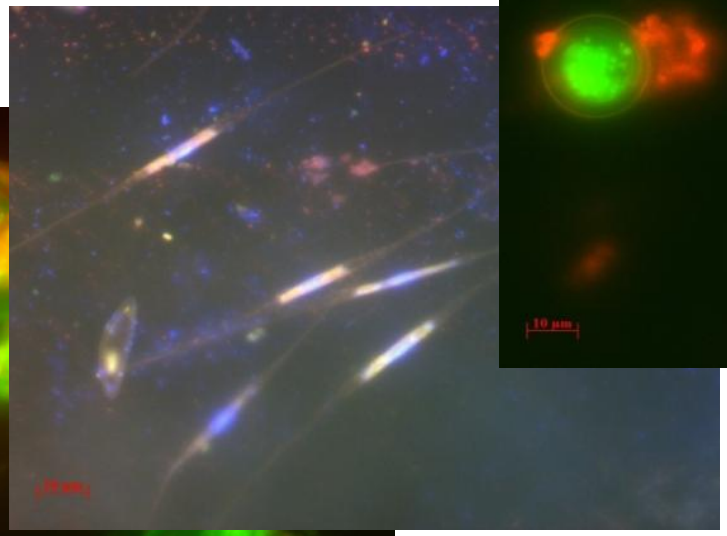
Mineralization
4 - 300 g/L
pH 7.6 – 9.5

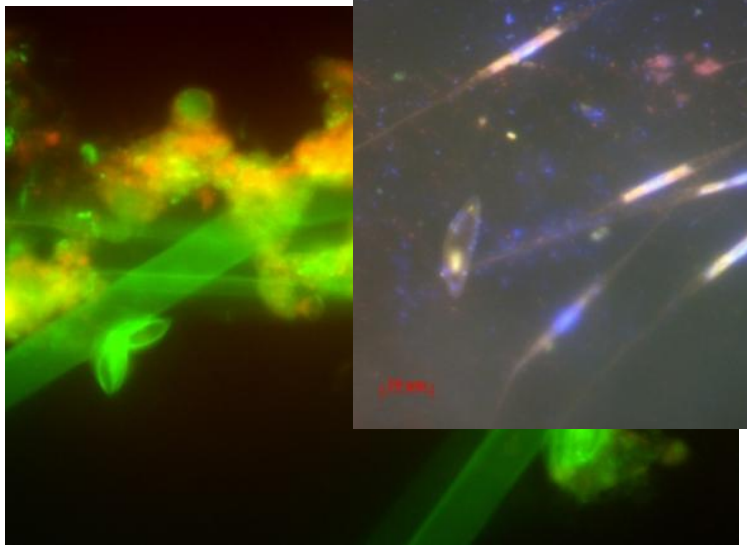


Lake Khoroshee.
Macrophotography of microbial mat.



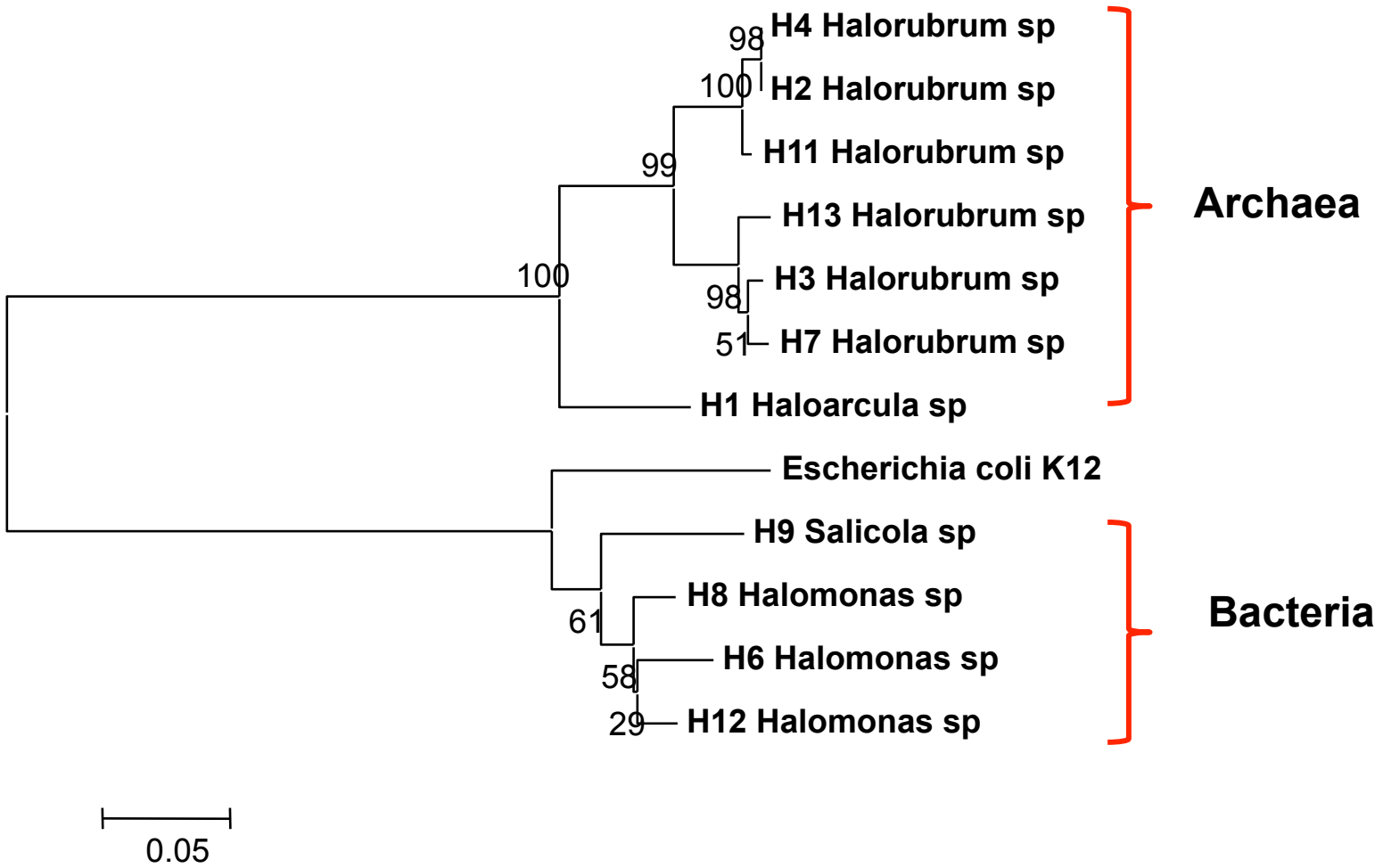




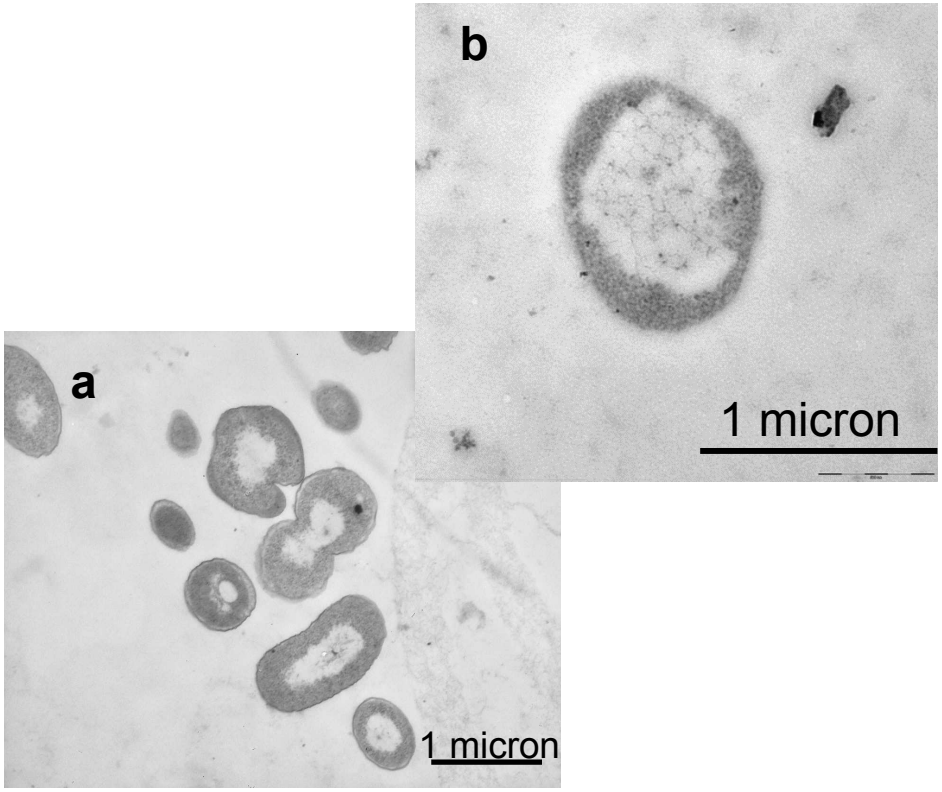


Microphotographs of microbial communities. Fluorescent in situ hybridization probes.
Scale, 10 micron.

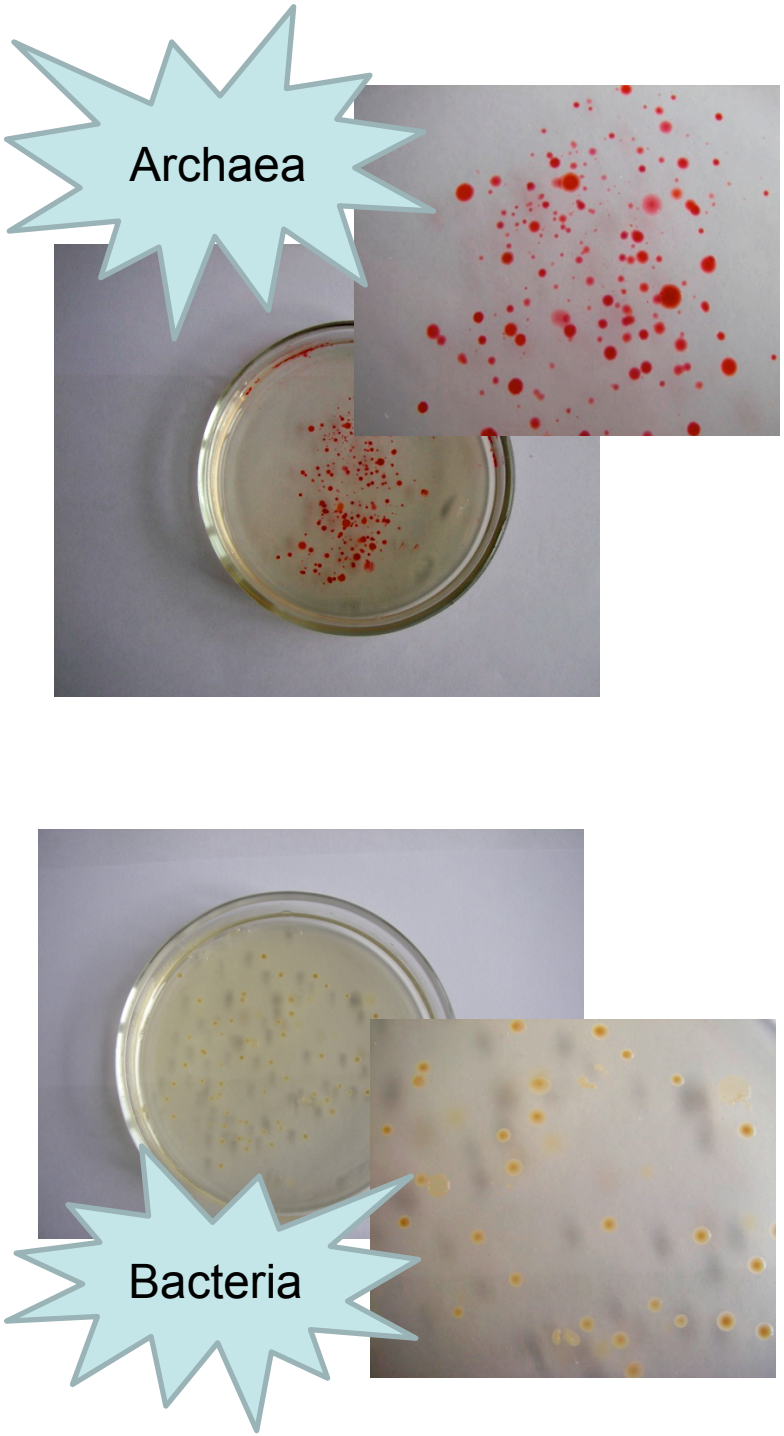
Phylogenetic tree of the obtained strains (based on the analysis of 16S rRNA genes)



Morphology of the strains

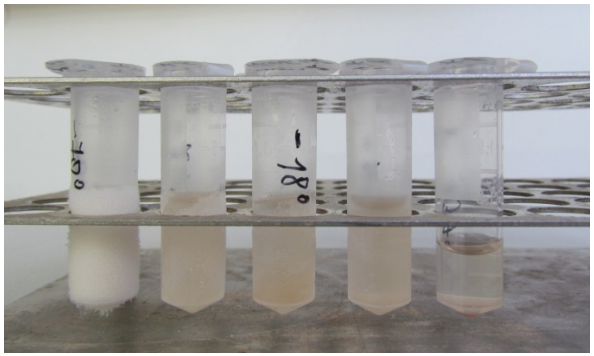


Electronic microphotographs of the strains H12 (a) and H4 (b).



The aim of this study is
learning adaptability of bacterial and archaeal strains of salt lakes of the Altai region and Novosibirsk oblast in conditions that simulate some parameters on Mars (low temperatures, salt solutions with high NaCl, $MgSO_4$, Na_2SO_4, $NaClO_4$ content)

Experiments:

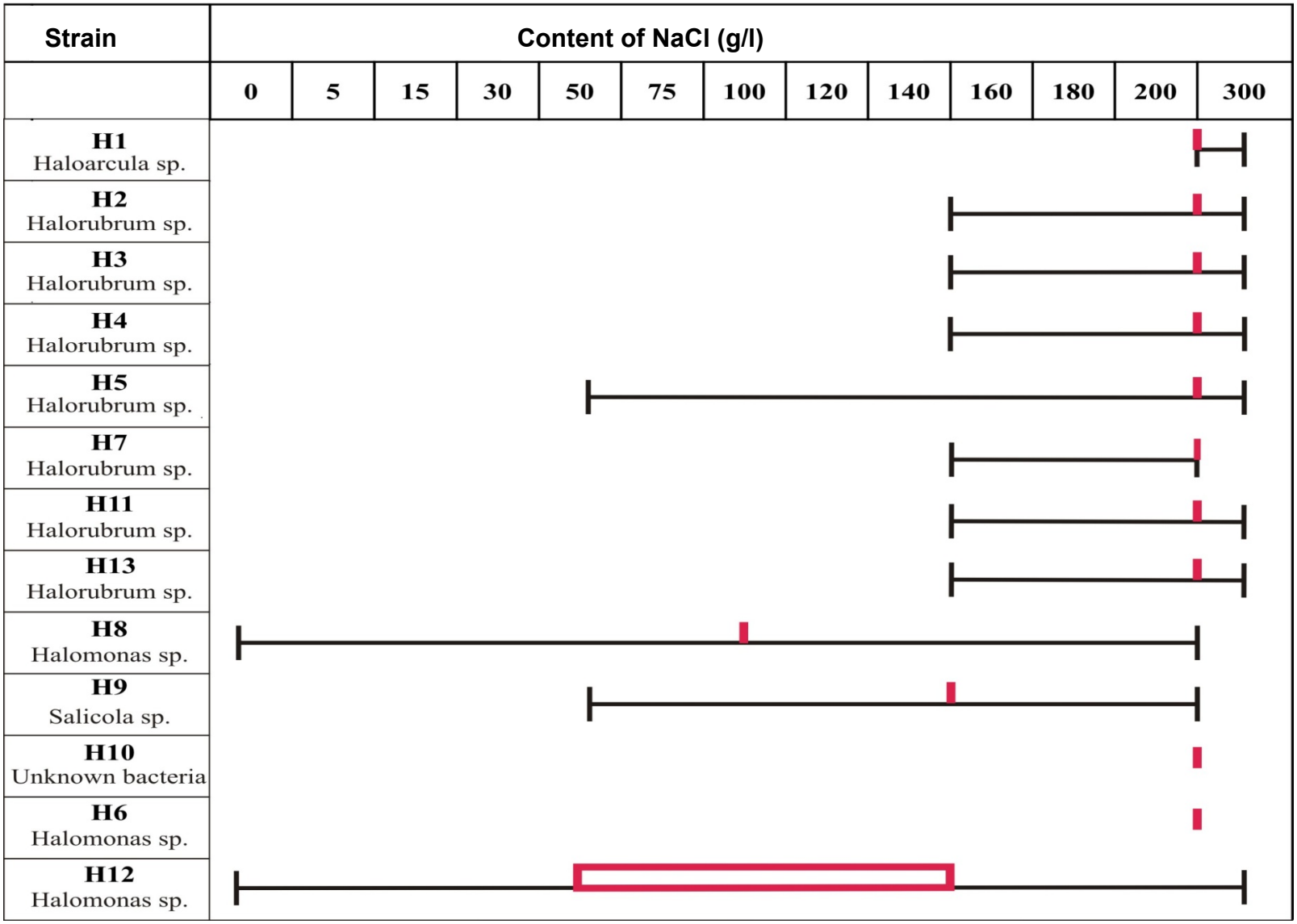


1. Determining the optimum conditions and growth range of strains at various pH and NaCl content.

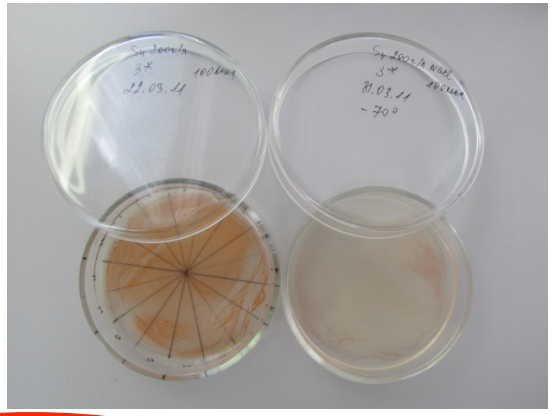
2. Assessing the impact of cooling (-18 °C) and freezing (-70 °C) at different concentrations of NaCl on the survival of strains.

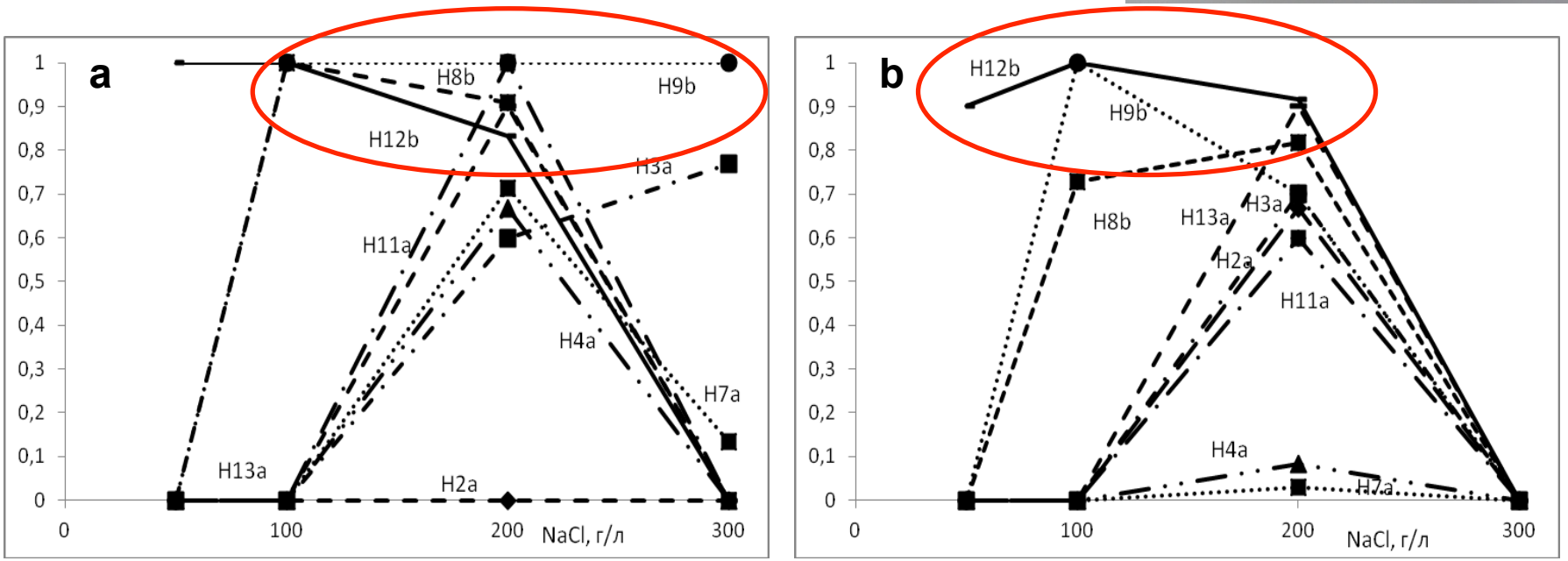
3. Assessing the impact of different concentrations of Na_2SO_4, $MgSO_4$, and $NaClO_4$ on viability of the strains.

Experiment 1. Growth range and optima of archaeal and bacterial strains at various NaCl content



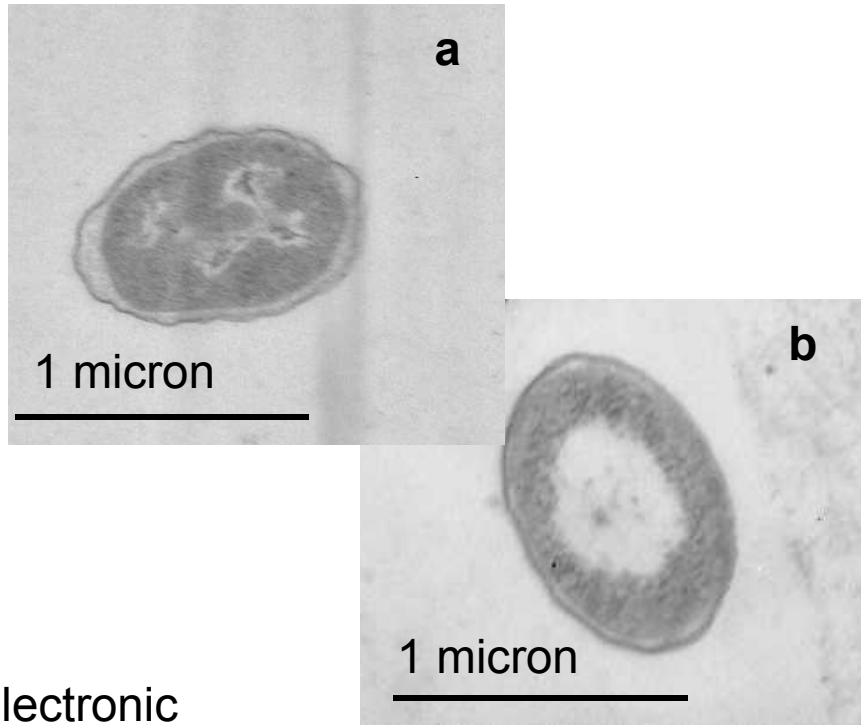
Experiment 2. The impact of cooling (-18°C) and freezing (-70°C) at various NaCl content on the viability of the strains.



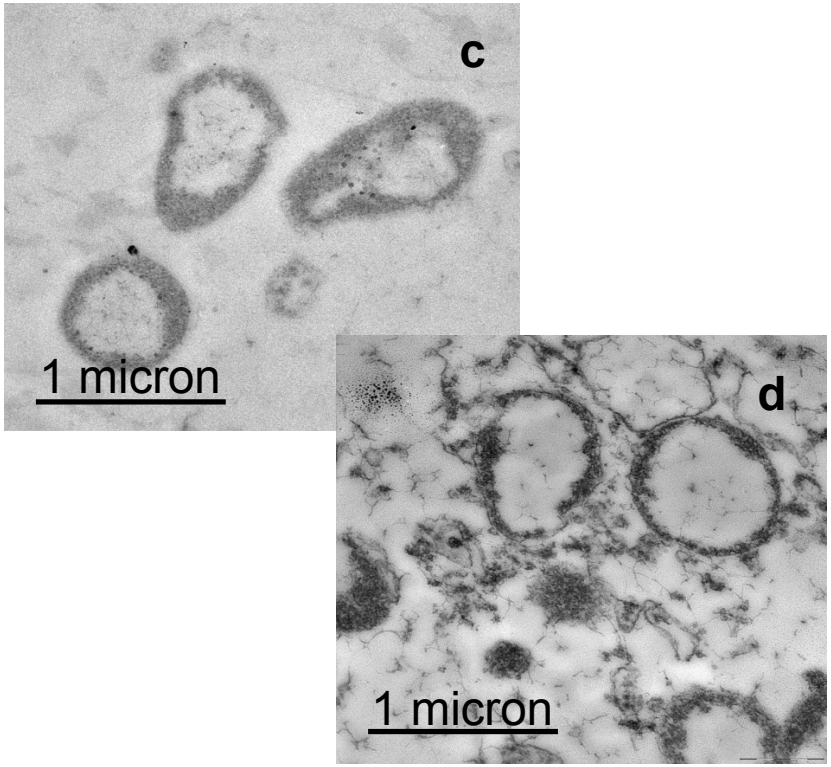


Ratio of the percentage of surviving organisms after cooling to -18°C (a) and freezing to -70 °C (b) to the control conditions at various NaCl content (g/L).

Morphology of the cells after freezing



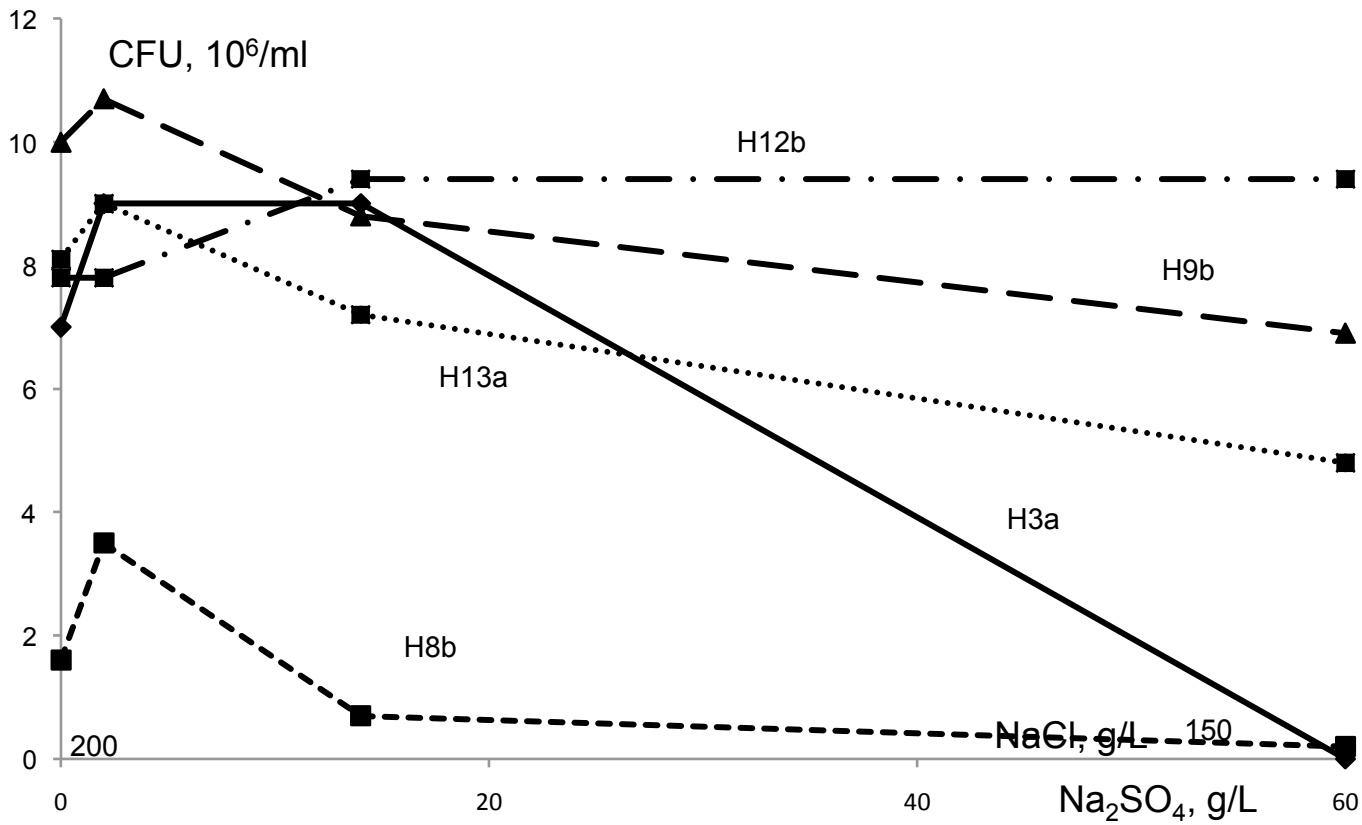
Electronic microphotographs of the H12 strain before (a) and after freezing at -70°C (b).



Electronic microphotographs of the H4 (c) and H7 (d) strains after freezing at -70°C.

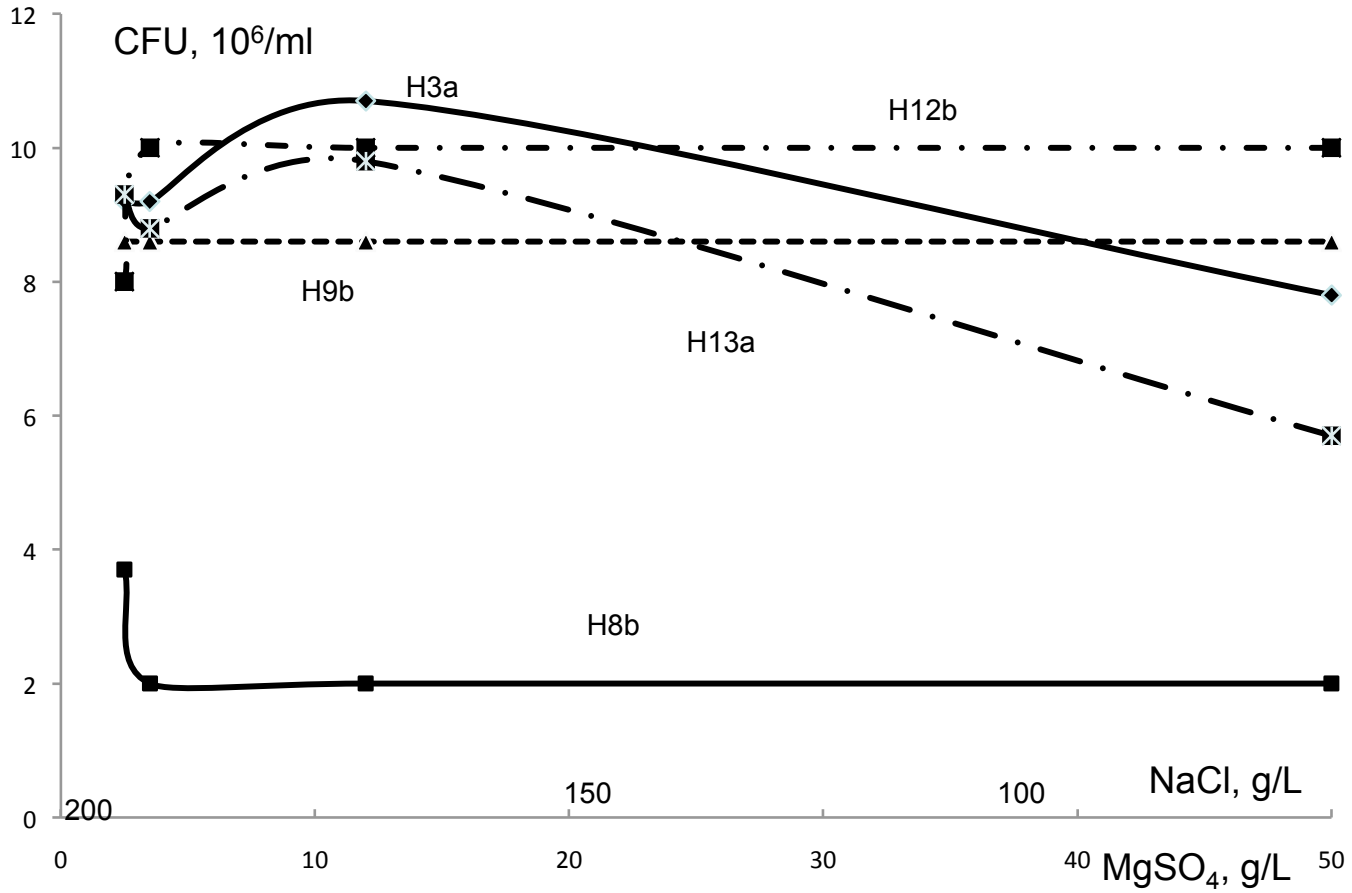
For the experiment with different concentrations of Na_2SO_4, $MgSO_4$ and $NaClO_4$ were selected 5 of 9 strains showing the best results on survival after cooling and freezing.

Experiment 3. Viability of strains in Na_2SO_4, $MgSO_4$, and $NaClO_4$ solutions.



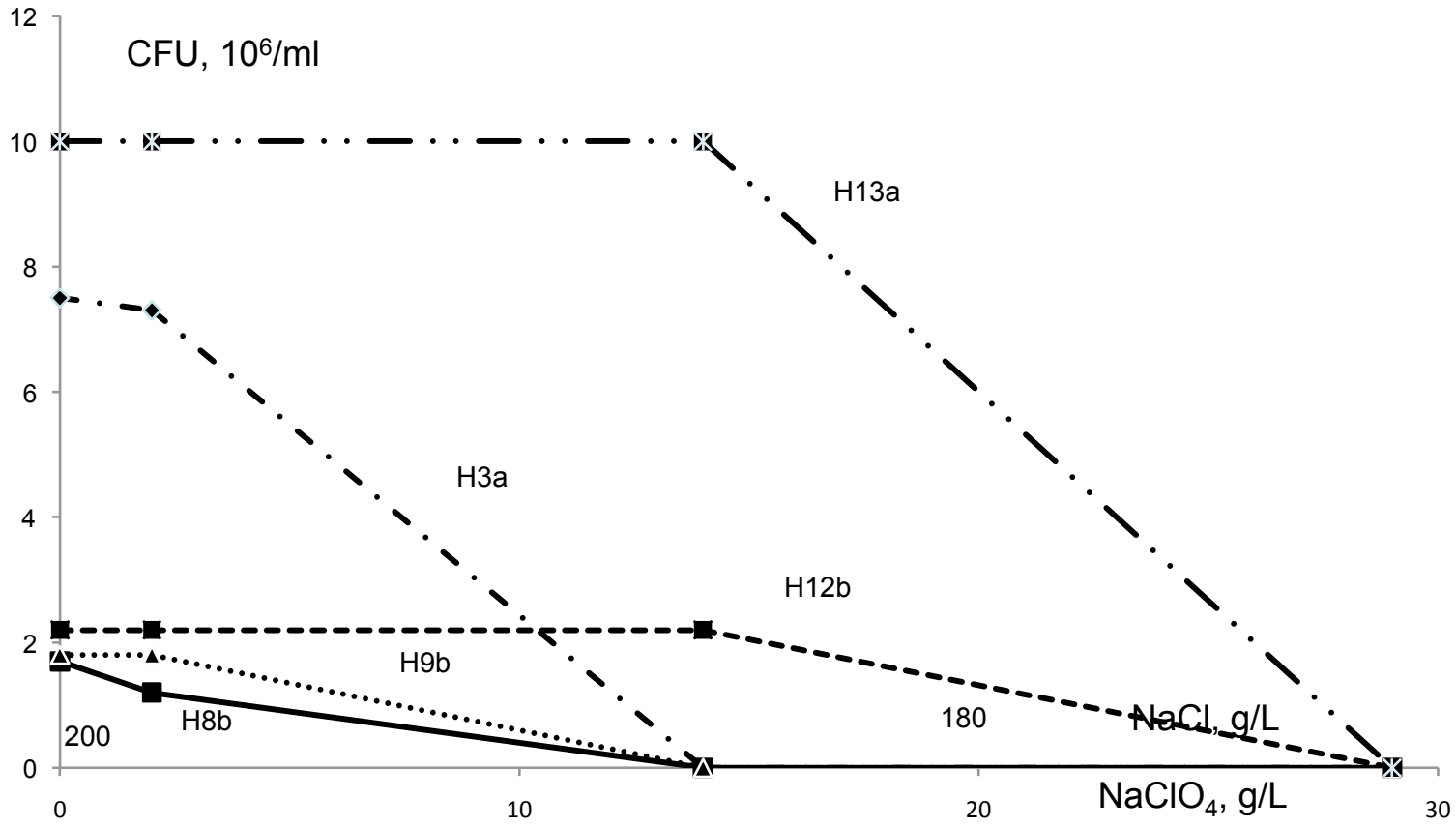
Growth of microorganisms at various NaCl and Na_2SO_4 content. Total salt content is 200 g/L.

Experiment 3.



Ratio of the percentage of surviving organisms at various NaCl and $MgSO_4$ content. Mineralization is decreasing from 200 to 140 g/L.

Experiment 3



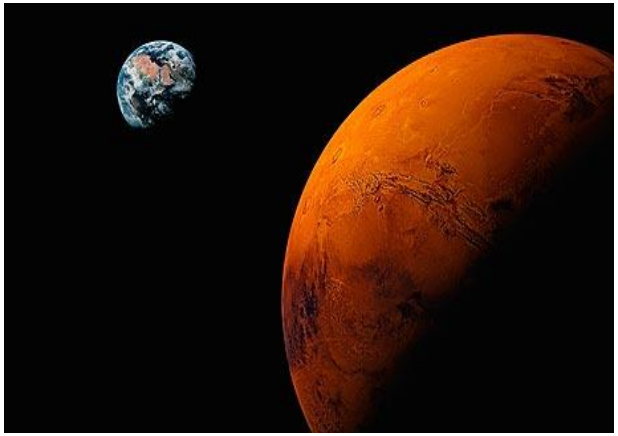
Ratio of the percentage of surviving organisms at various NaCl and $NaClO_4$ concentrations.

Total salt concentration is 200 g/L.

Results

- Archaeal strains had narrower growth ranges, and growth optima were at 200-300 g/L NaCl content. Growth optima of the bacterial strains were at 100-200 g/L NaCl content.
- The viability maximum of the strains was at mineralization values close to the growth optima.
- Halomonas sp. H12 and Salicola sp. H8 bacterial strains had the greatest resistance to high sulfate content.
- Halomonas sp. H12 and Halorubrum sp. H13 strains were resistant to $NaClO_4$ content up to 14 g/L.
- Halomonas sp. H12 bacterial strain and Halorubrum sp. H13 archaeal strain tolerate the widest range of various extreme factors.

- Based on the results of our experiments, we can assume that archaea and bacteria of the salt lakes of the Altai region and Novosibirsk oblast - the remnants of an ancient sea - may be analogs of organisms that existed on Earth billions of years ago and could potentially survive in Martian conditions, since they can survive at wide range of salt solutions and low temperatures with minimal loss of viability.



Further studies:

1) Microorganism growth at low temperatures (-5, 0, +5, +8, +25, 37°C).
2) Microorganism growth in the presence of various anions (BO_3^{3-}, HCO_3^{-}, HPO_4^{2-}, NO_3^{-}). Finding optimum media for studying the impact of low temperatures.
3) Impact of various substances (Fe^{2+}, Fe^{3+}, Mg^{2+}, H_2O_2) on the viability at low temperatures.
4) Microorganism growth in the presence of low concentrations of organic substances (7 ppm on Mars, 4 000 ppm at experimental conditions).
5) Viability of microorganisms at low atmospheric pressure and high radiation intensity (300 nm, high-energy protons).