SPEAR

Solitary Probe for Electrochemical Analysis and Reporting

Or

Subsurface Penetrator for …

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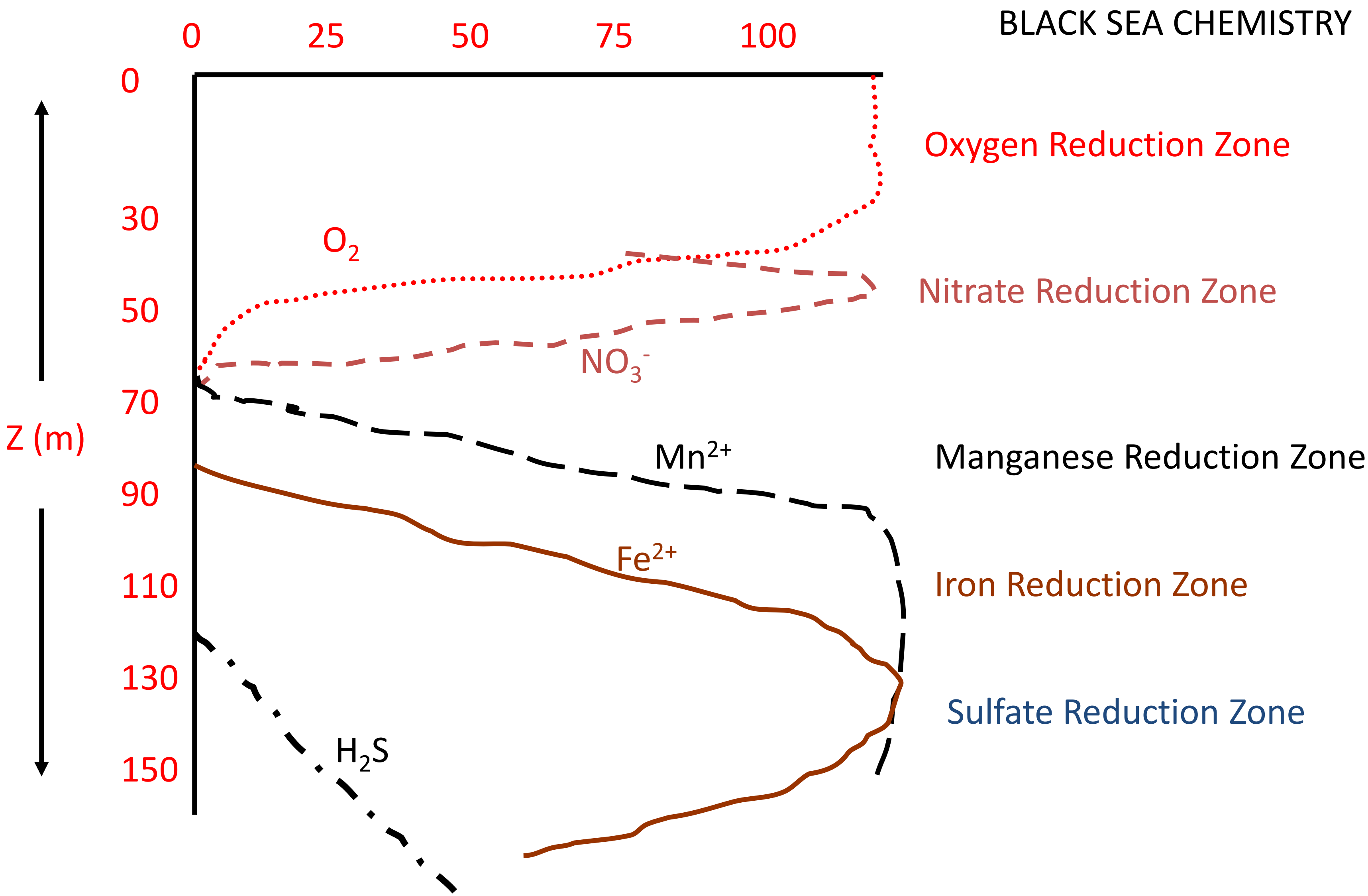
The Rationale

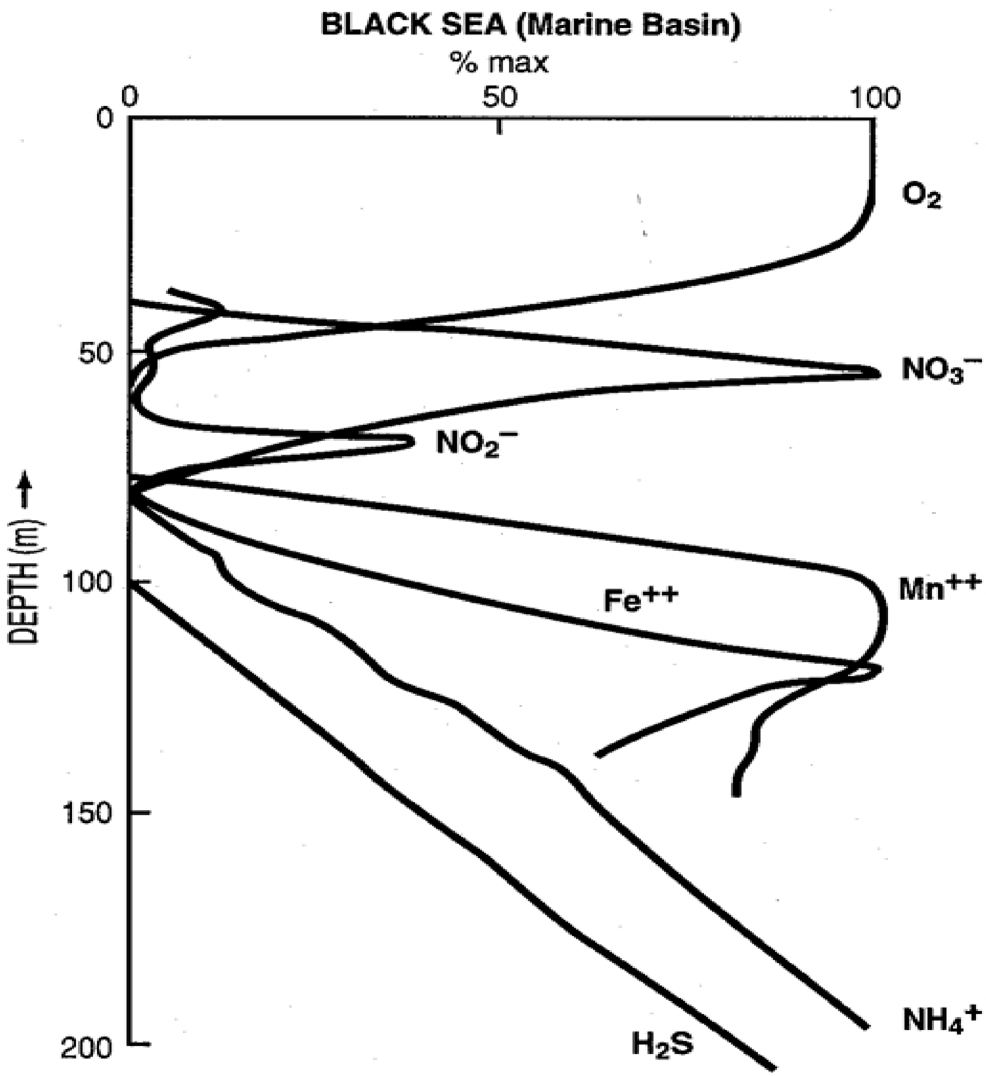
Diffusion is slow

Metabolism is fast -- nutrients deplete
wastes accumulate

Life forms gradients


BLACK SEA CHEMISTRY
0
25
50
75
100
0
30
50
70
90
110
130
150
Z (m)
O_2
NO_3^-
Mn^{2+}
Fe^{2+}
H_2S
Oxygen Reduction Zone
Nitrate Reduction Zone
Manganese Reduction Zone
Iron Reduction Zone
Sulfate Reduction Zone

Biogeochemical Processes



Oxygen Diffusion from Atmosphere

Oxygenic Photosynthesis
Oxygen Respiration

Nitrification

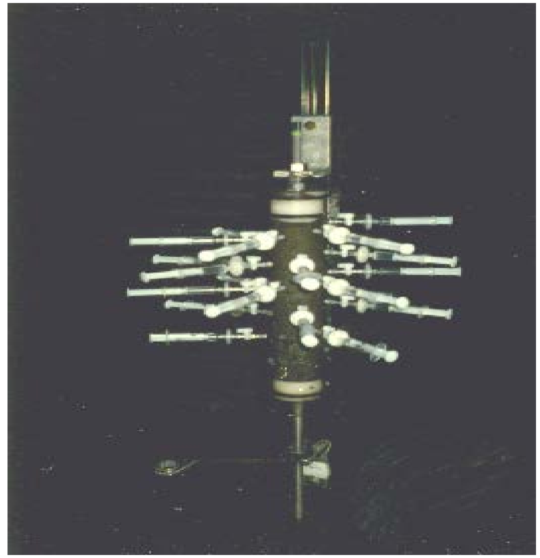
Denitrification

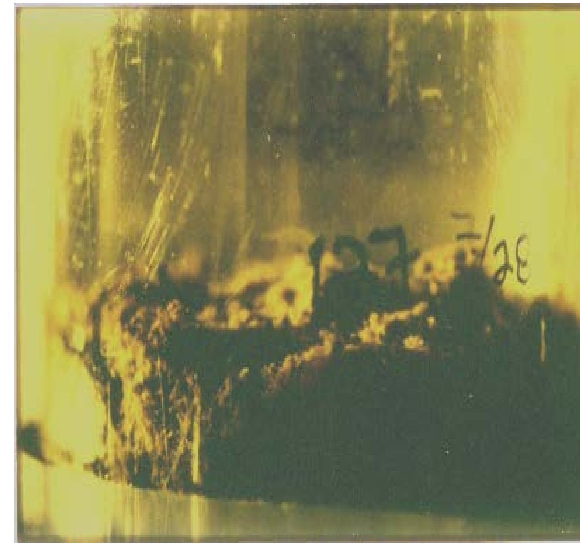
Mn oxidation
Mn reduction
Fe oxidation

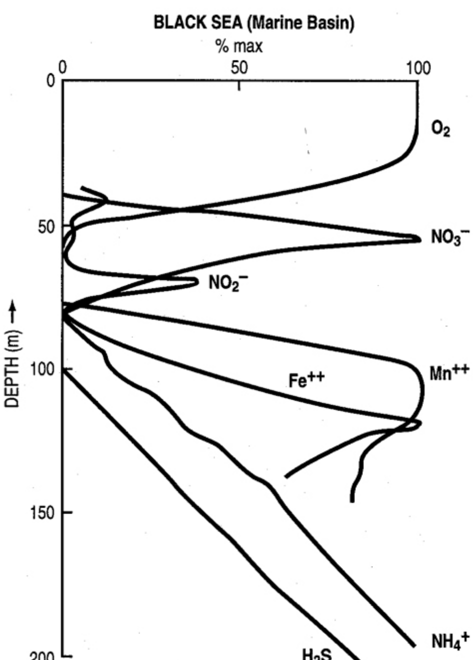
Fe reduction
Sulfide oxidation

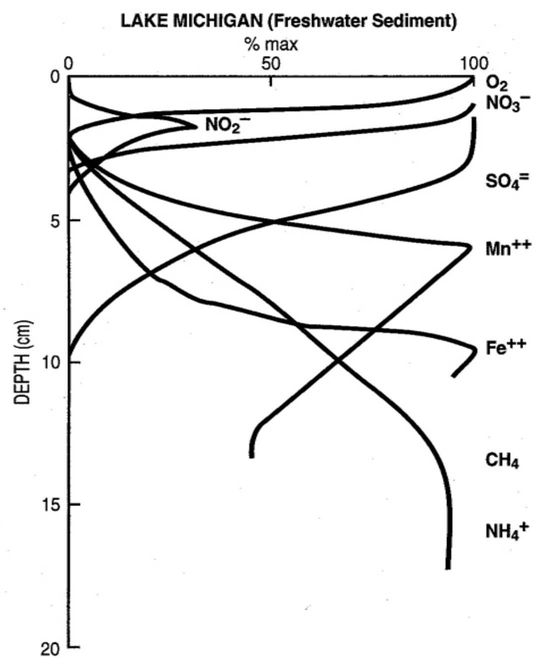
Sulfate reduction

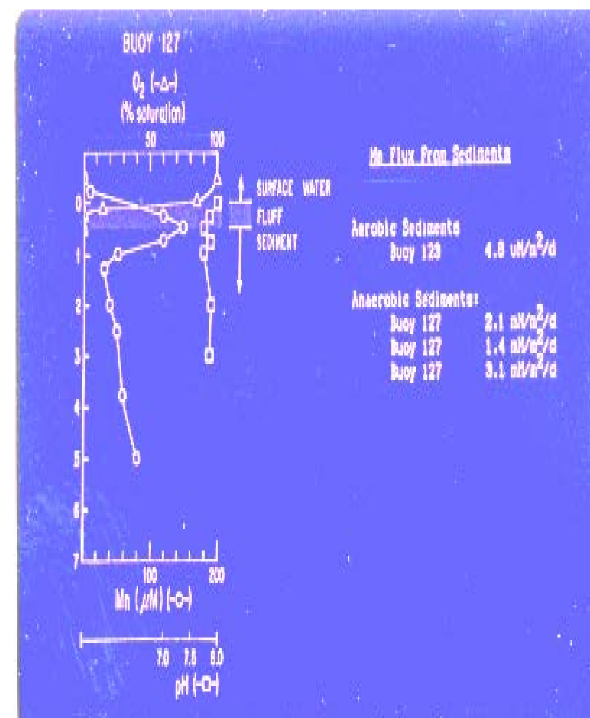
Geobiology **USC** *Astrobiology*



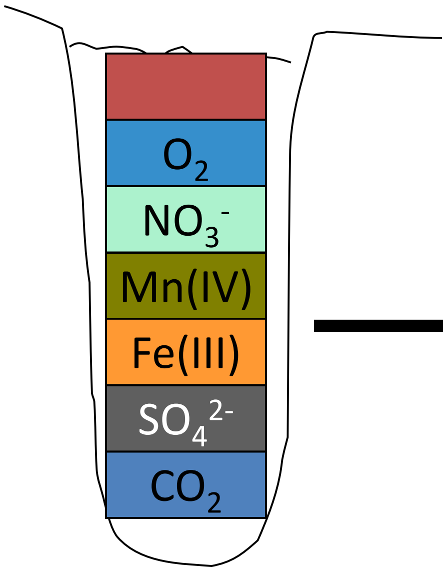




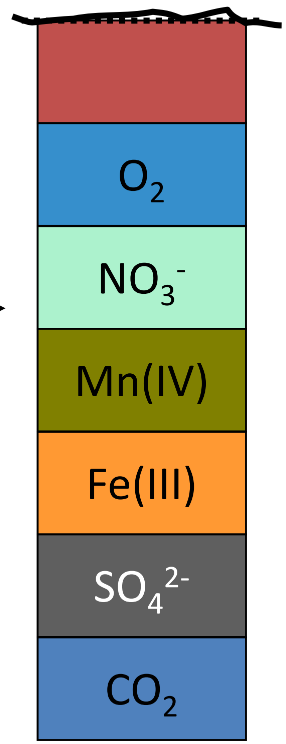




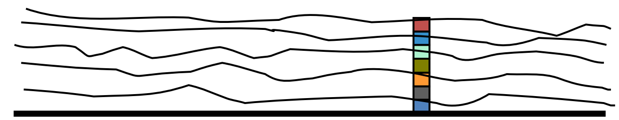
Occurrences of LMCs



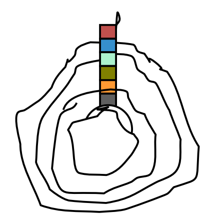
Stratified
Lakes
And
Marine
Basins
(meters)



Water Saturated
Sediments and
Mat Systems
(cm – mms)



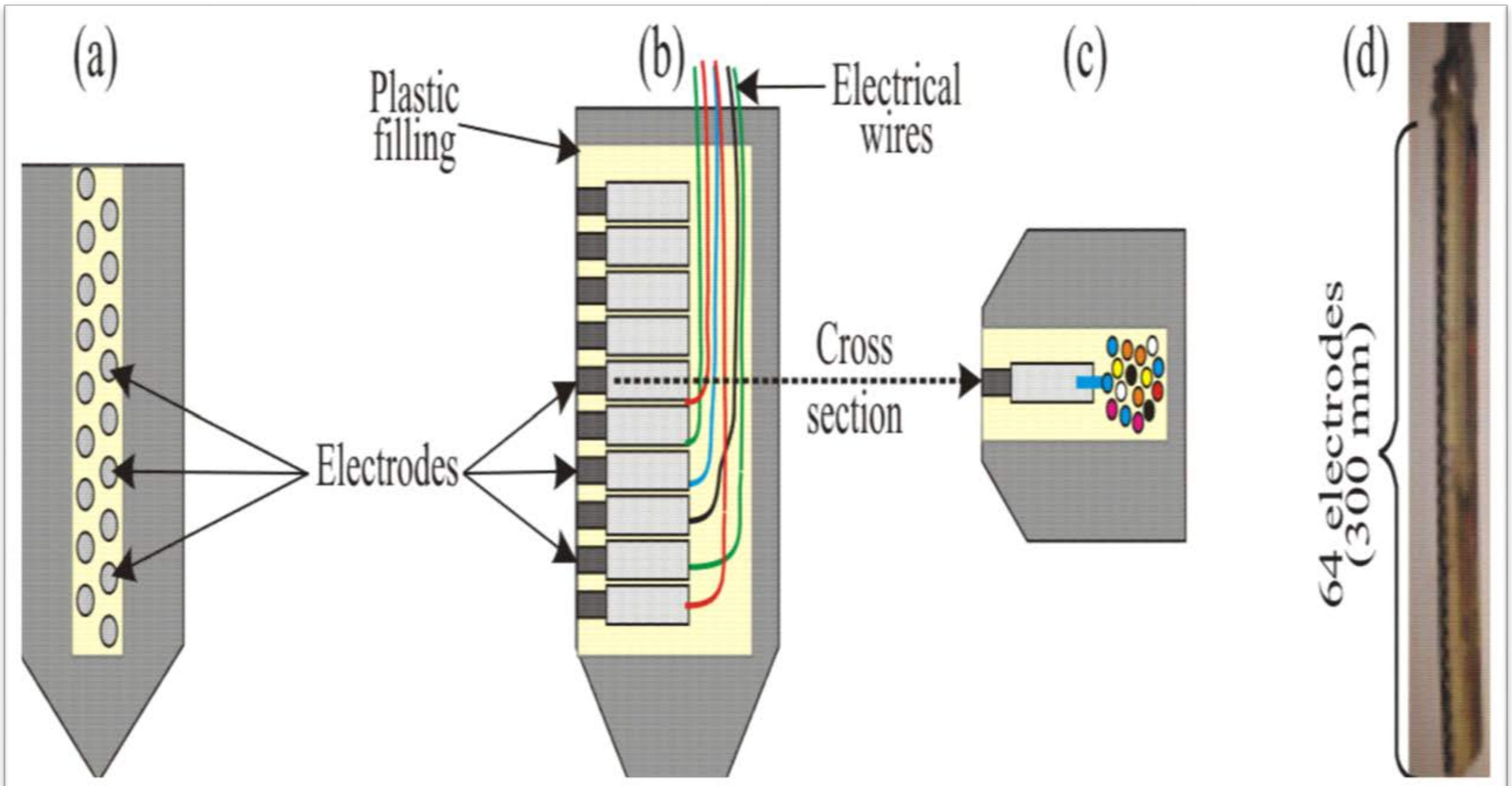
Biofilms -- micrometers



Particles in Unsaturated Sediments
(mm - micrometers)

The idea -- detect the gradients

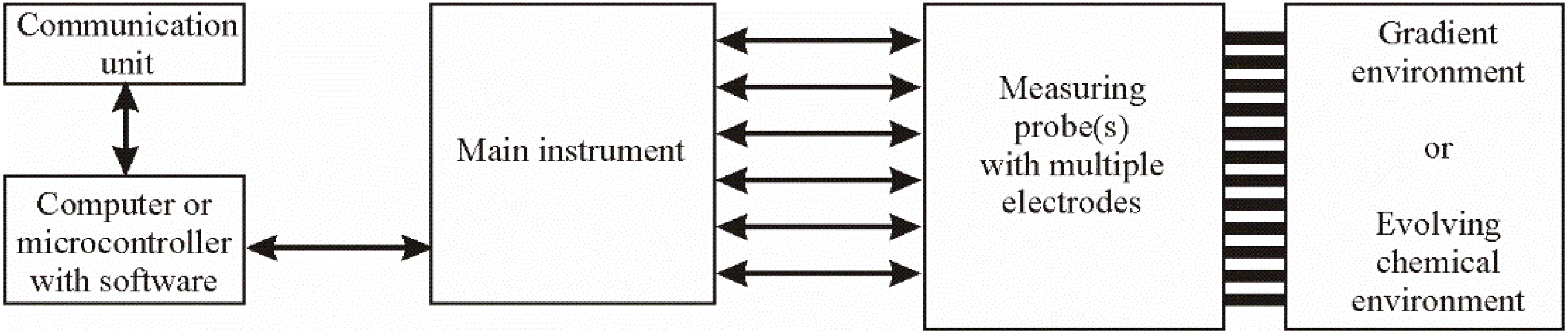
Usual approach: series of microelectrodes – move each up and down
Disrupts gradients -- Our approach:



SPEAR added features

MECA measurements

Conductivity measurements on Mars using the MECA wet chemistry laboratory 2007 Phoenix Mars Scout Lander (Kounaves et al., 2009).



SPEAR measurements

Redox potential

Cyclic voltammetry (various types)

Conductivity

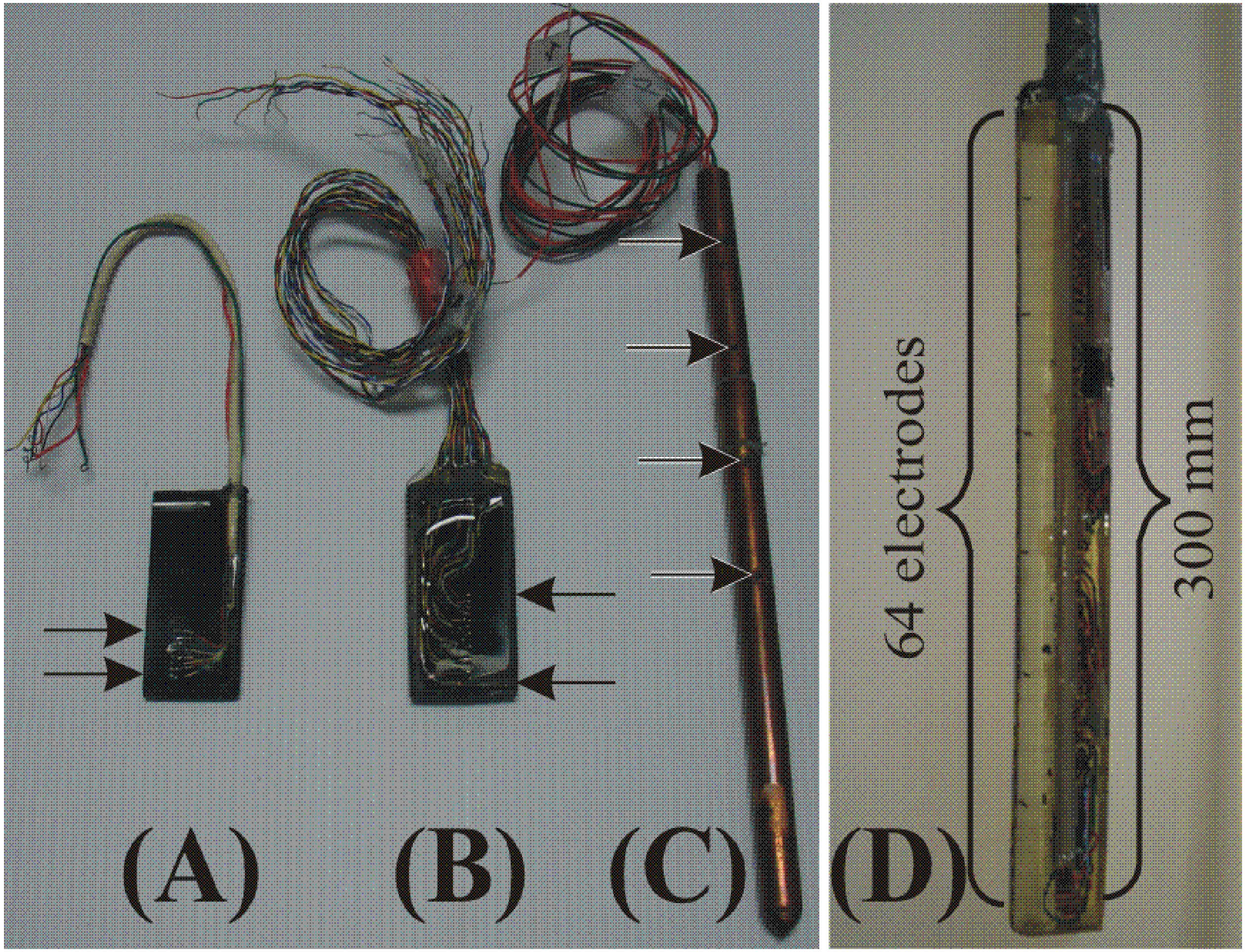
Main objectives

~ 1mm resolution

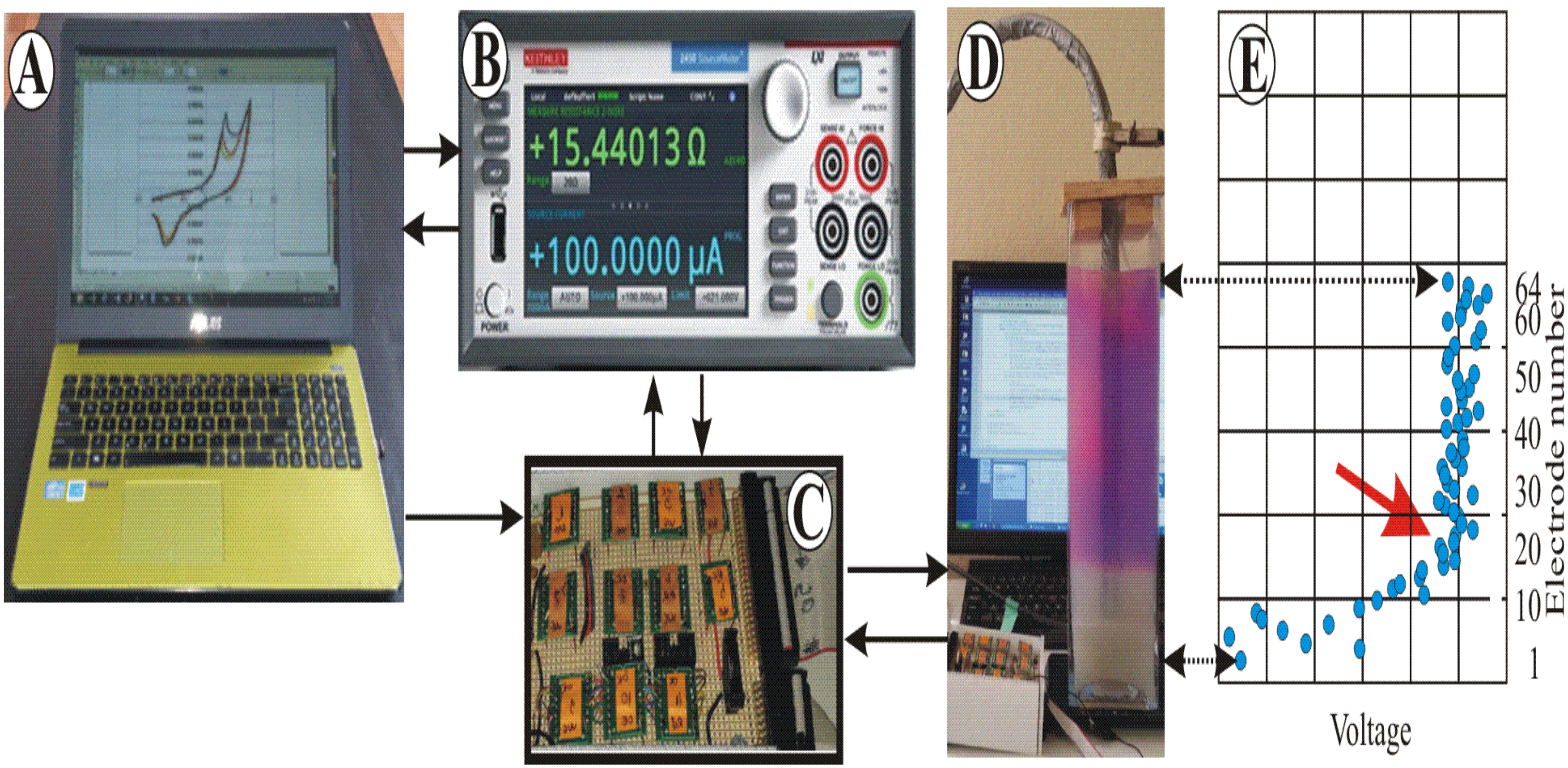
Electrodes defouling, temperature probes, conductivity probes, local heaters

Withstand freeze/thaw and heavy penetration

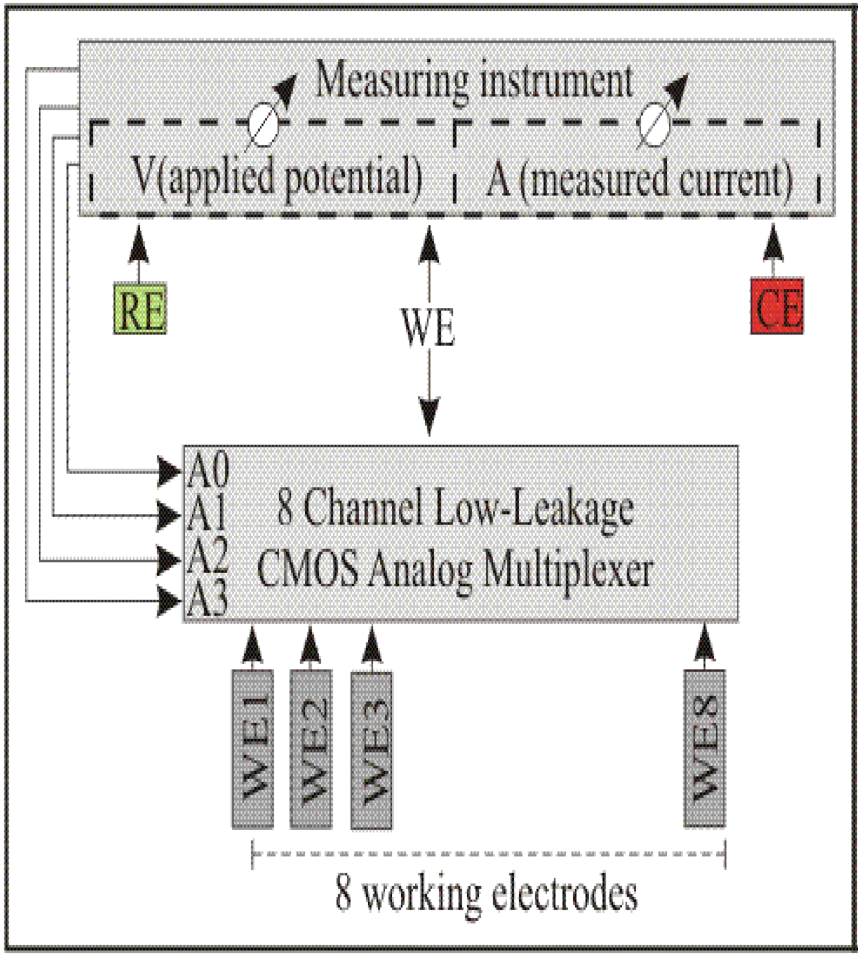
Assembled in the lab

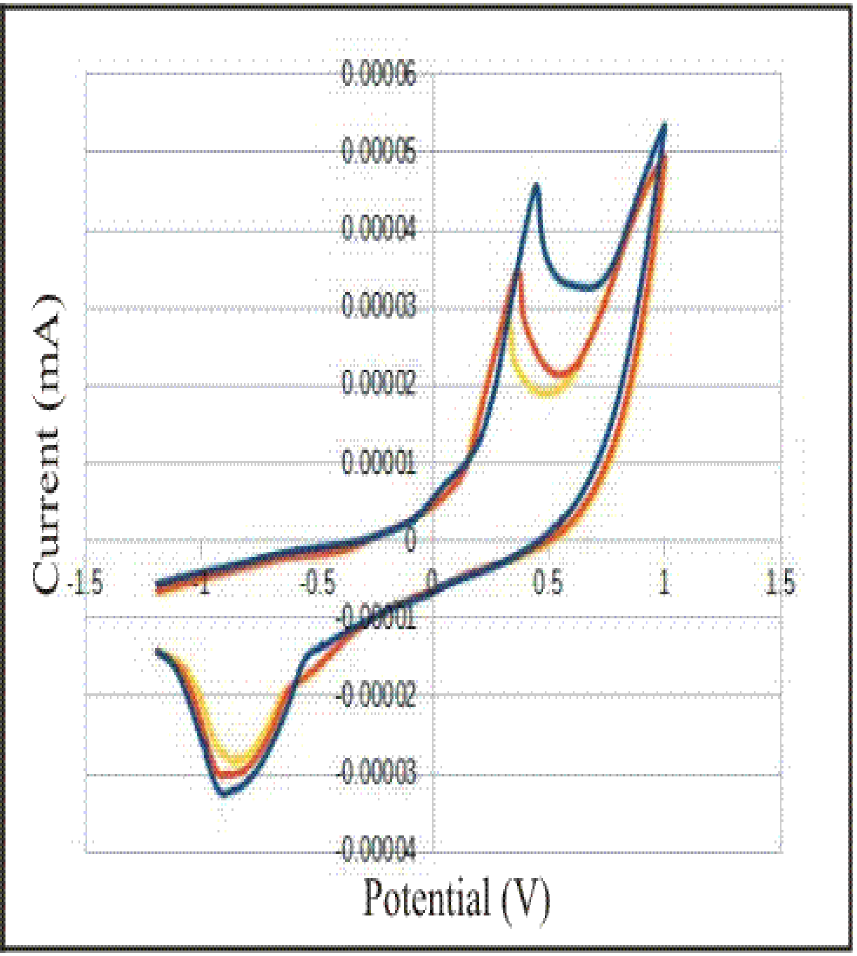


Overall layout of system – 64 electroes

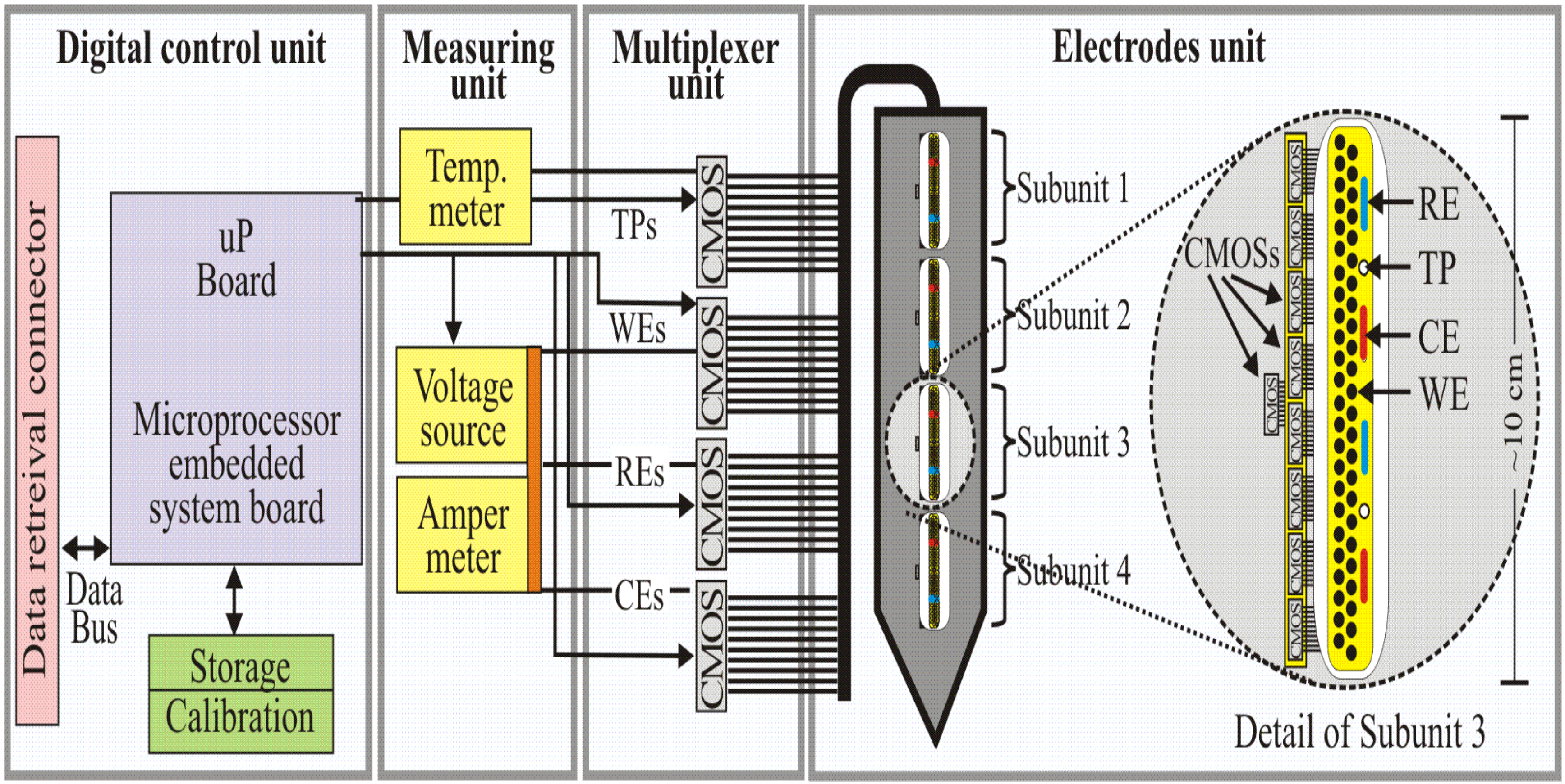


Cyclic voltametry using one of 64 electrodes

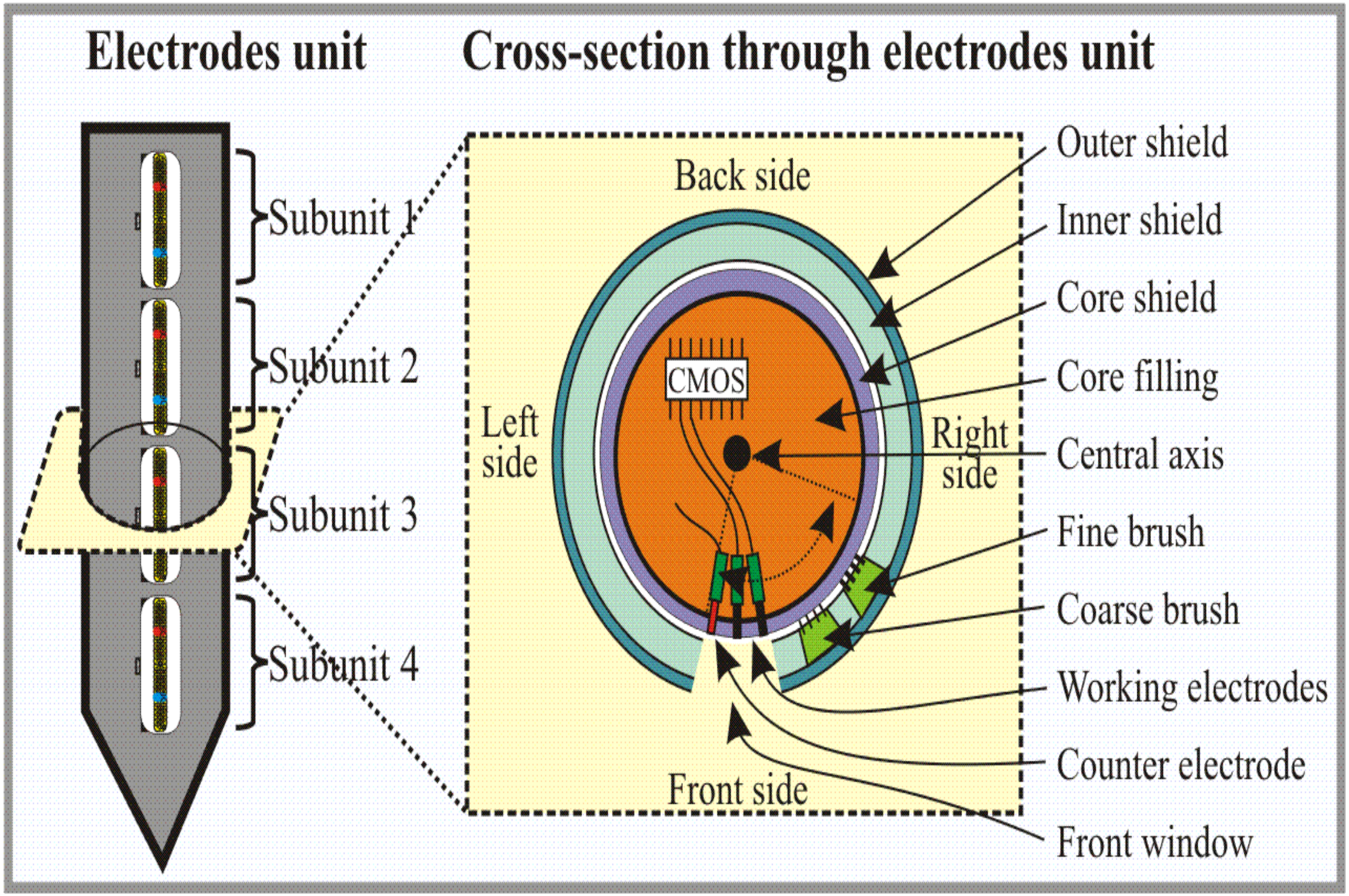




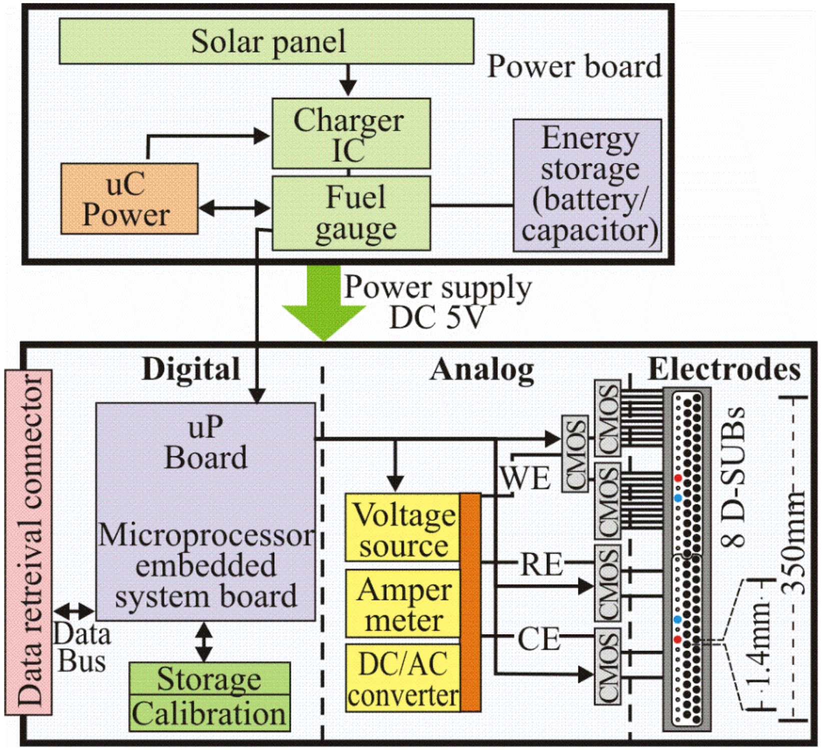
Design of what is being built: 256 working electrodes – 8 counter- and 8 reference electrodes



Details of what we are building

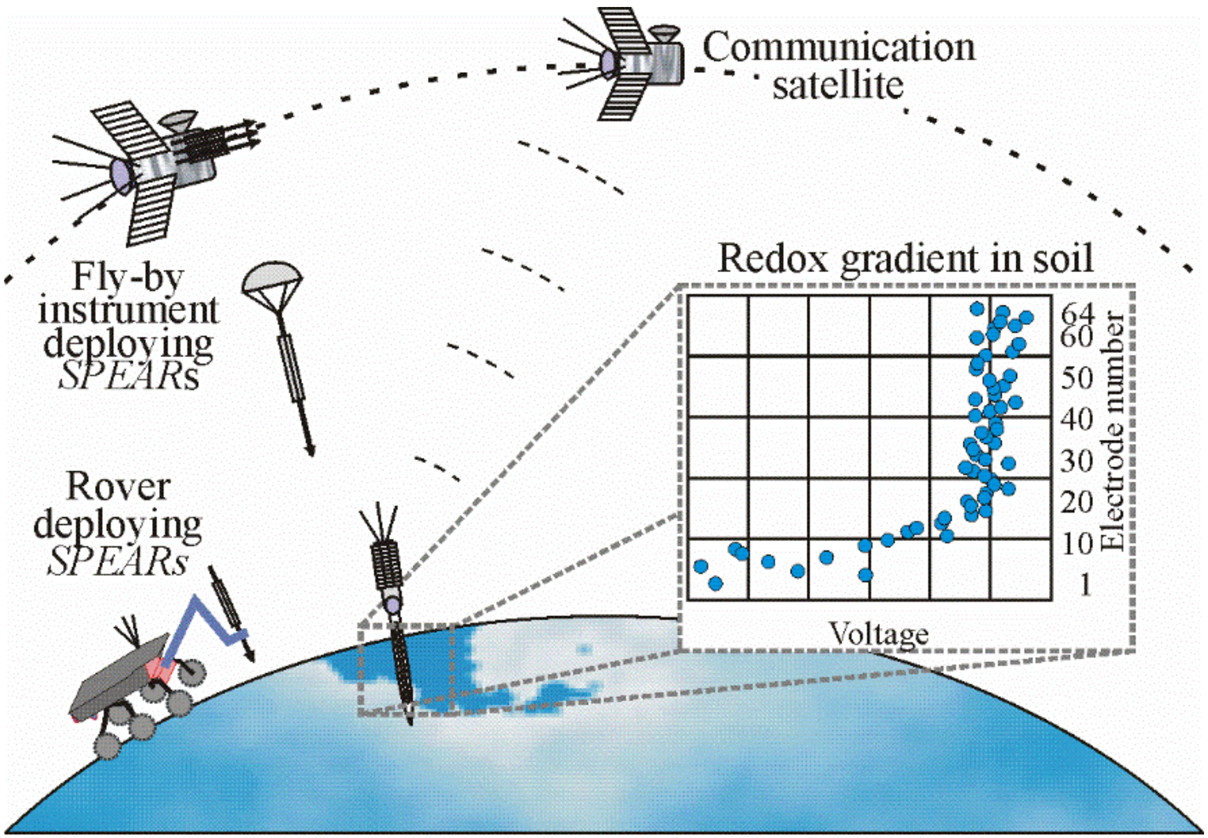


SPEAR - Generations



Proposed: SPEAR with
512 WEs, 64 REs; 64 CEs; Flat layer electrodes;
Electrode cleaning, heating, salinity and T° probes

Goal: Many sites on planet
Profiling of gradients: temporal changes



Chemical profiling of evolving environments
Finding places that can support life