



**SEARCHING FOR LIFE ON EARLY
MARS VIA SAMPLE RETURN:
LESSONS FROM THE PILBARA**

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How hard is it to find evidence of life in a terrestrial ancient life site?



Lessons drawn from 2011 Spaceward Bound field trip to Pilbarra Australia

J.D.A. Clarke and C. Stoker, Searching for stromatolites: the 3.4 Ga Strelly Pool Formation (Pilbarra region, Western Australia) as a Mars analog, *Icarus* 224, 413-423, 2013.

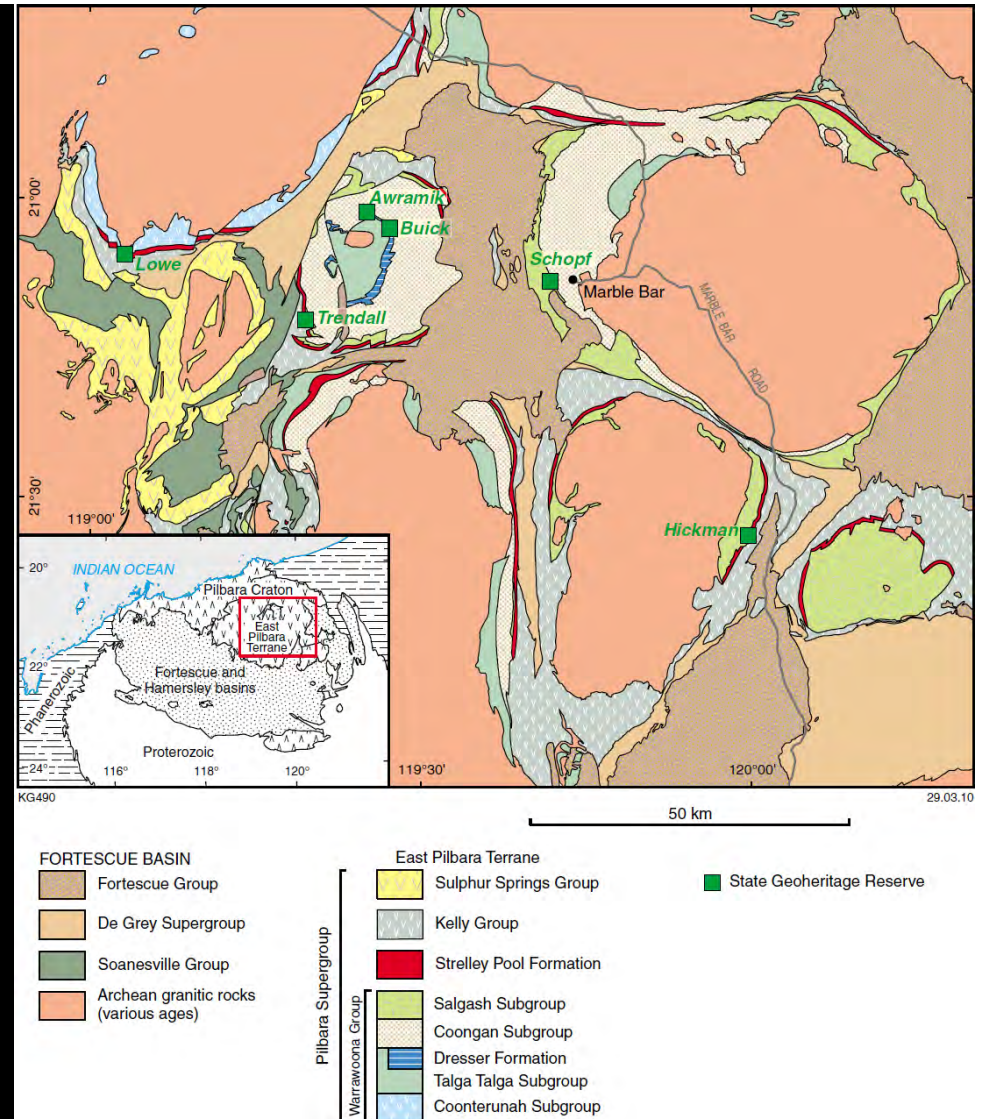
Importance of stromatolites

- The earliest conclusive evidence of life on Earth
- Oldest stromatolites of the pilbarra at ~3.5Ga
- Mesoscopic – recognisable at the outcrop scale
- Associated with other evidence – chemical, microfossils
- Dome and pillar-shaped carbonate growths formed by colonies of algae
- Photosynthetic - grow vertically towards the light
- Bacteria and other microorganisms also important
- Stromatolites of phosphate, silica, sulphides, iron oxide, and sand also known
- May not always be photosynthetic

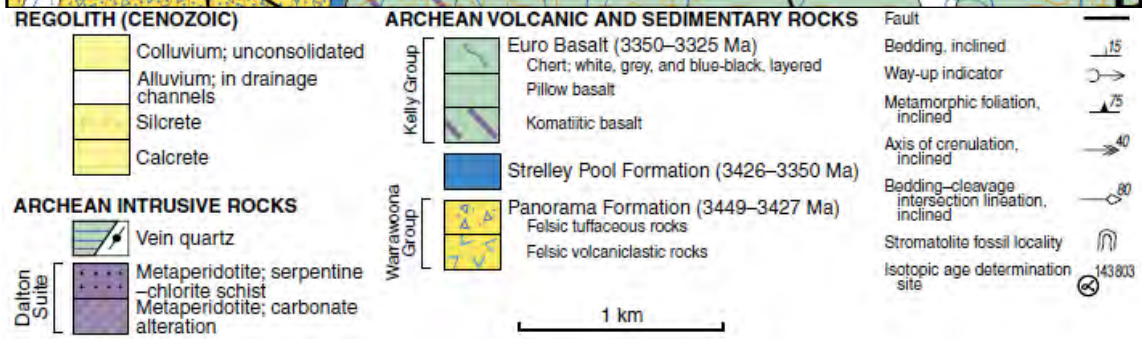
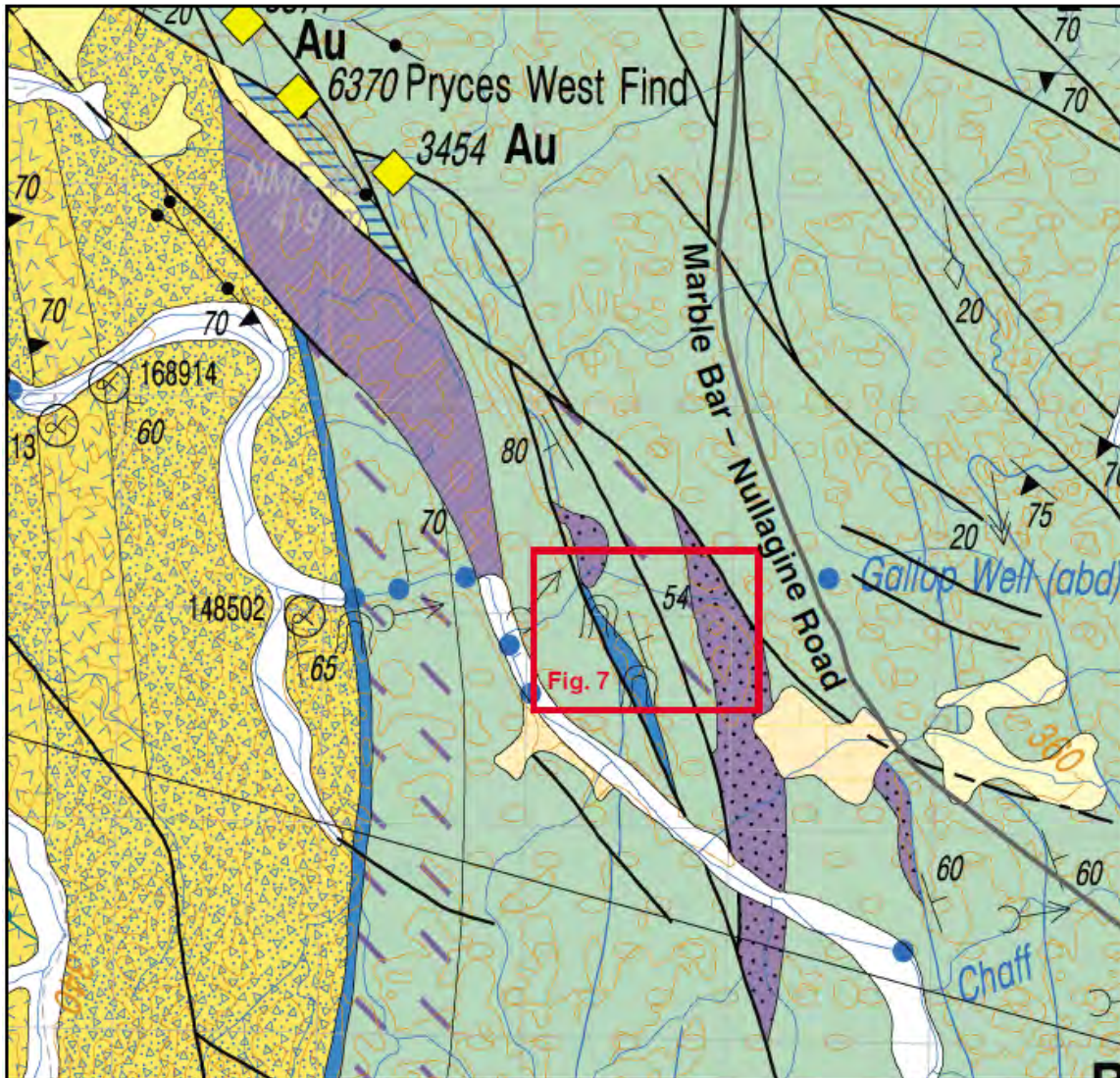


Pilbara Region WA

- Granite-greenstone terrains Mostly 3.8-3.2 Ga
- Younger 2.7-2.5 Ga cover successions
- Stromatolites main evidence for life during deposition
- Strelley Pool Fm. Mapped over 30,000 km²
- Deposited during 75 myr period 3426-3350 myr
- Typically only 20-100m thick

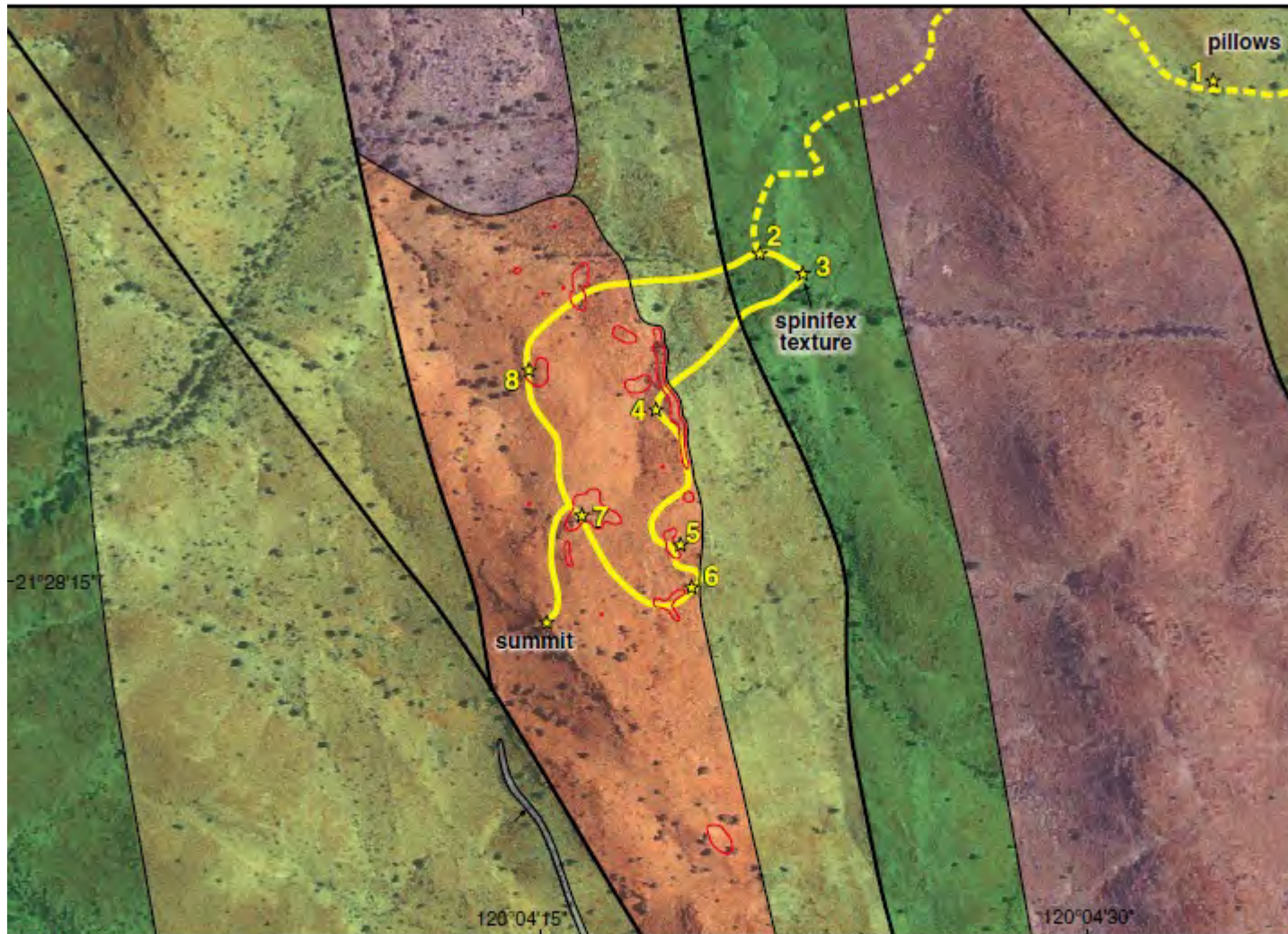


Grey et al. 2010



In 2011 as part of Spaceward Bound Pilbarra field expedition, we visited “Dawn of Life Trail” and mapped stromatolite outcrops, imaged, obtained IR spectra and sampled.

Grey et al. 2012 “The proposed Dawn of Life Geotourism Trail”



IG507c 06.09.1

100 m

DALTON SUITE (c. 3185 Ma)

Metaperidotite intrusion

PILBARA SUPERGROUP

Kelly Group

- Euro Basalt (3350–3325 Ma)
- Chert; white, grey, and blue-black, layered
- Pillowed basalt
- Komatiitic basalt; local spinifex texture

Strelley Pool Formation (3426–3350 Ma): layered chert, including silicified carbonate rocks, with basal sandstone and conglomerate

Outcrops with stromatolites

Fault

Walking trail

Vehicle trail

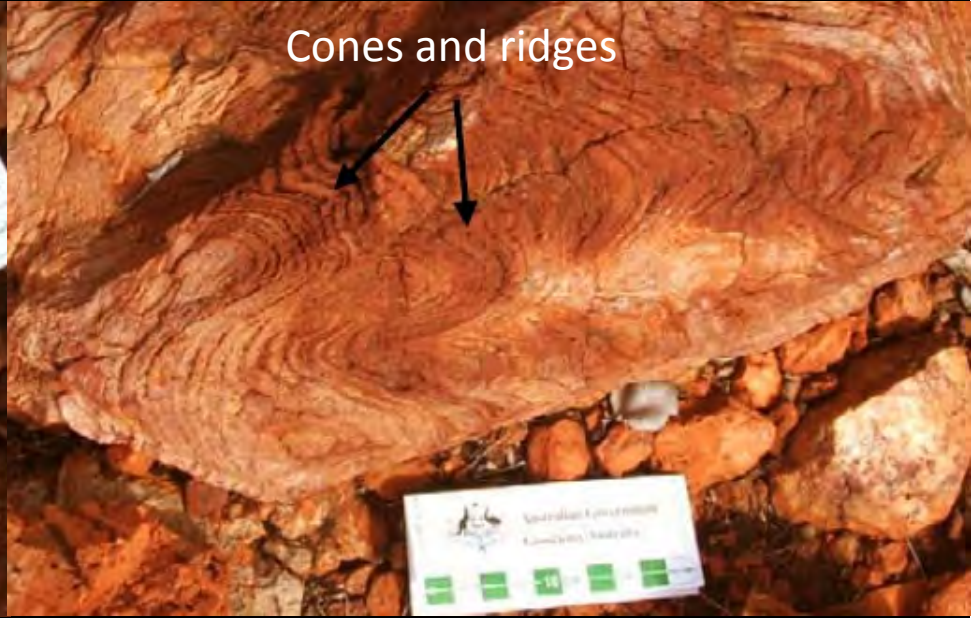
Locality on trail

18 outcrops
of
stromatolite
s mapped
and imaged

Dawn of Life Trail stromatolites



Near horizontal laminae connecting to cones



Pustular mat similar to current Sharks Bay

Conical stromatolites are strong morphological evidence of biogenicity.

Numerous examples at this site.



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AHH640

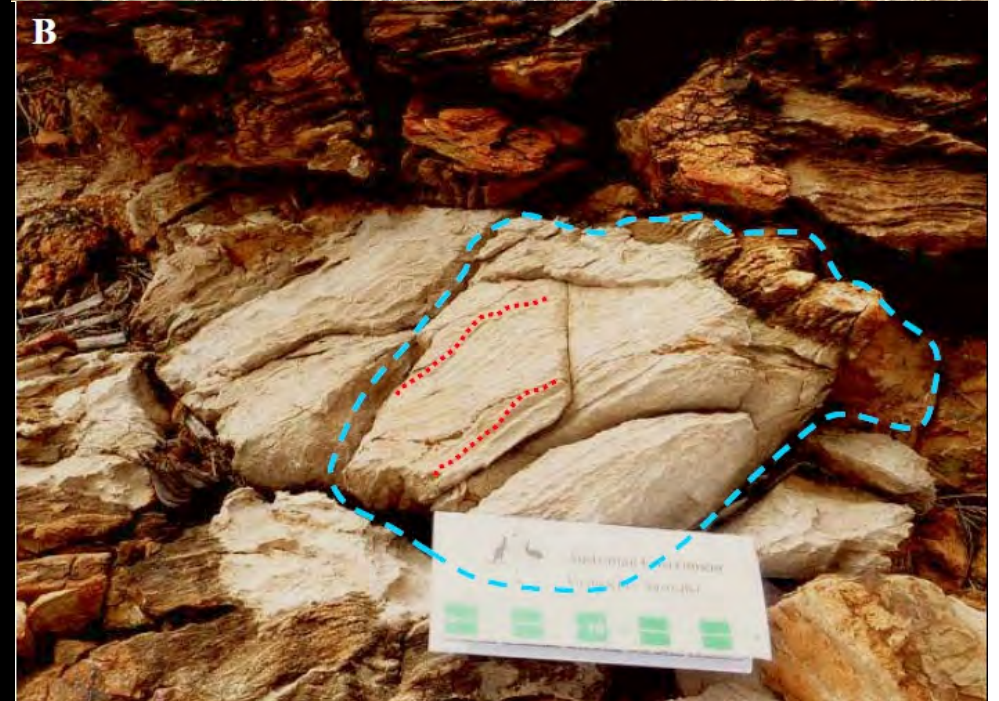
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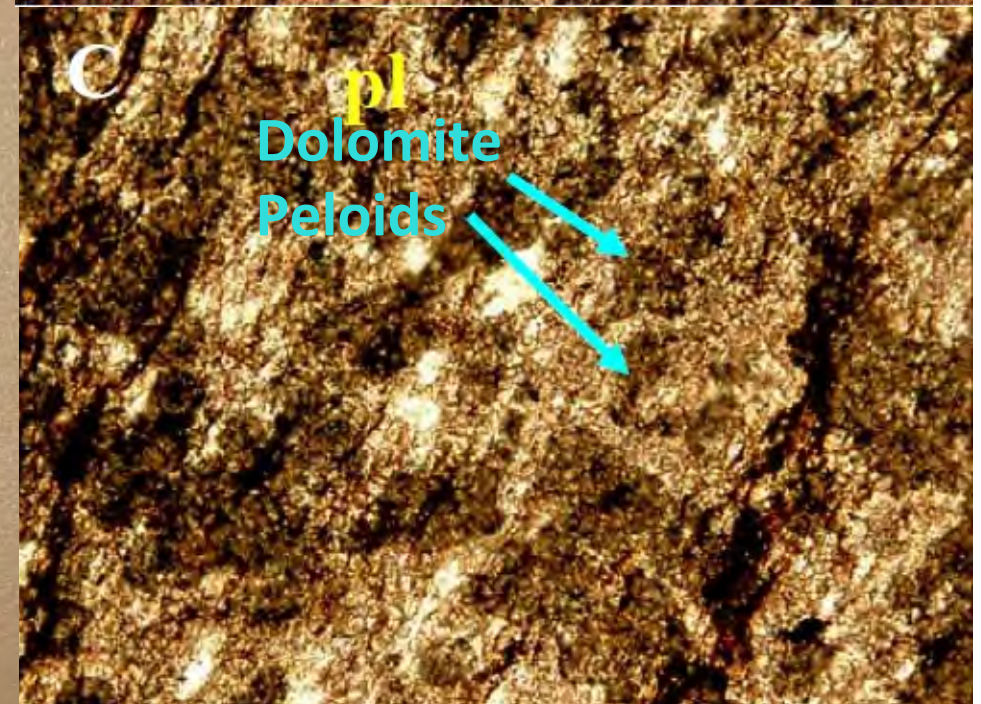
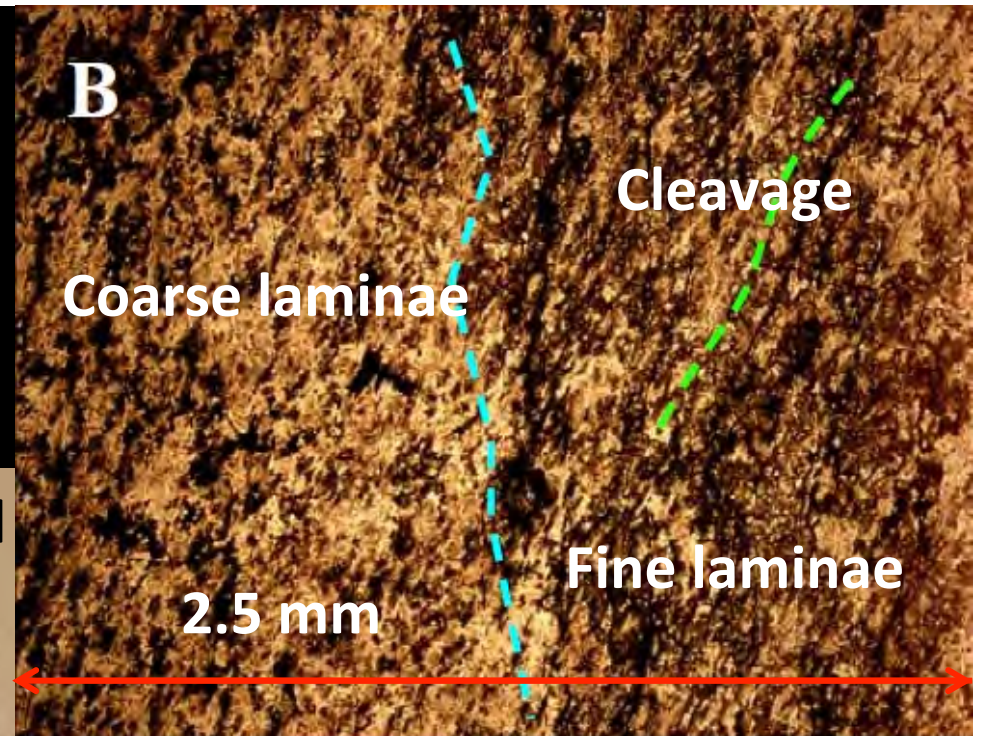
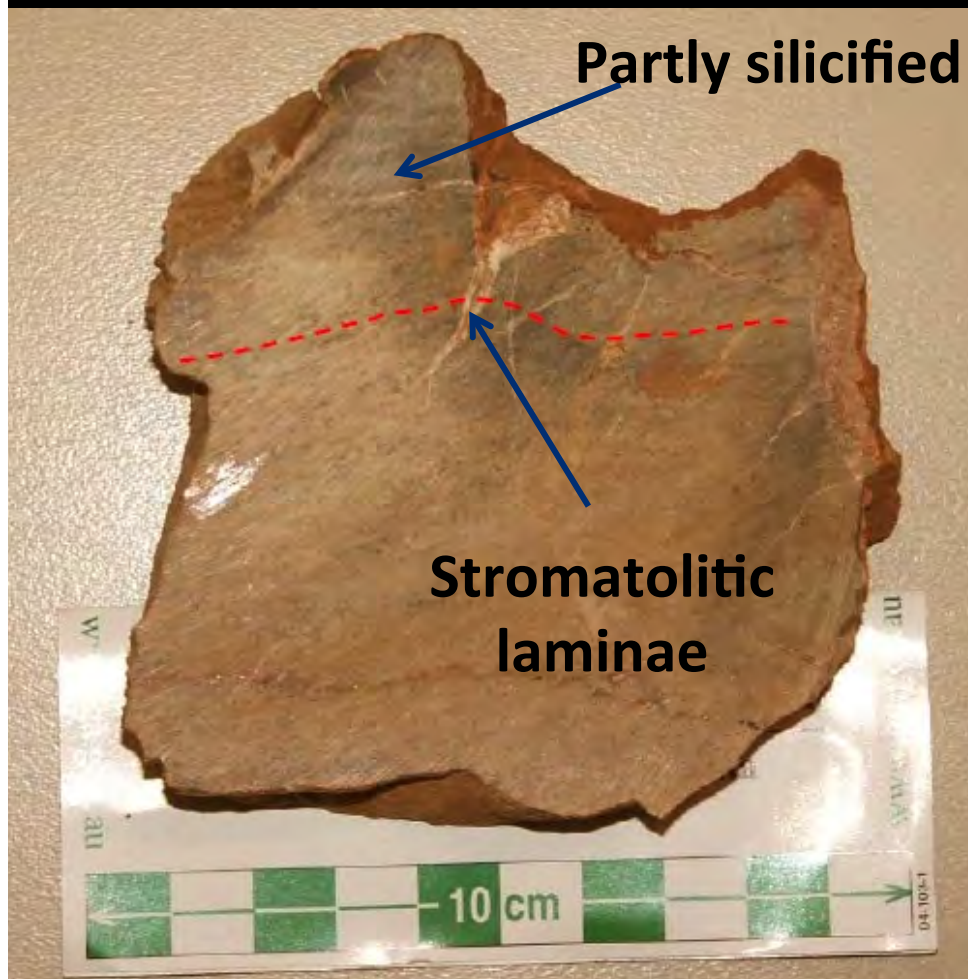
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However
macroscopic
stromatolites
often don't yield
other evidence
of life (organic
sequestration,
microfossils).



DLT stromatolites under microscope – no distinct biogenic features

Sawn face



Lessons from Pilbarra

- Evidence for 3.5 Ga life in the Pilbara is rare!
- Occupy less than one millionth of the area of the mapped succession in the Pilbara
- An explorer could travel hundreds of km in the Pilbara and not see any signs of ~3.5 Ga life
- First signs were not recognised until the late 1970s, after more than 100 years of detailed geological exploration (stromatolites being known elsewhere since 1830s)
- Proof of biogenicity on oldest Pilbara stromatolites was controversial for many decades (and continues even now)
- Many samples contain no microscopic evidence suggesting biogenic formation, even when the morphology strongly suggests it

What was needed to demonstrate authenticity of 3.5 Ga life in the Pilbara?

- Regional investigations providing context sites over 10,000s km²
- Traverses of 100s of km
- Detailed field studies of specific sites (>10)
- Multiple samples (>100s kg, possibly tonnes) from each sites
- Multiple teams (20-30)
- Diverse investigative techniques (50-100 used)
- Long time period (~30 years of targeted research)



Pilbara-equivalent conclusions on Mars will require:

High-res. regional hyperspectral data in dust-free areas to locate targets

Long range traverses (100s -1000s km)

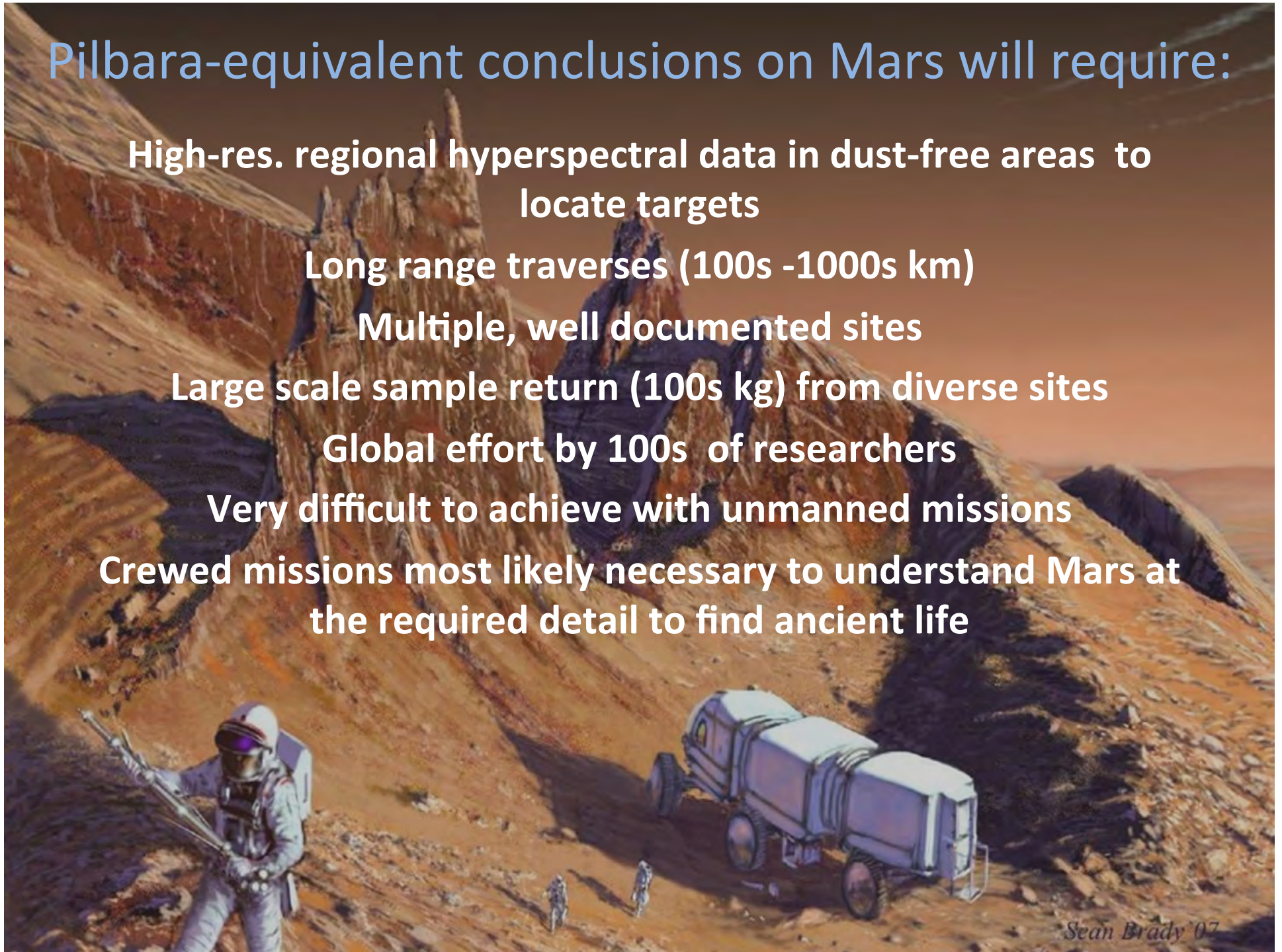
Multiple, well documented sites

Large scale sample return (100s kg) from diverse sites

Global effort by 100s of researchers

Very difficult to achieve with unmanned missions

Crewed missions most likely necessary to understand Mars at the required detail to find ancient life

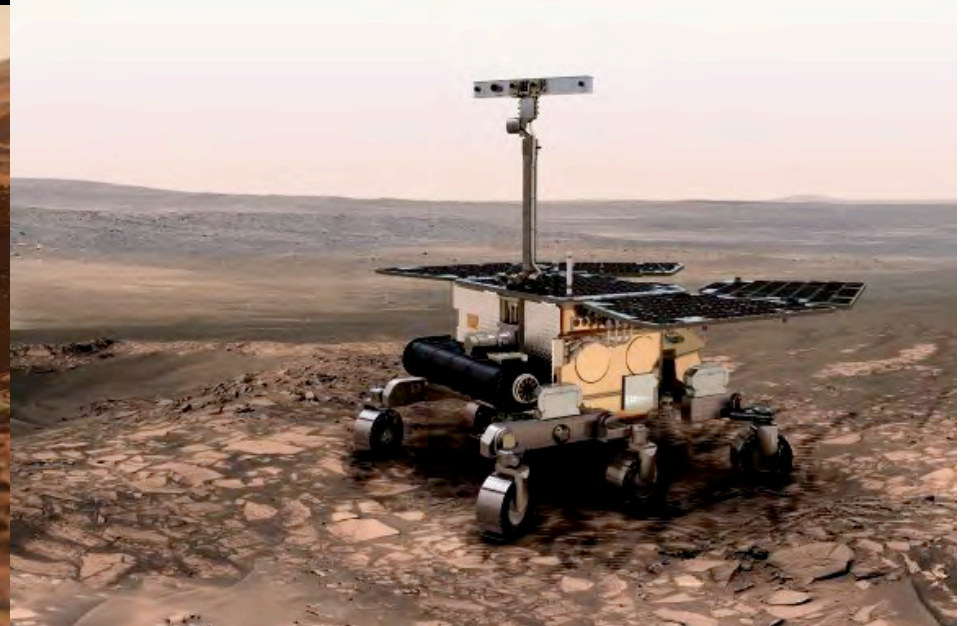
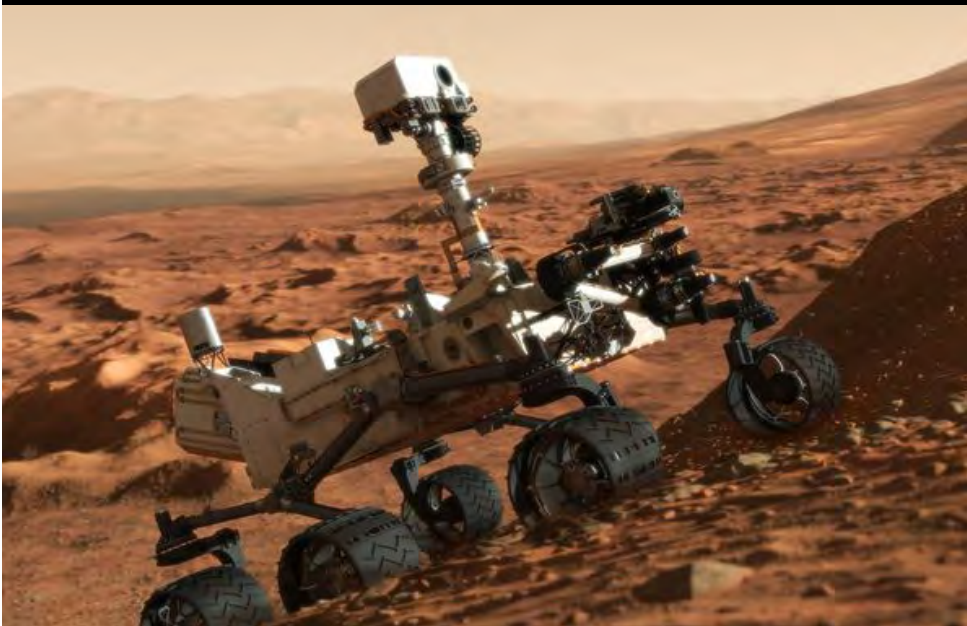


What role for unmanned sample return

- We should not expect conclusive evidence of early Mars life from unmanned rovers
- Even stromatolites (if found and sampled) unlikely to be sufficient
- Unless they get very lucky!
- Primary role will be problem scoping and parameter defining for future missions –crewed missions

HOWEVER

- Any returned sample is better than none
- Almost any sample suite will yield diverse data



CONCLUSIONS

- Finding conclusive evidence for early life in the Pilbara was hard
- Finding conclusive evidence for (or against) the presence of life on early Mars will be at least as hard
- Robotic exploration and sample return too limited to have high likelihood of successful proof on ancient life on Mars

QUESTIONS?



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