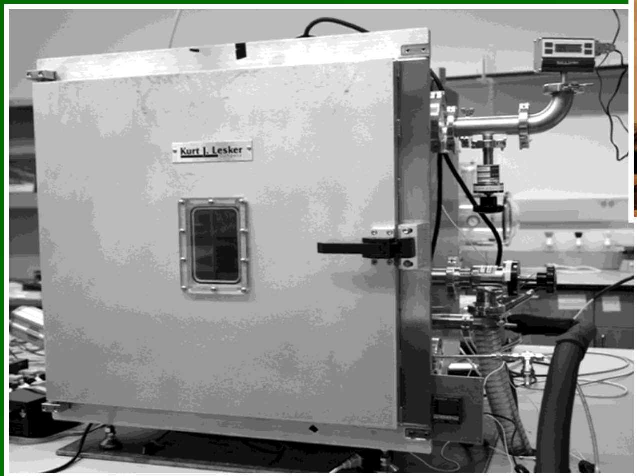

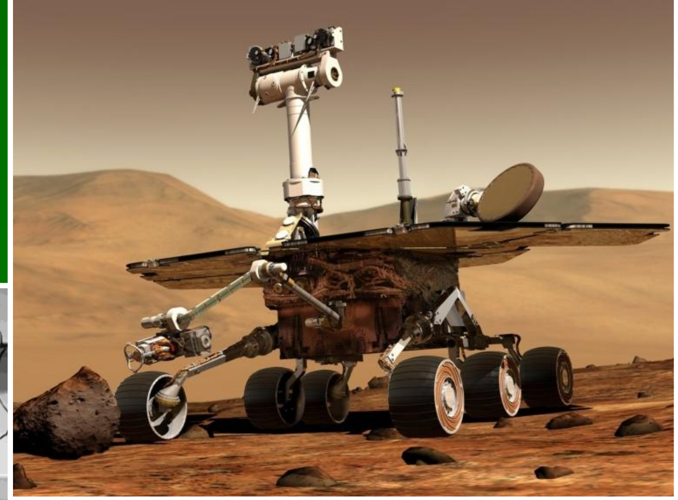

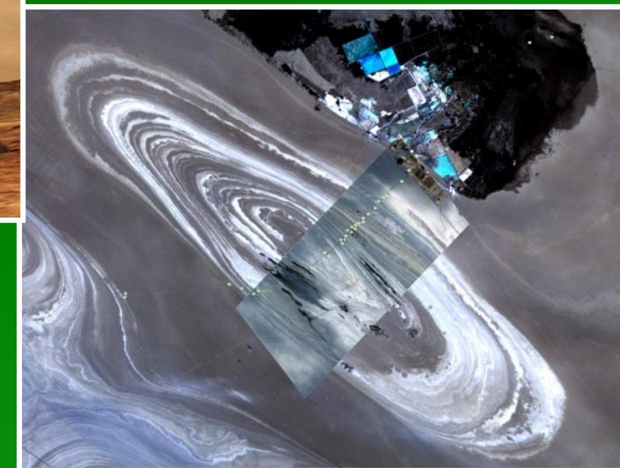

A potential habitable zone

within the subsurface at the equatorial region on Mars

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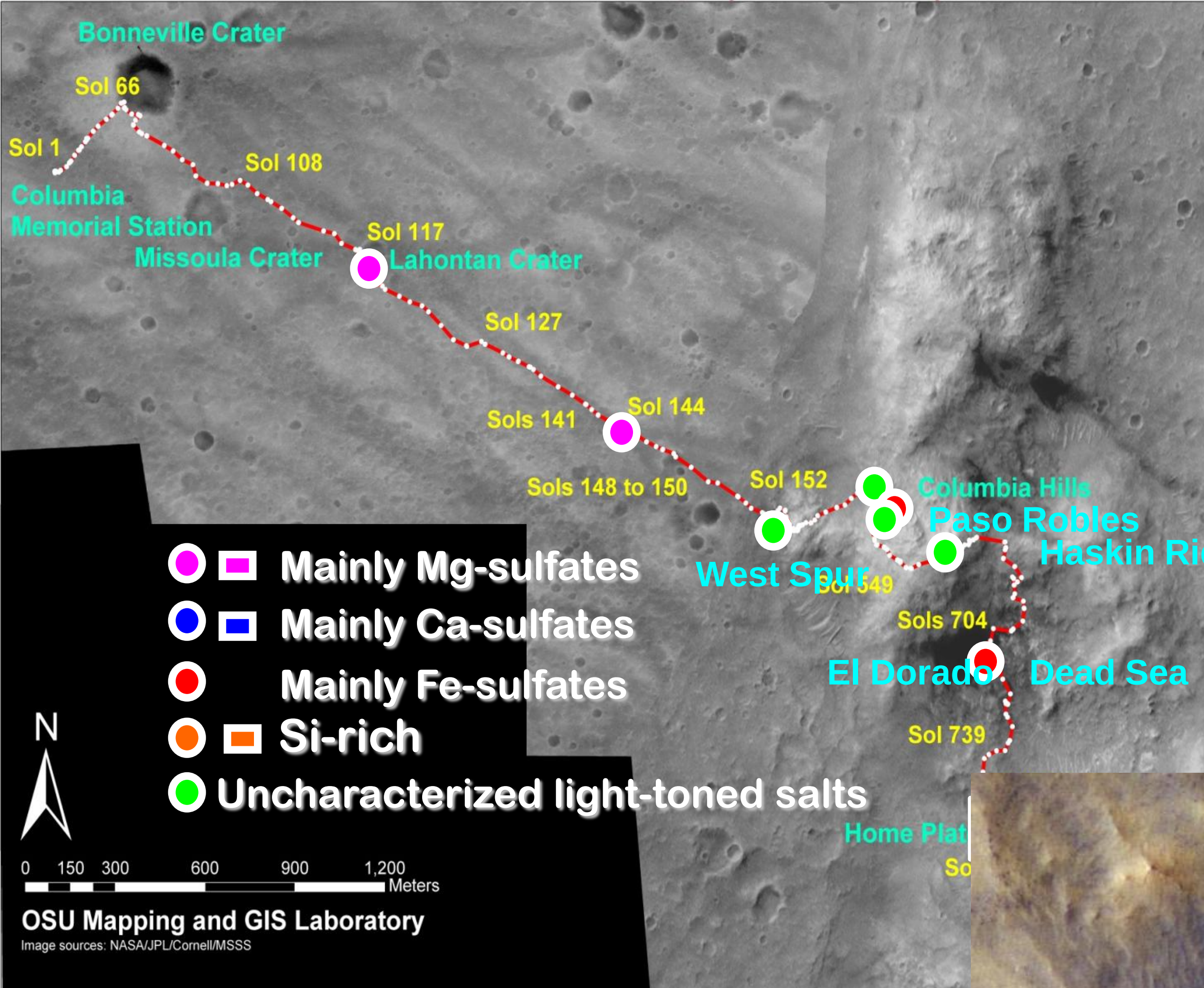
Content

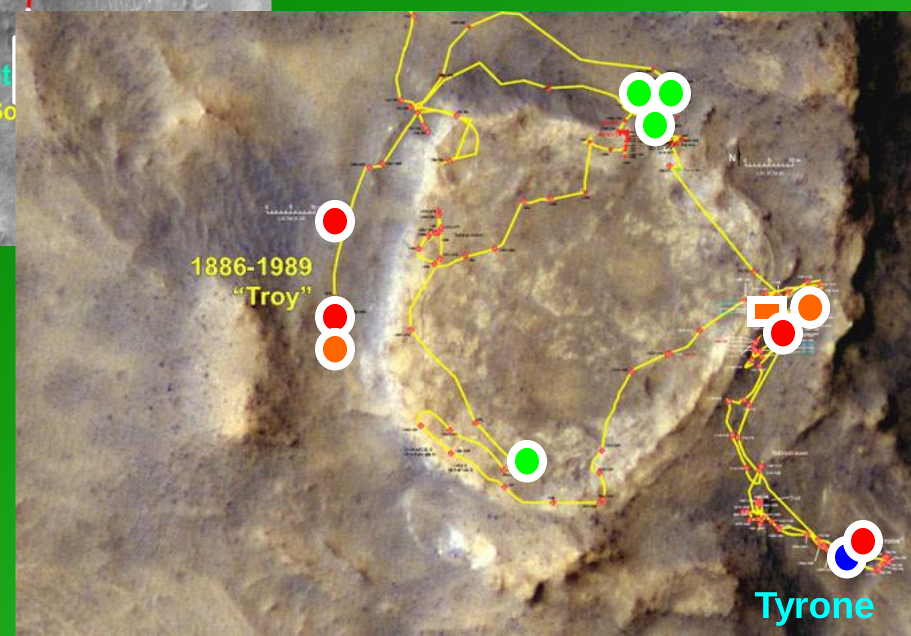
- **Observations at Gusev on Mars;**
- **Observations at a terrestrial analog site;**
- **Extrapolation from a thermal model** *(Mellon et al., 2004);*
- **Laboratory observations @ low T.**

Mars salt-rich subsurface:

Low T, high RH, liquid H_2O film

→ habitable or habited ?

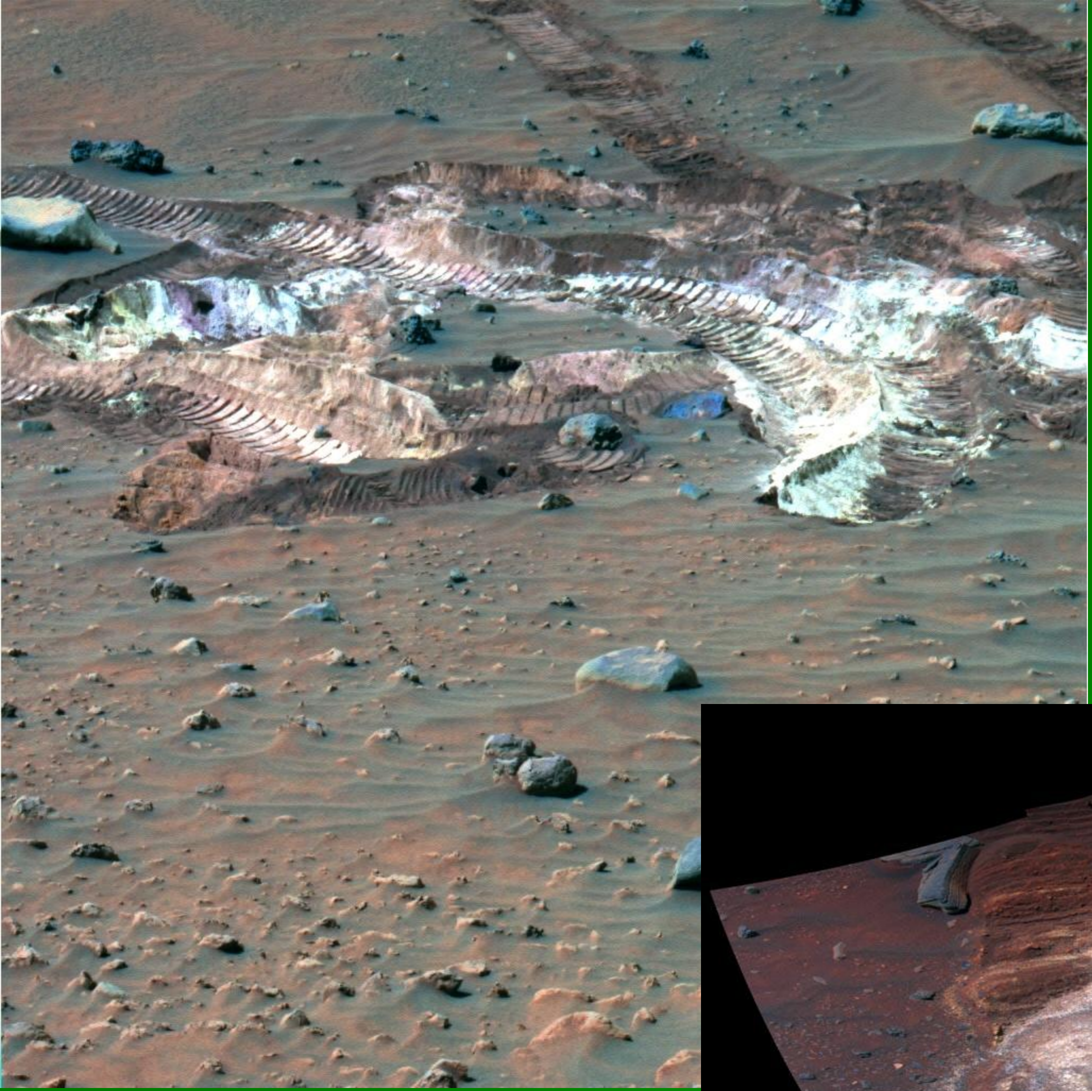


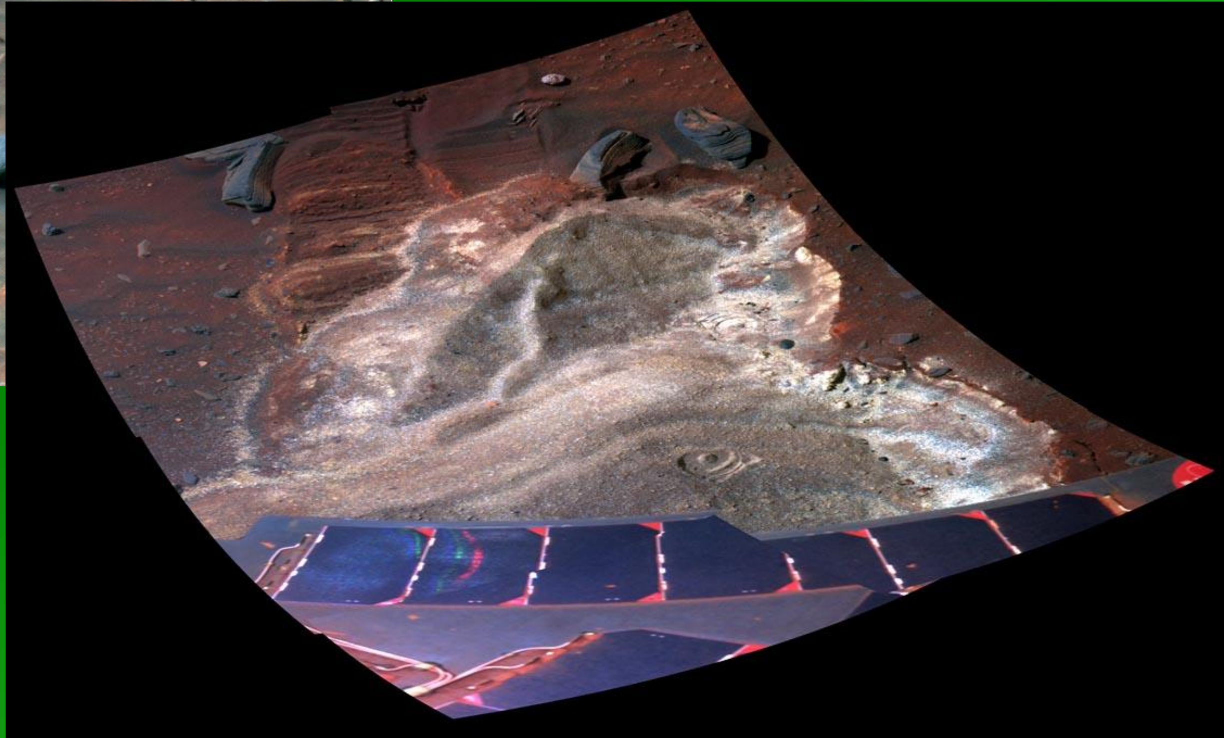


A Spirited Road

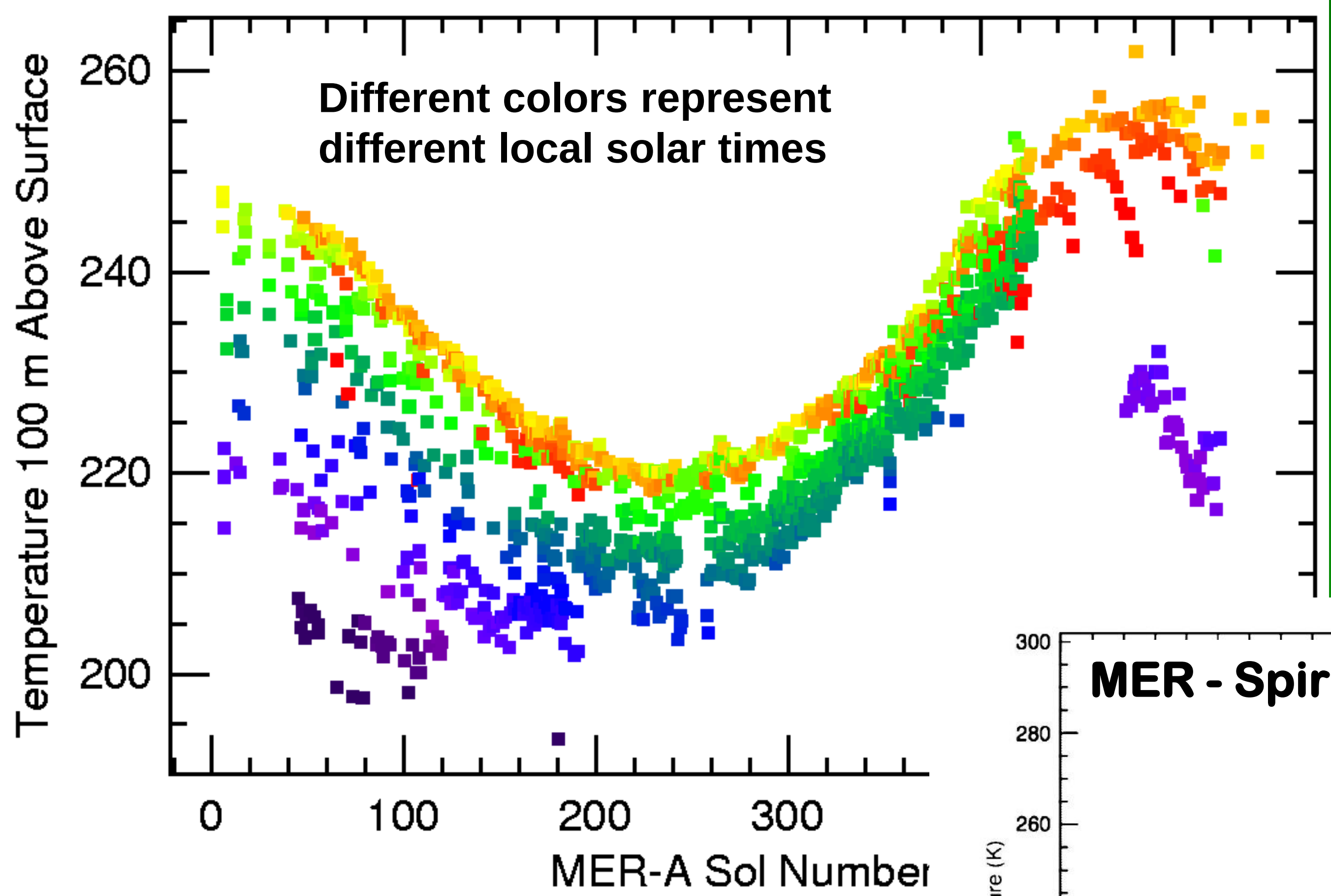
Subsurface salty soils

Mainly, Hydrous Sulfates (Mg, Ca, Fe)

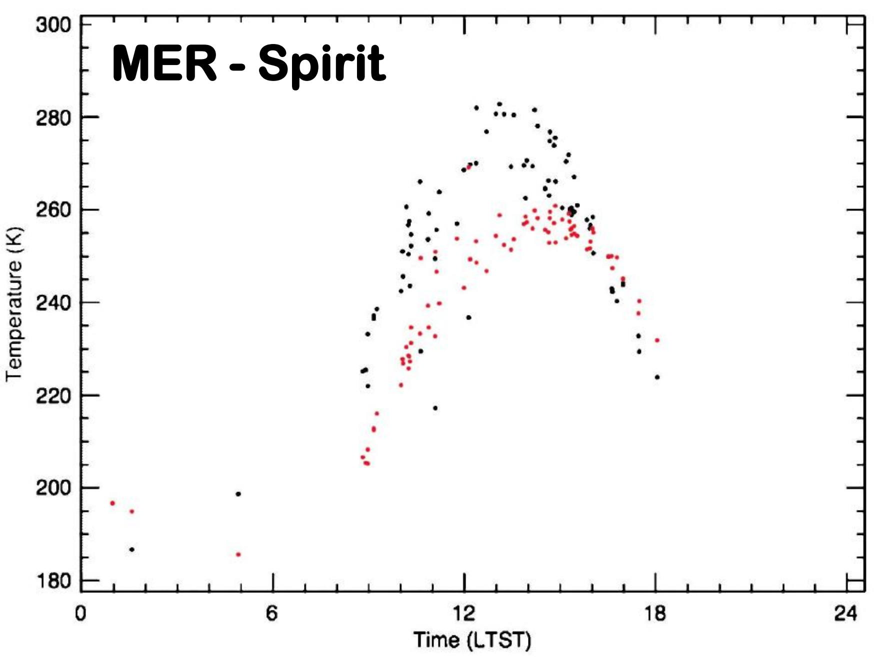




Atmospheric (near ground) Temperature Variation



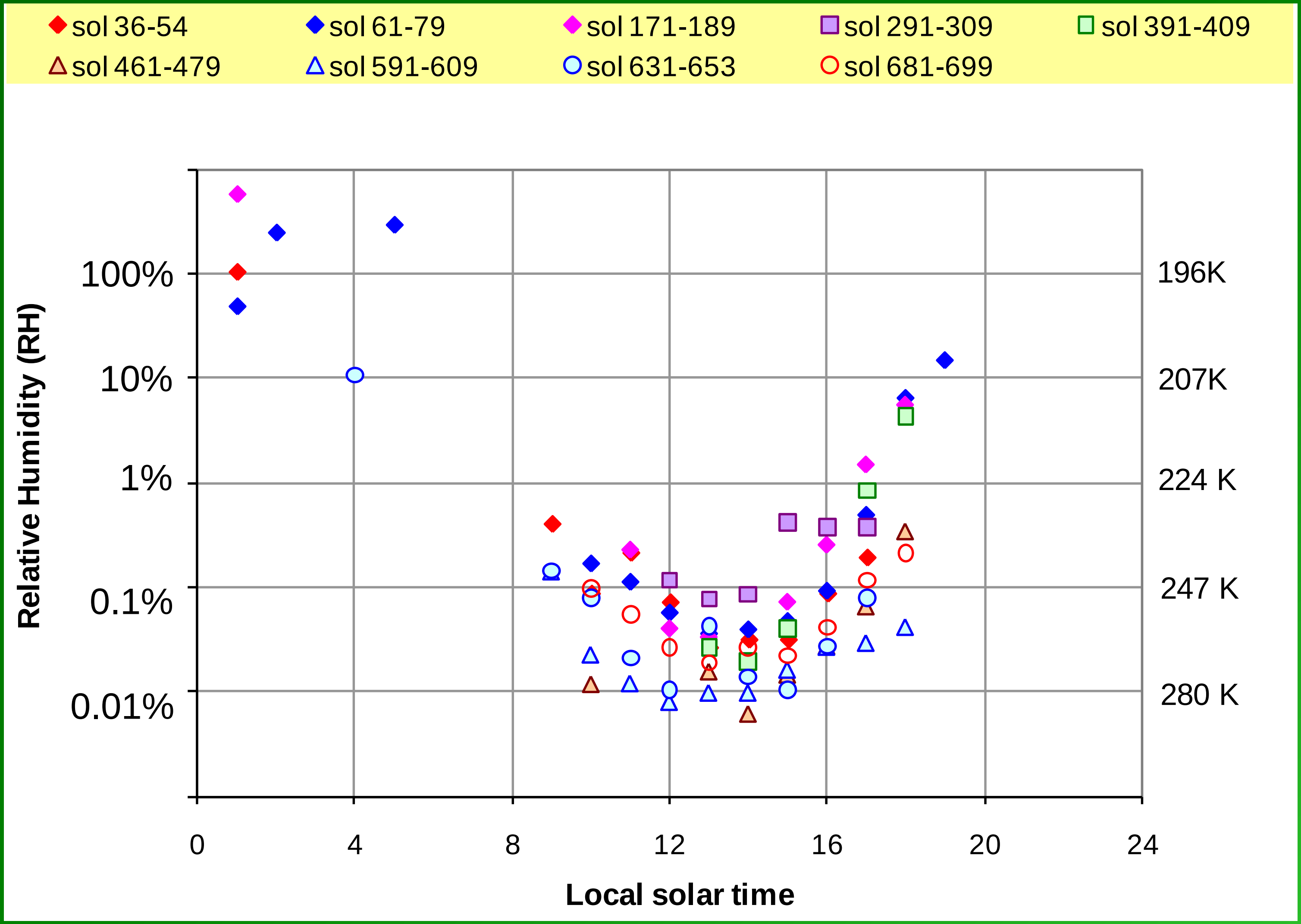
Smith et al., 2005



Spanovich et al., 2006

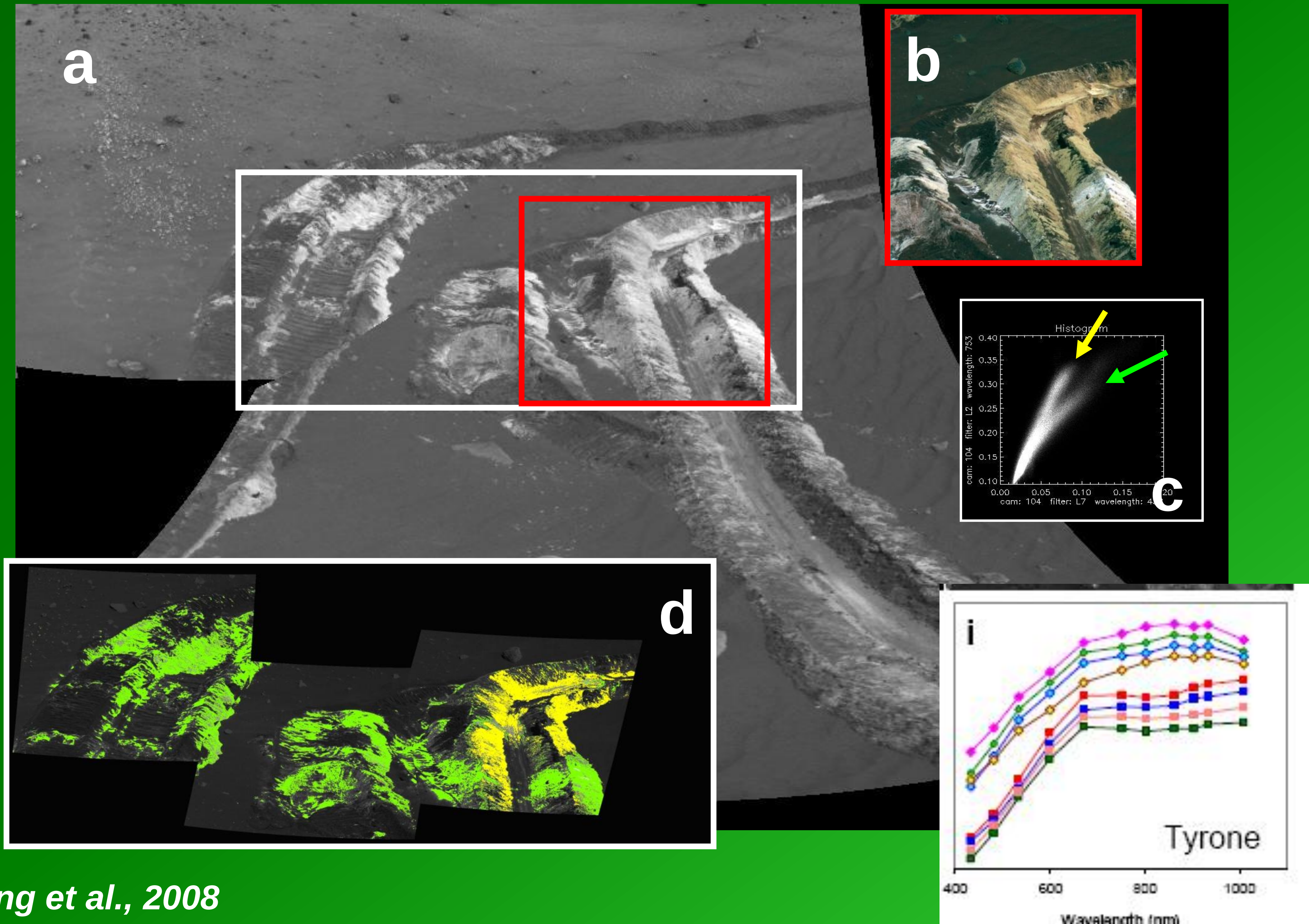
Calculated Variation of Relative Humidity

H_2O vapor pressure (ave): 10^{-2} kg/m^2



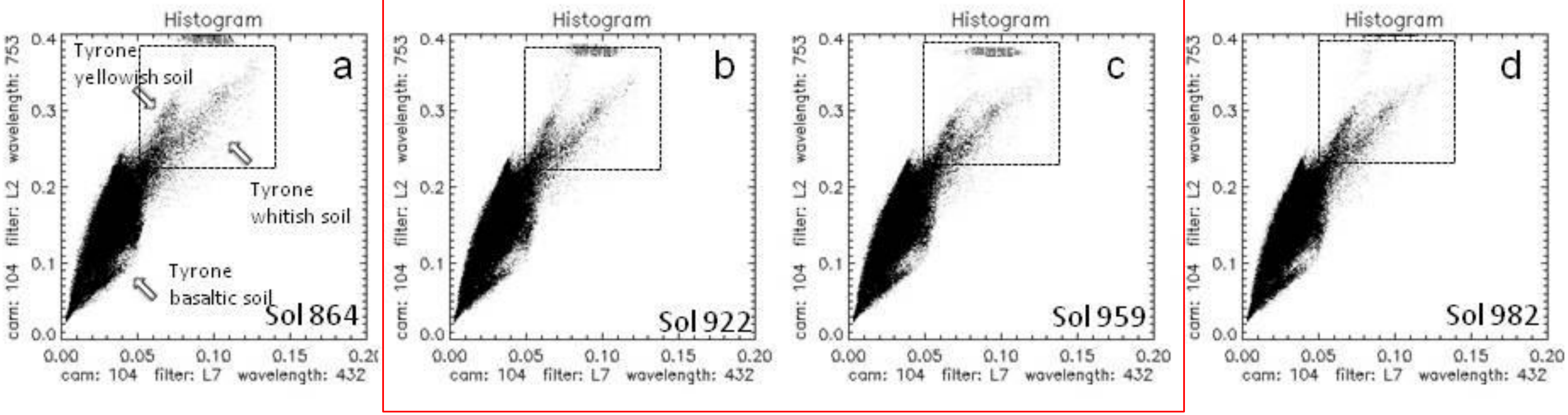
Wang and Ling, 2011

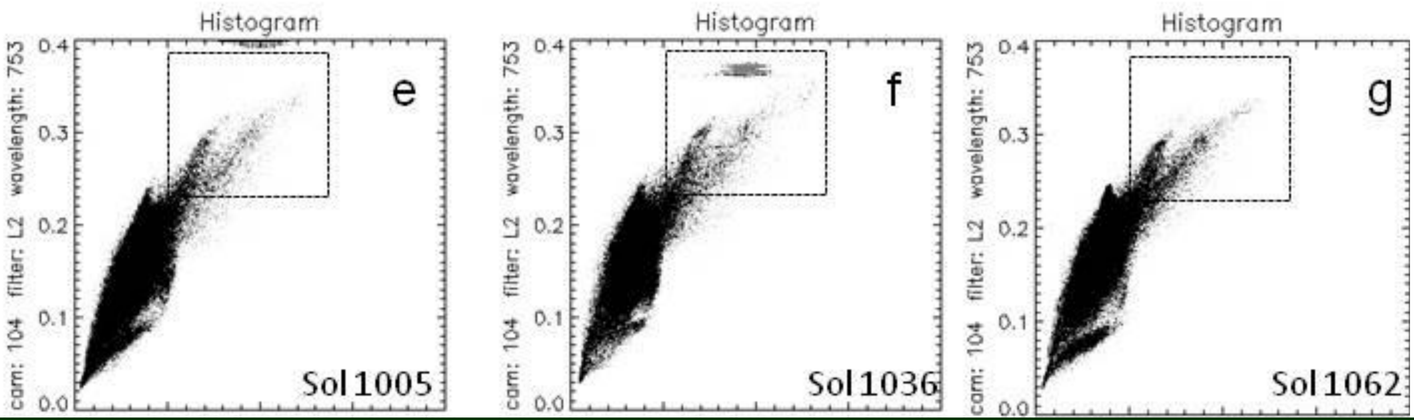
Two distinct layers of salty soils at Tyrone

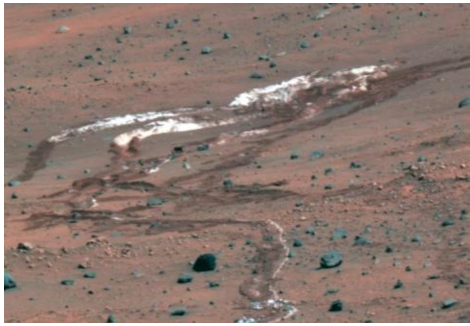


Wang et al., 2008

Seven Pancam Observations

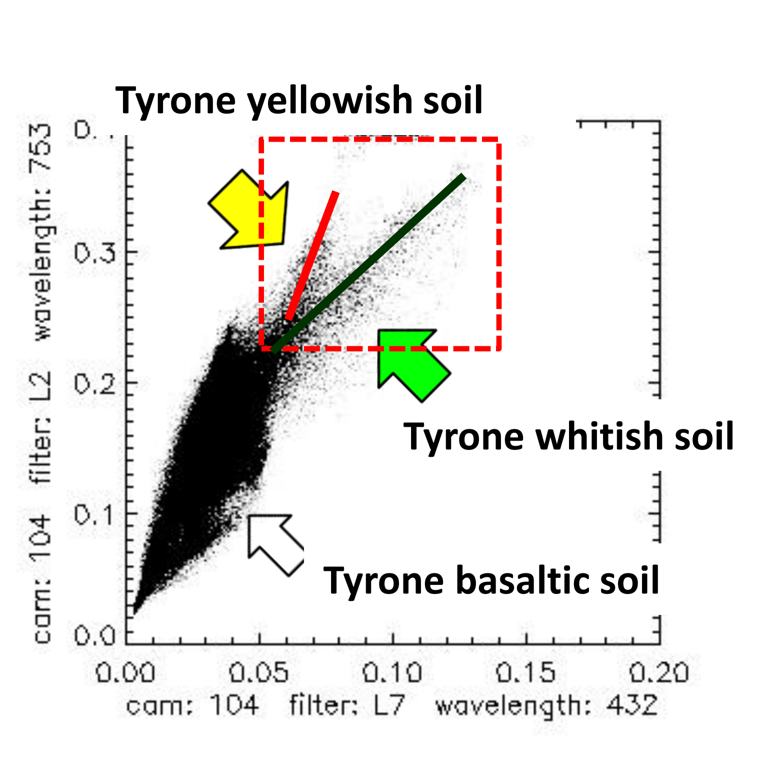




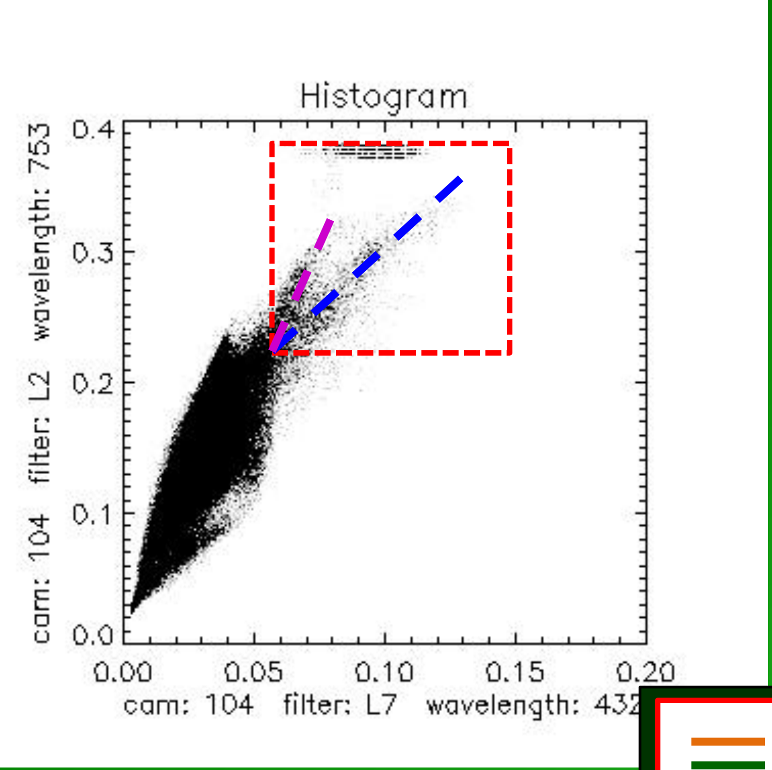


Spirit stayed at the **same location for 198 sols**,
7 measurements took at ***almost same local solar time***,
w/very ***small tau variation*** during the most part of 198 sols.

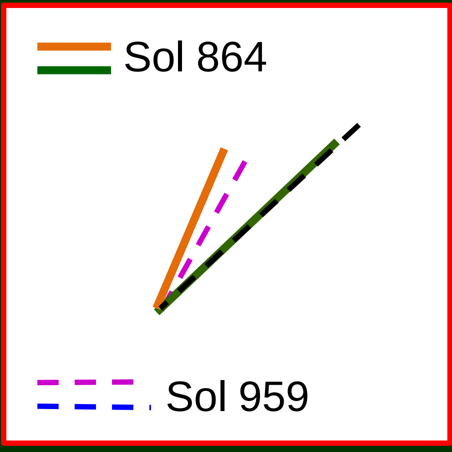
Property change of Fe-sulfate-rich Subsurface salty soil (R^*_{L2} vs. R^*_{L7})



Sol 864



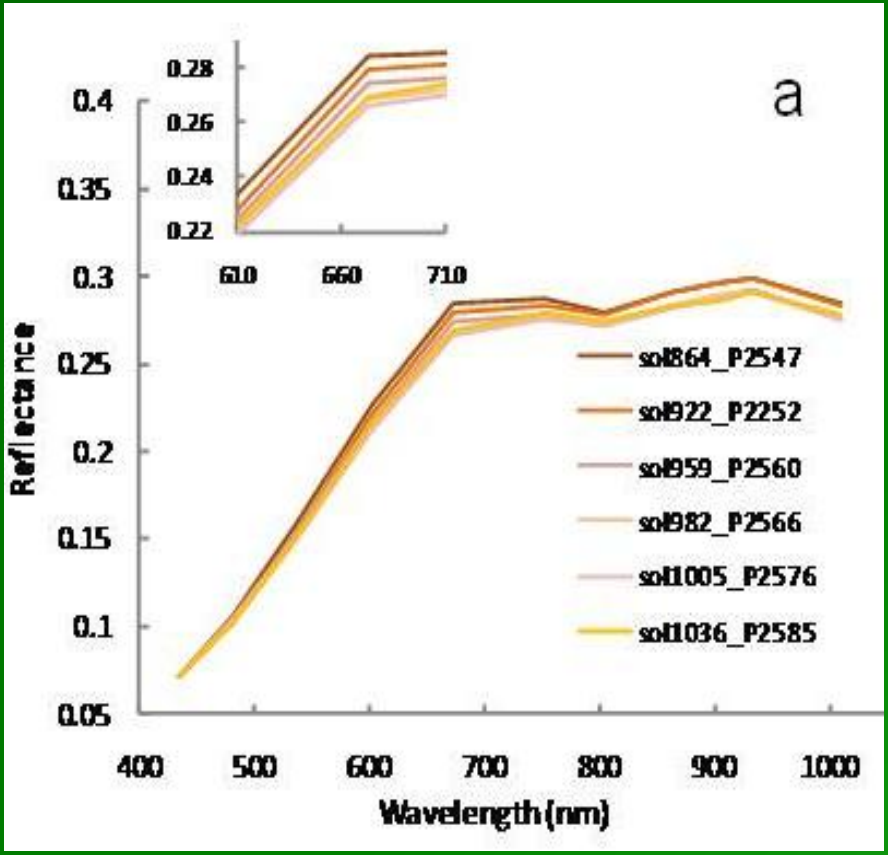
Sol 959

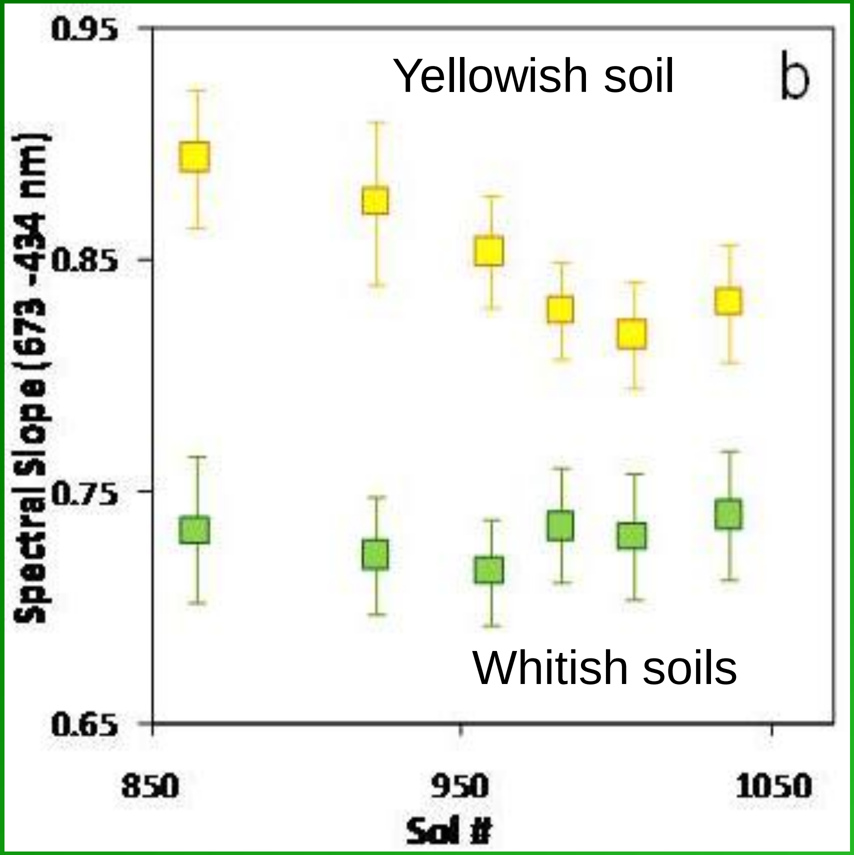


L7: wavelength 432 nm

Change of spectral slope of deep soils

Selection of AOI → salty soils from deeper depth show 434 -753 nm spectral slope reduction.





Johnson et al., 2007 **-- One of the major component of yellowish soils is ferricopiapite.**

Lab observation #1: Phase transition Pathway

Ferricopiapite (21C), Wang et al., 2010

RH	6.60%	11.30%	33.00%	54.10%	58.80%	69.70%	75.40%	85.00%	94.40%	100%
hours										
2	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri
8	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri
20	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri
48	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	ferri, deliq
96	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	ferri, deliq	Deliq
216	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	ferri, deliq	Deliq	Deliq
384	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	ferri, deliq	Deliq	Deliq
552	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	ferri, deliq	Deliq	Deliq
720	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri, Delic	Deliq	Deliq	Deliq
1080	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri, Delic	Deliq	Deliq	Deliq
1992	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri, Delic	Deliq	Deliq	Deliq
3840	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri	Ferri, Delic	Deliq	Deliq	Deliq
8664	Ferri +Am?	Ferri	Ferri+Rhon	Ferri	Ferri	Ferri+Rhon	Ferri, Delic	Deliq	Deliq	Deliq
10488	UK#9	UK#9	Ferri+Rhon	Ferri, para	Ferri	Ferri	Ferri, Delic	Deliq	Deliq	Deliq
14520	Ferri	Ferri	Ferri	Ferri, para	Ferri	UK#20	Ferri, Delic	Deliq	Deliq	Deliq
17688	Ferri	Ferri+Rhon	Ferri	Ferri, para	Ferri, 7w	Ferri	Deliq	Deliq	Deliq	Deliq
24912	Ferri	Ferri	Rhom, Fer	P9w, Ferri	P9w, Ferri	Ferri	Deliq	Deliq	Deliq	Deliq

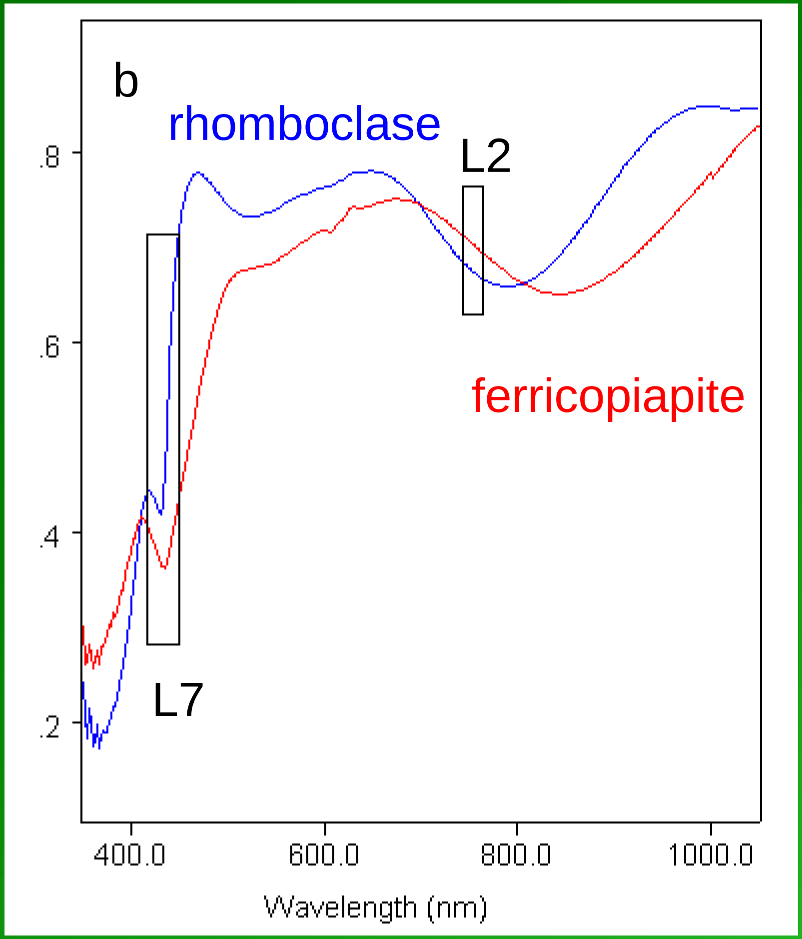
Ferricopiapite dehydrates through two pathways:

pathway #1 → 9w, 7w, rhomboclase (4w);

pathway #2 → Amorphous species (5-11w, 14-19w).

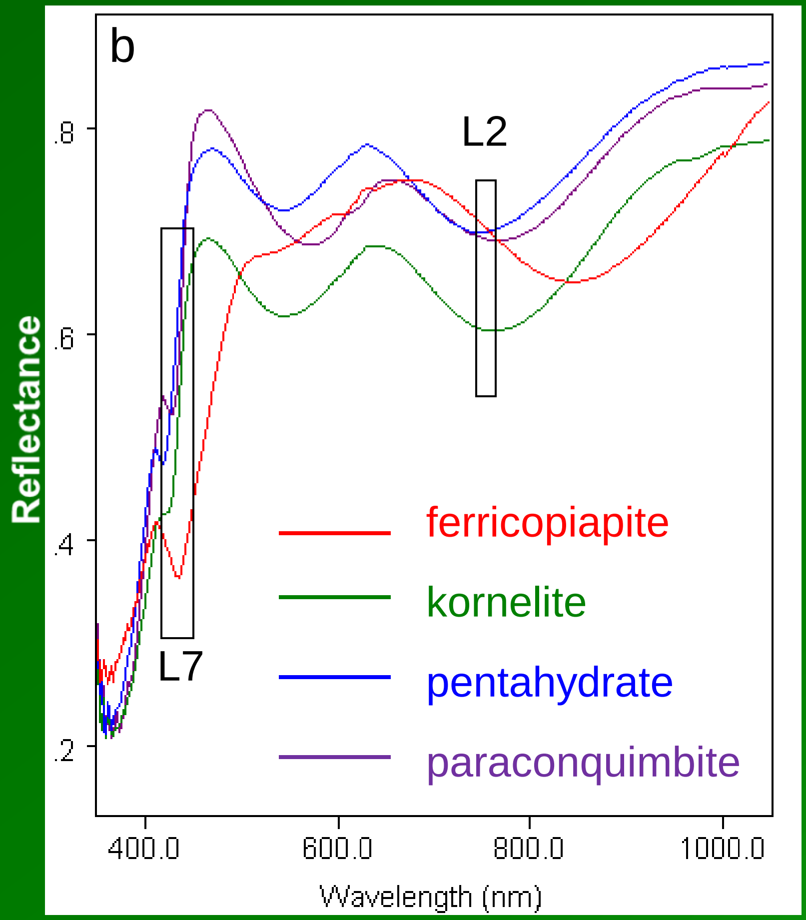
Ferricopiapite → Rhomboclase

When the last drop of liquid dried

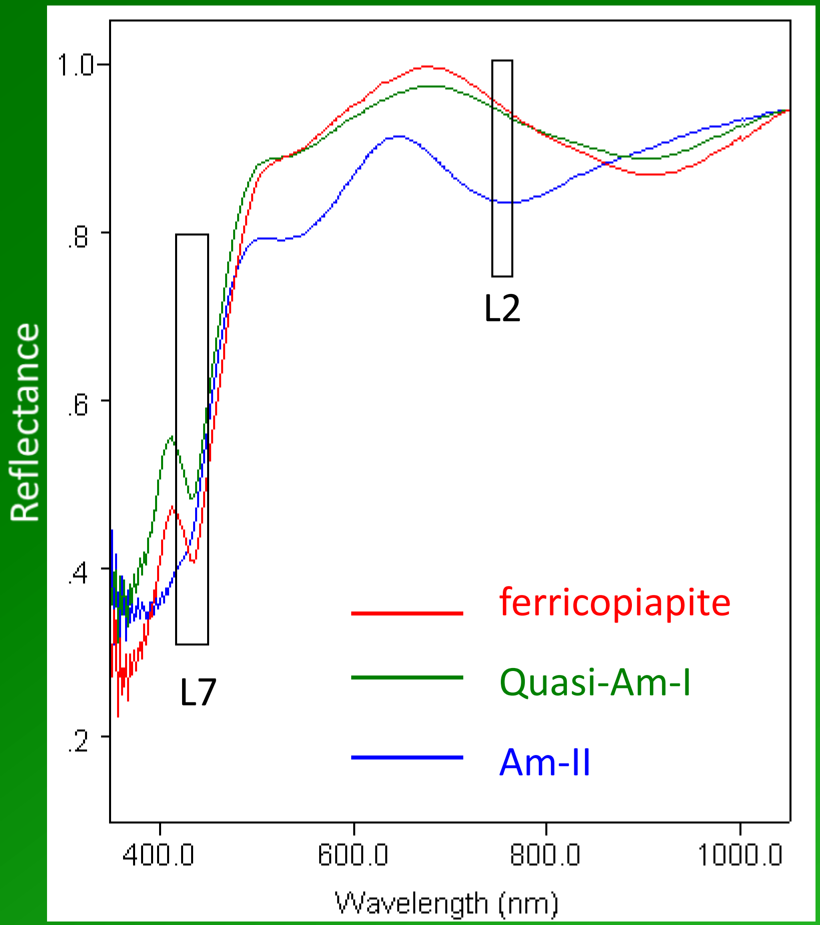


It will cause the spectral slope reduction from 434 nm to 753 nm *(Wang & Ling, 2011)*

pathway #1 → 9w, 7w, Rhom

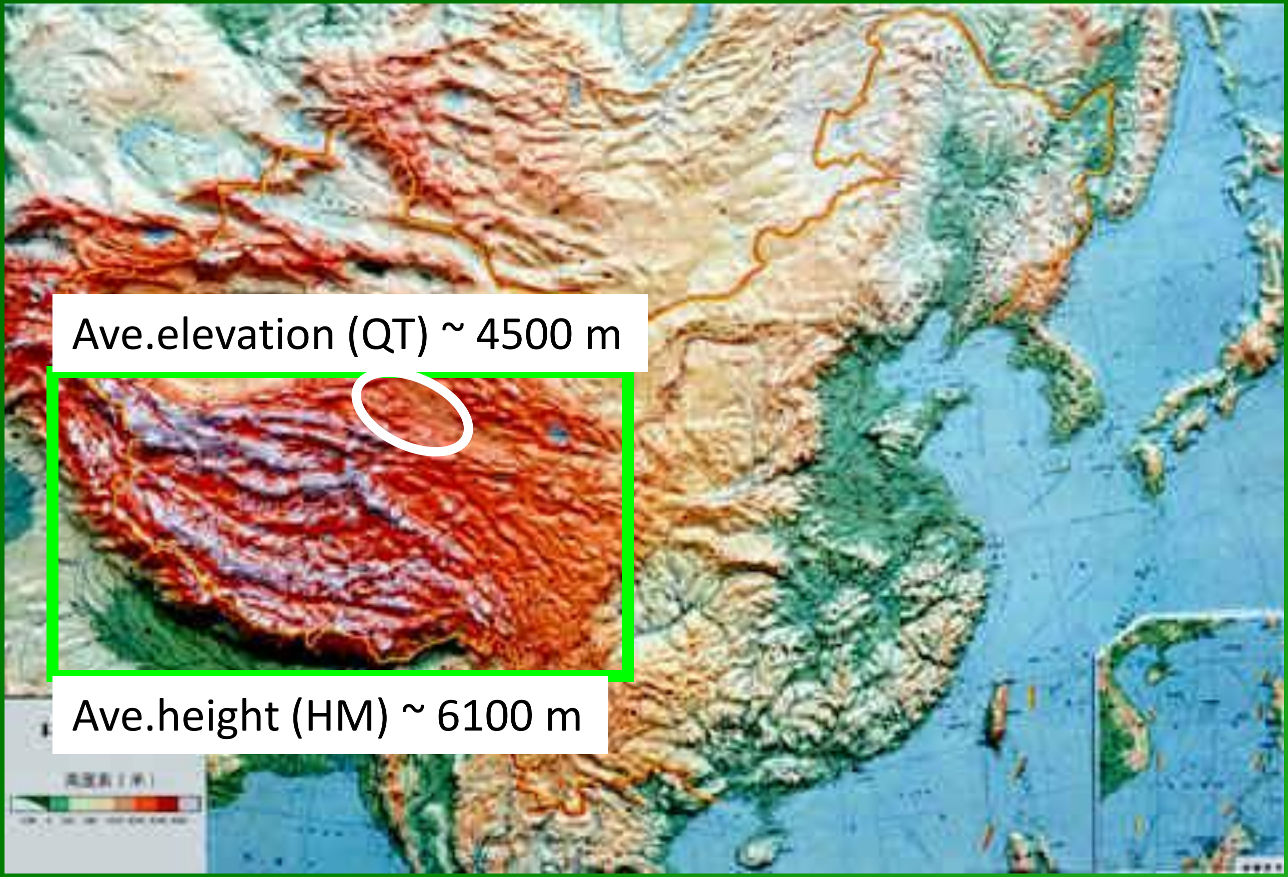


pathway #2 – Am (I, II)



The spectral change of Tyrone subsurface soil is consistent with dehydration of ferricopiapite

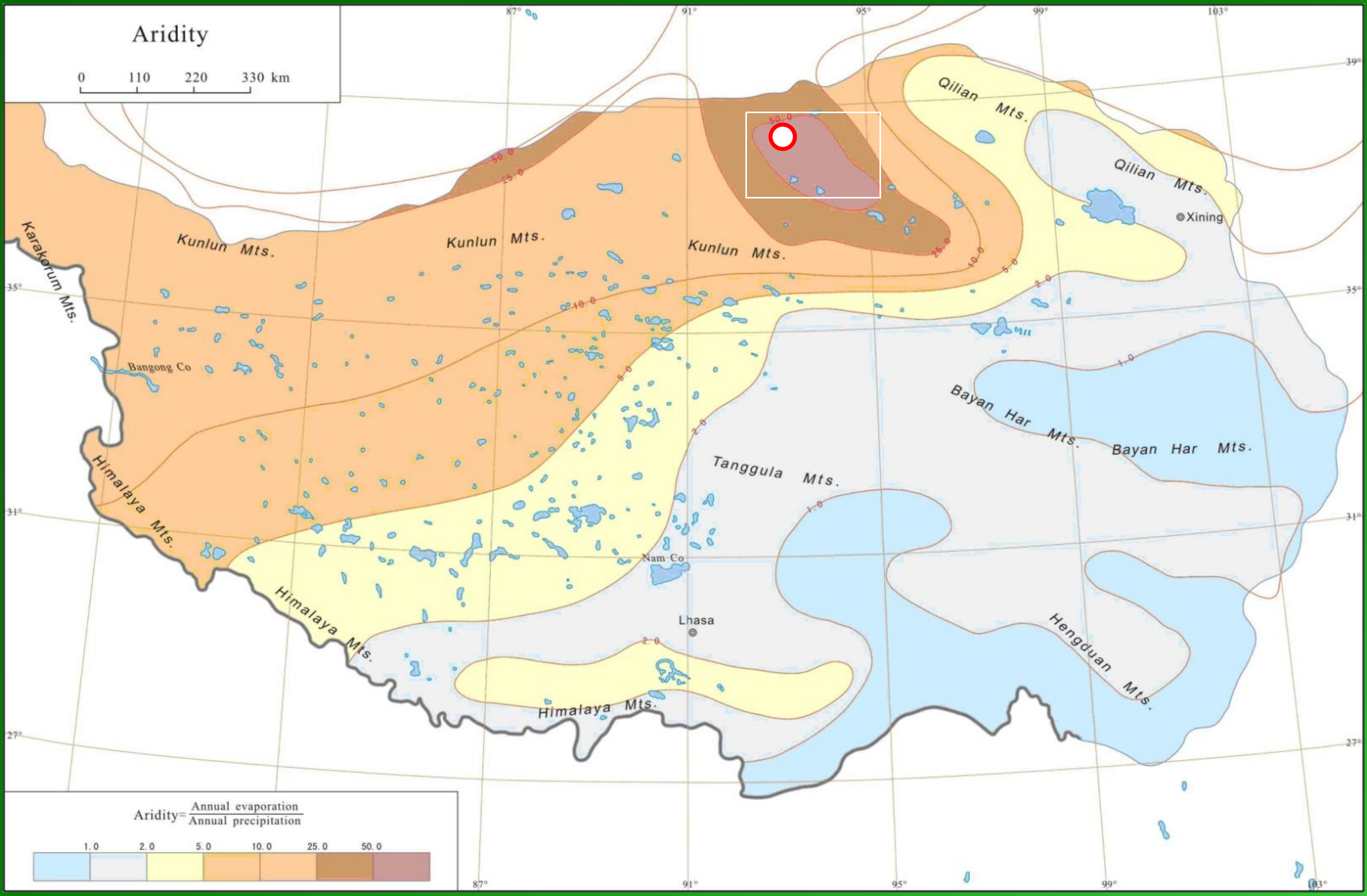
Terrestrial Analog Site Study (Tibet)



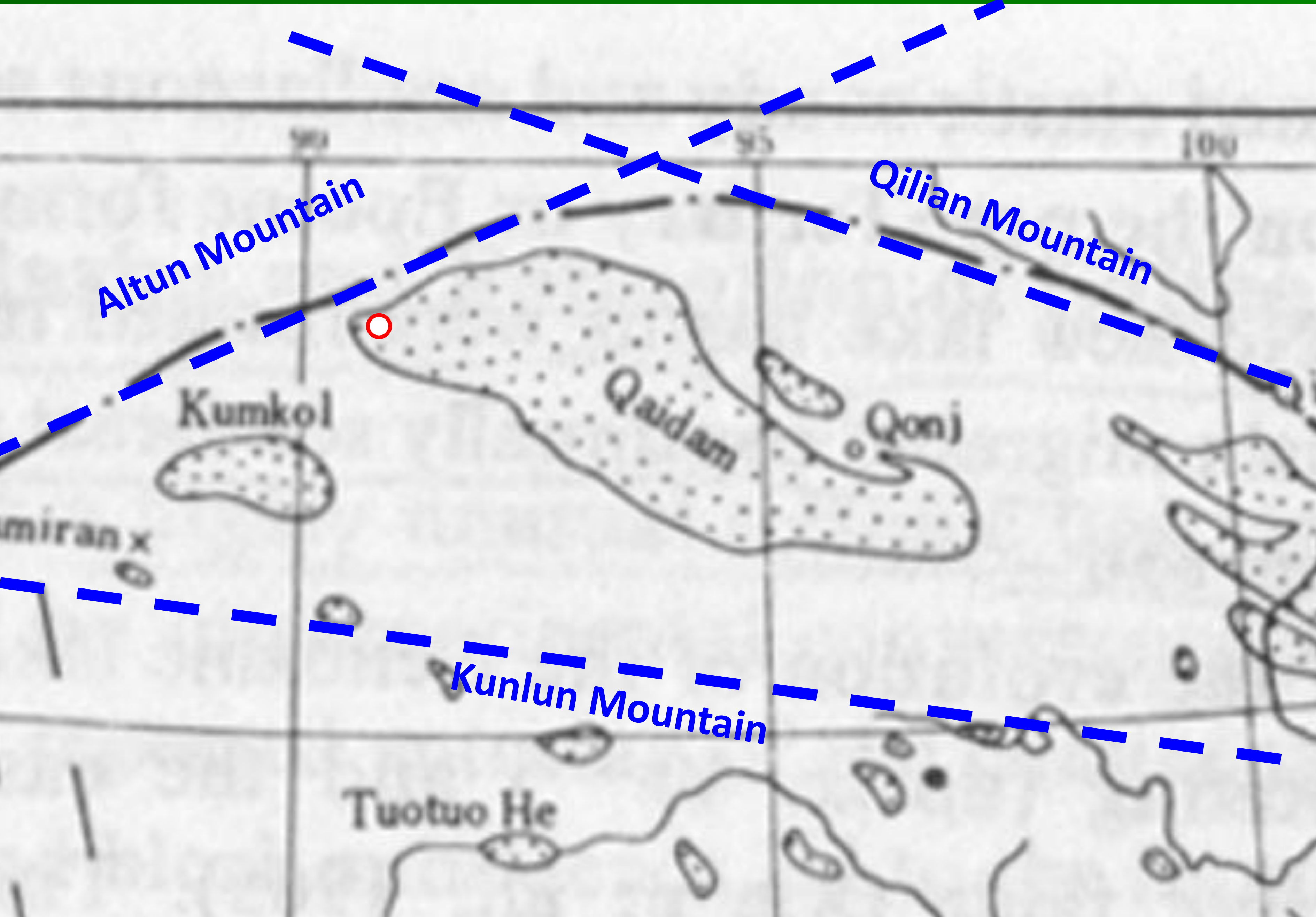
Climate conditions

– low P, low T, large ΔT, high UV, & **hyperarid**

Aridity map of QT :
DLT has the highest aridity (AI<0.01)



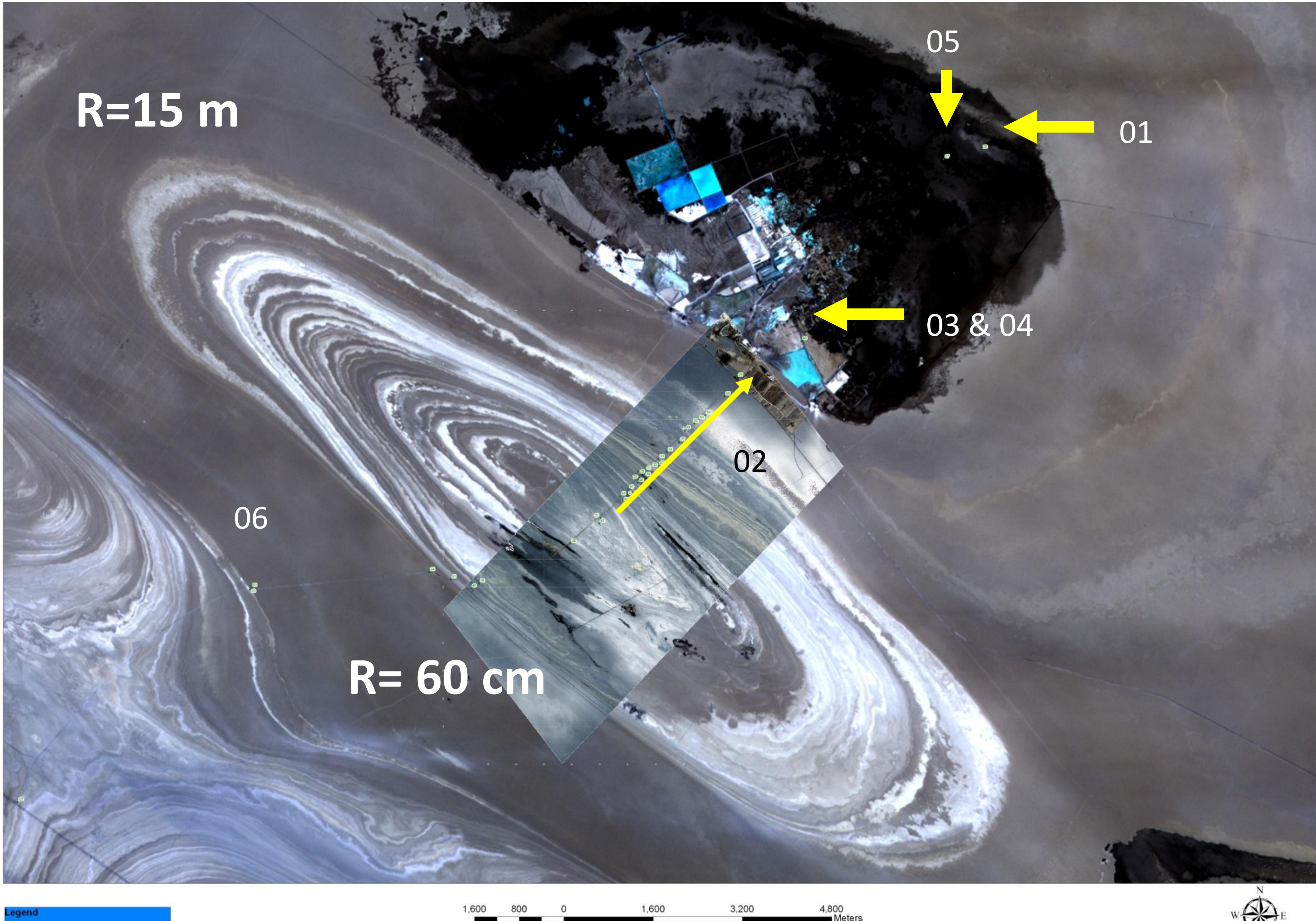
Qaidam paleolake (Pliocene-early Pleistocene)



Satellite photo of Da Langtan (DLT) area

General View of the area

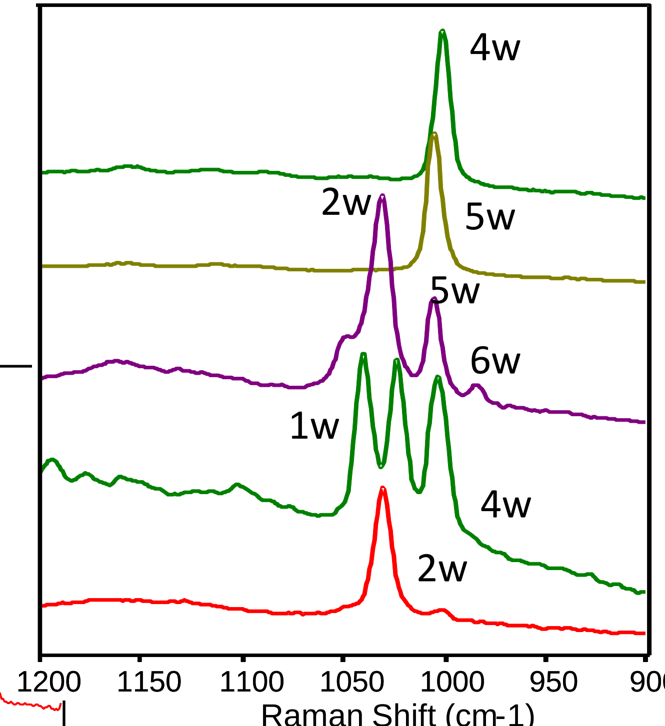
Satellite photos of DLT w/sampling sites



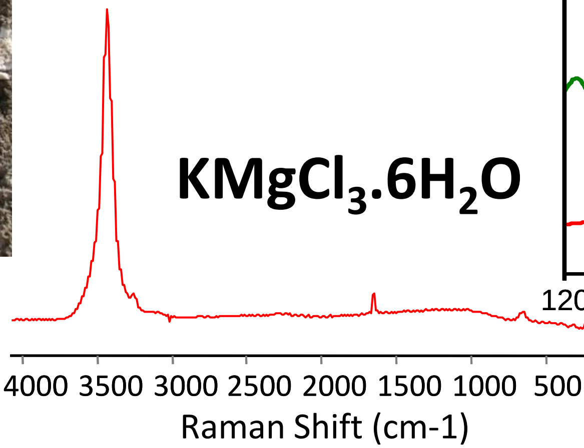
Sampling through a cross section

Subsurface salts w/high degree of hydration

$MgSO_4$. (4-6) H_2O



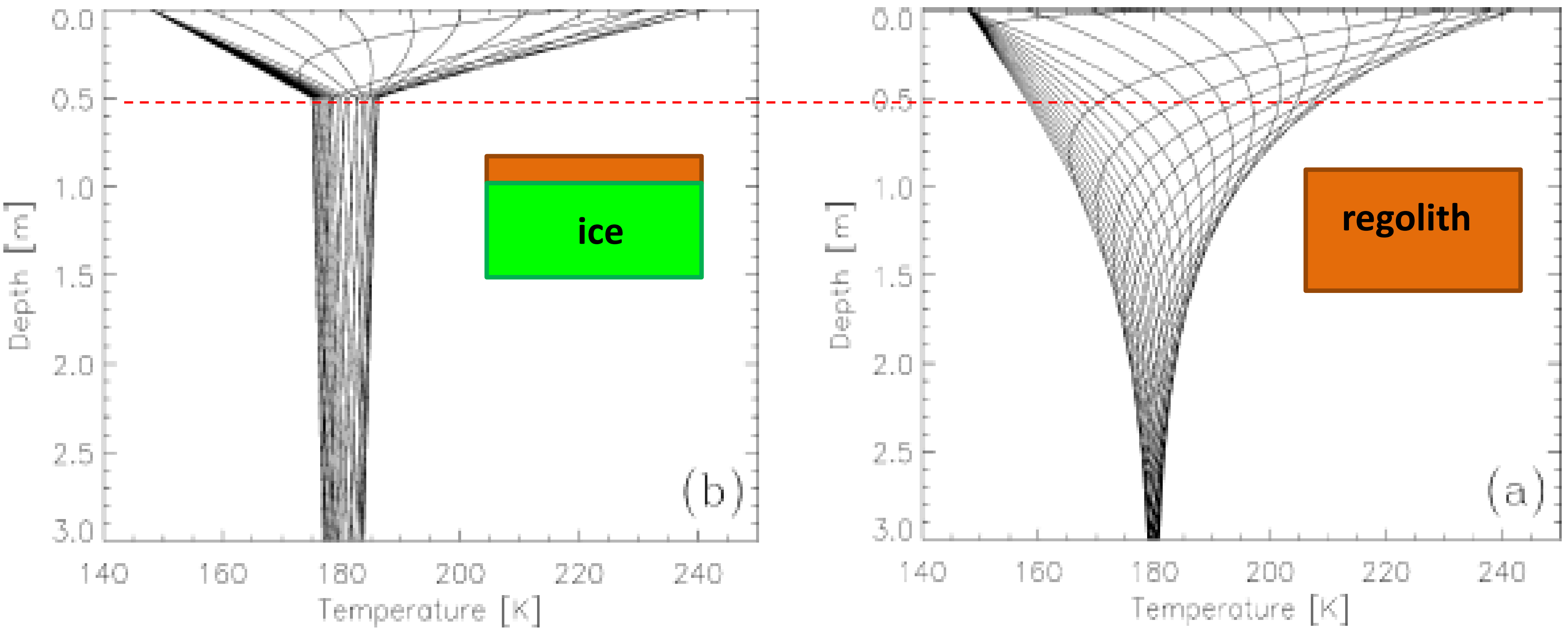
$KMgCl_3.6H_2O$



Highly hydrated salts are preserved in the *subsurface* of a hyperarid region.

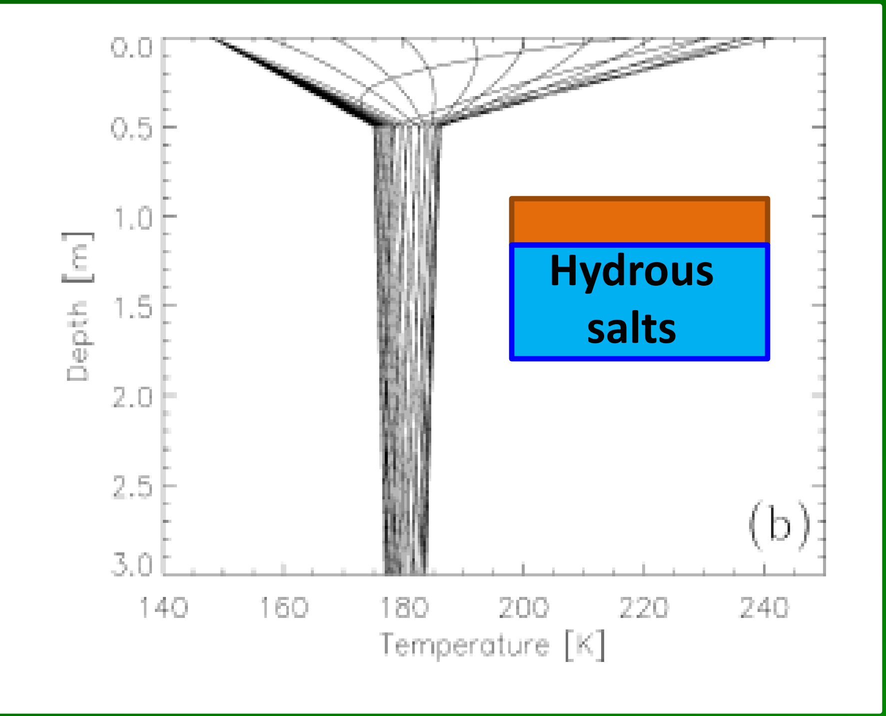
A thermal model by Mellon et al., 2004

T profile in regolith



Ice -rich subsurface: low T_{ave} & small ΔT

Extrapolation of Mellon's model



Assumption -- Hydrous salts have higher thermal inertia than surface regolith.

Lower T_{ave}, smaller ΔT

Higher RH, smaller ΔRH

Atmospheric conditions at the surface have less influence in salt-rich subsurface ;

Large quantity of hydrous salts will buffer the RH of the environment

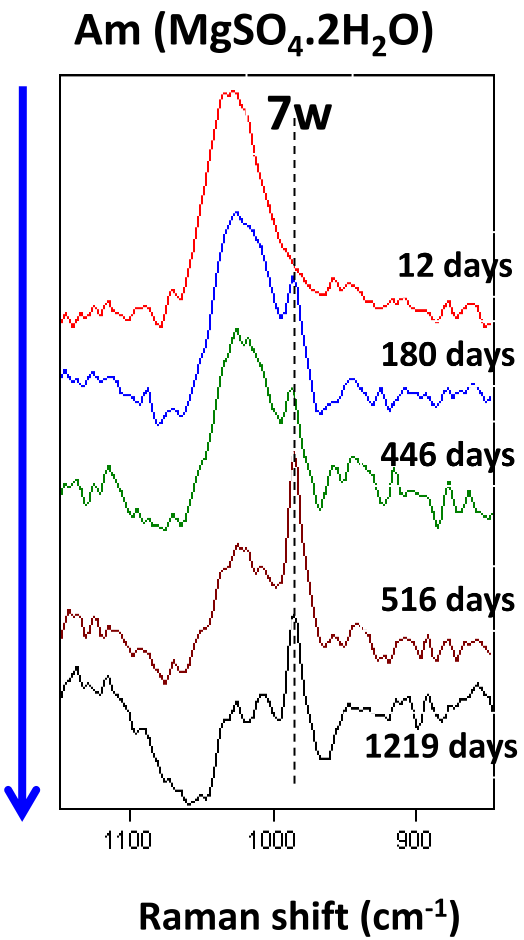
Laboratory observation #2

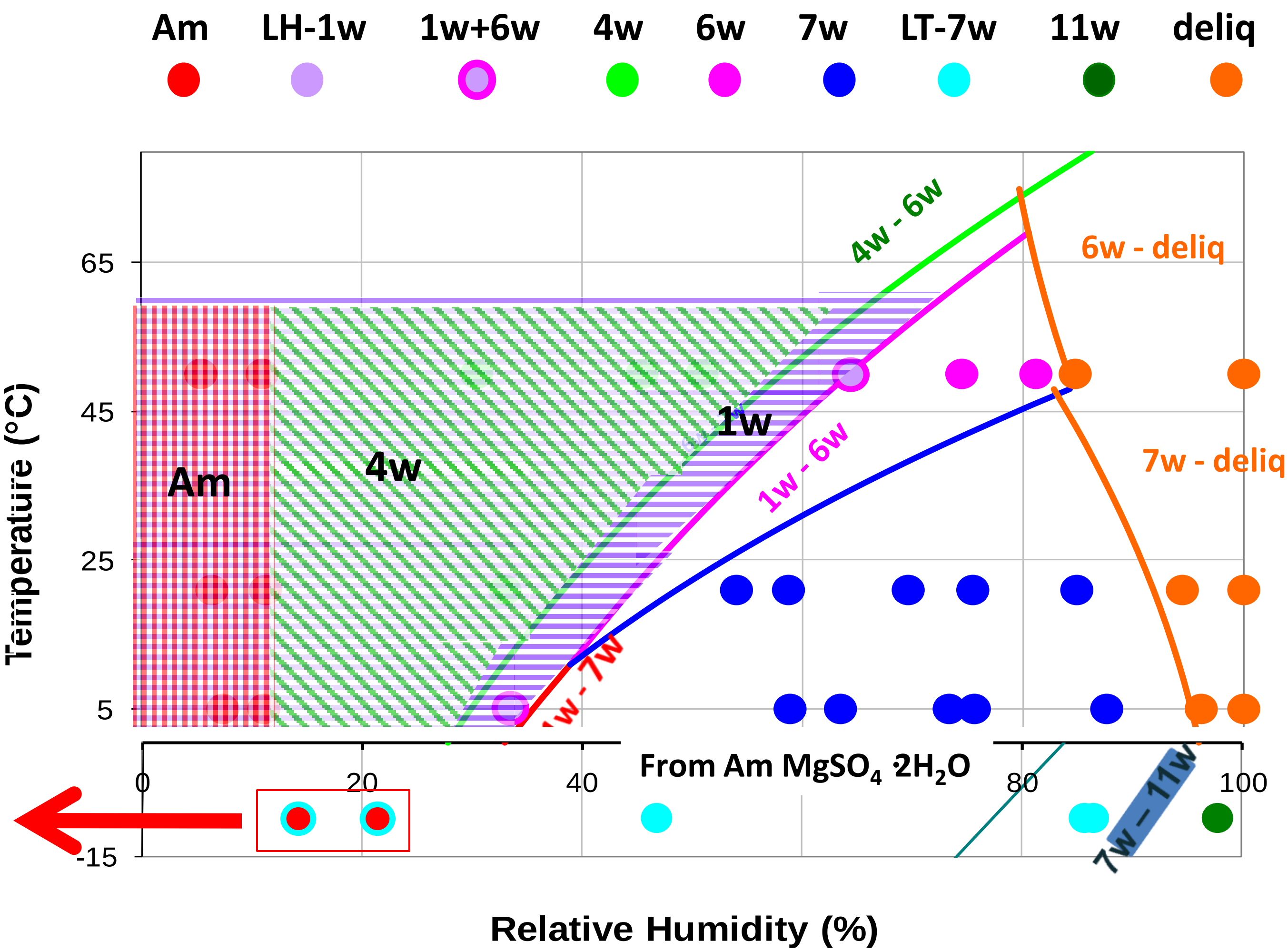
At -10 °C, a space filled w/$MgSO_4.7H_2O$
RH ~ 96 – 97%

At -10 °C, a space filled w/ferricopiapite
RH ~ 75 -79%

W/enough quantity,
Highly hydrated salts can keep a high RH within subsurface

Laboratory observation #3





Large stability fields of $MgSO_4.7H_2O$ @ low T

Mars -- salt-rich subsurface at equatorial region → Low T, high RH ;

Earth -- subsurface salty layer in a hyperarid region → High RH;

Thermal model -- A salt-rich subsurface would be less influenced by atmospheric conditions;

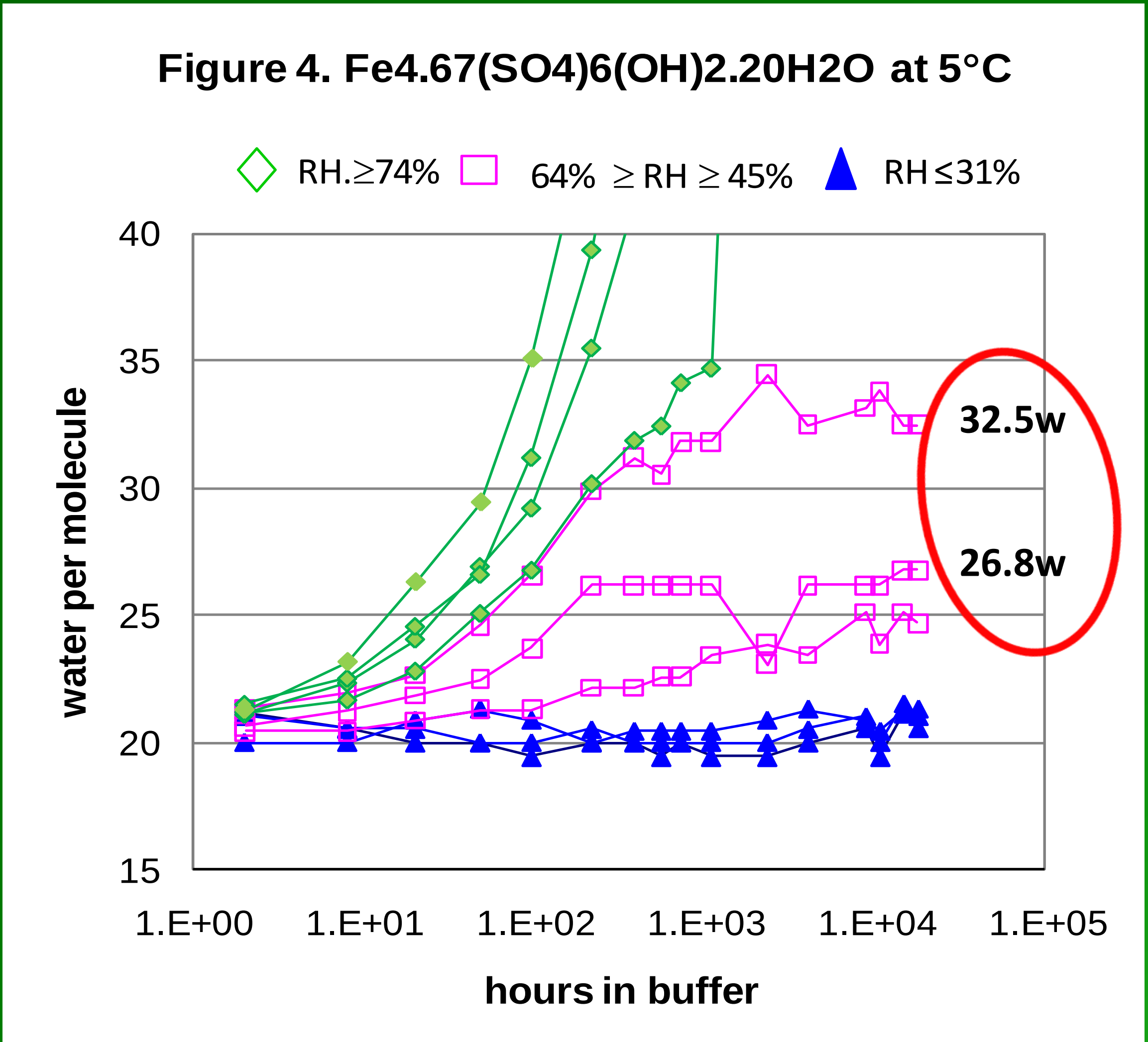
Lab – highly hydrated salts can buffer a high RH environment at low T;

Lab – highly hydrated salts have large stability field (RH) at low T.

↓

What about Liquid water…

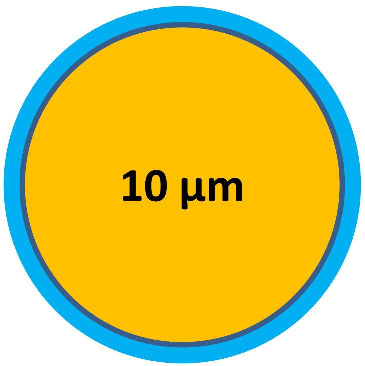
Laboratory observation #4



26.8w, 32.5w suggest extra 6.8w – 12.5w at grain surfaces

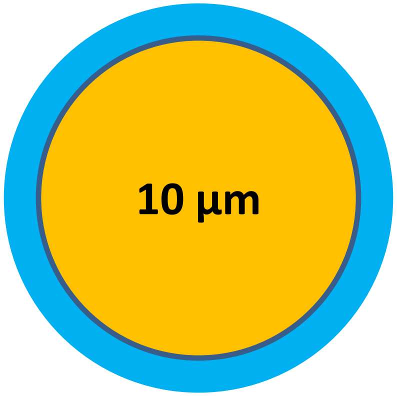
The meaning of extra 6.8w – 12.5w per ferricopiapite molecule

6.8w/molecule



1137 layers of H_20 (0.35 µm)

12.5w/molecule



2090 layers of H_20 (0.65 µm)

Thin film of liquid H_2O has formed at the grain surfaces of ferricopiapite

Low T, high RH, H_2O film

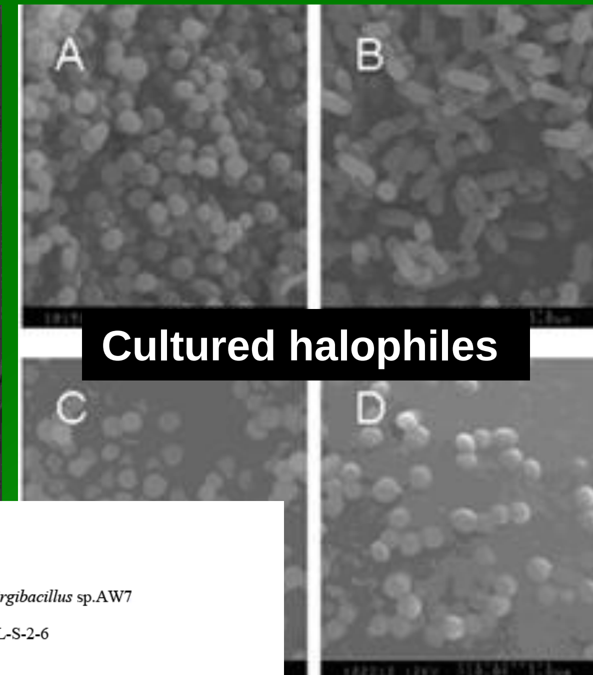
↓

Habitable ?

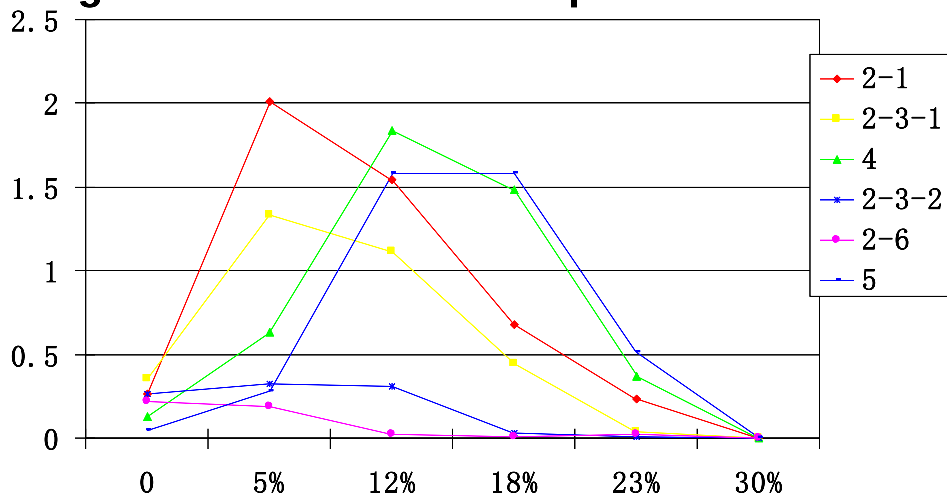
↓

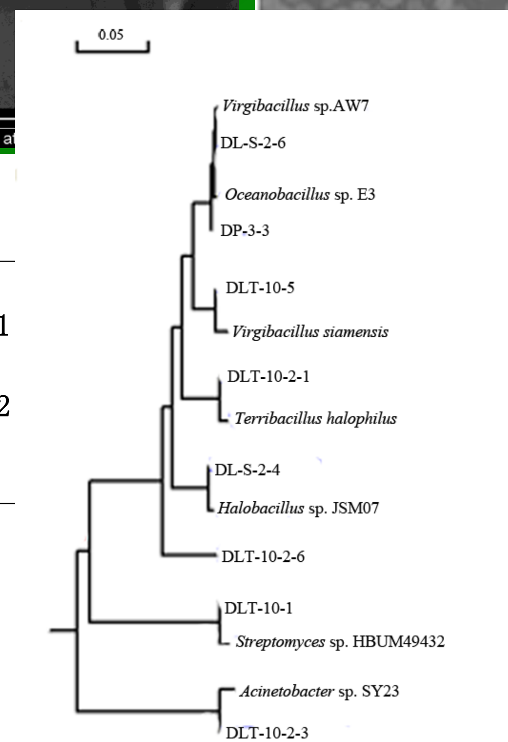
Inhabited ?

Inhabited at QT -- halophiles



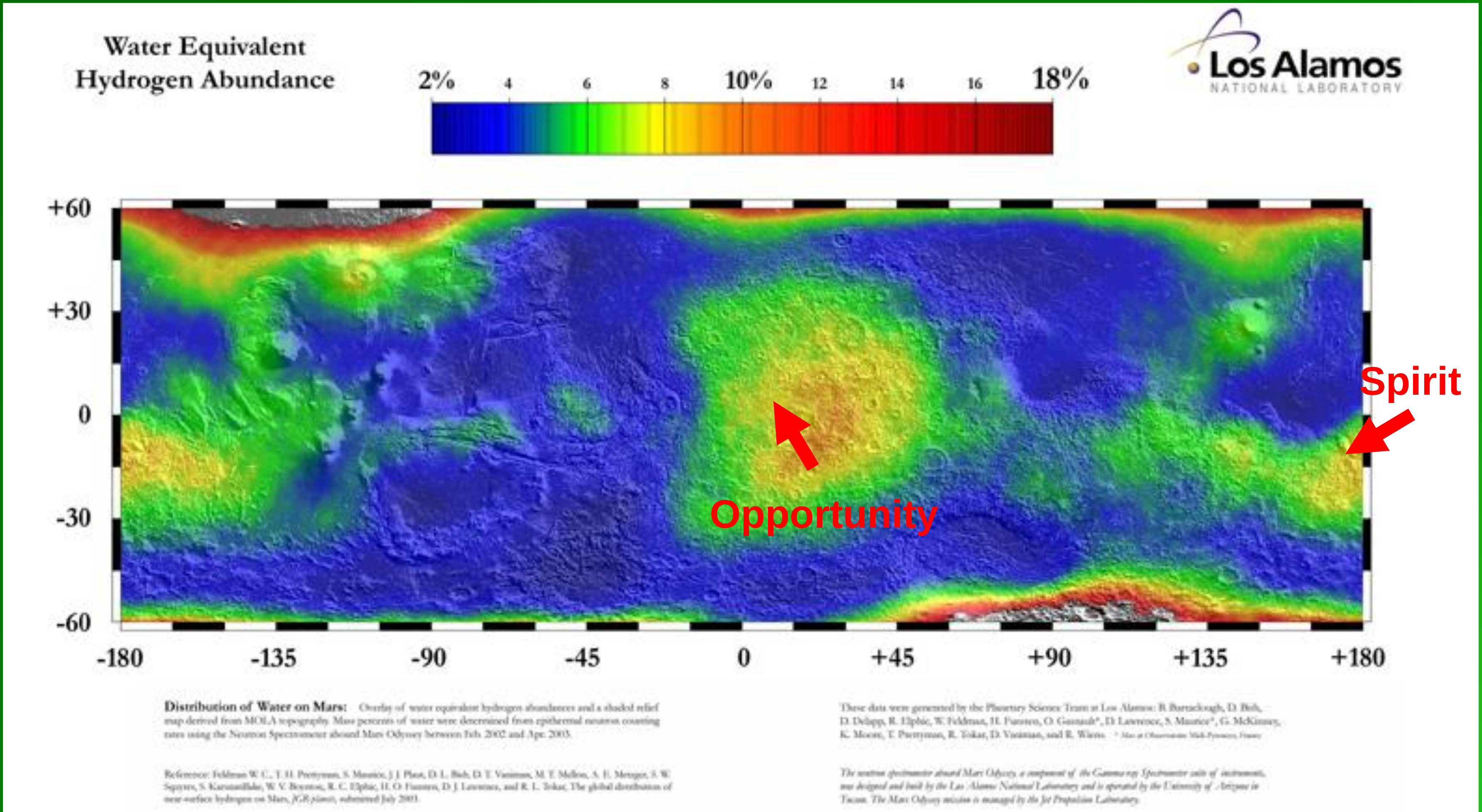
The growth curve of six halophile strains





16S rRNA gene sequences for eight strains halophiles

Subsurface in equatorial regions on Mars ?



Habitable?

inhabited ?