

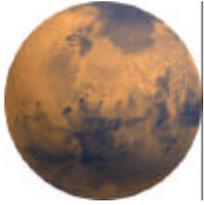
Gusev Crater (MER A)

Overview of Relevance, Science, and Testable Hypotheses



What Makes Gusev an Outstanding MER A Site

- ✧ 1.0 Unambiguous evidence of the past presence of water.
- ✧ 2.0 Unambiguous evidence of long term fluvio-lacustrine interaction between Gusev and Ma'adim.
- ✧ 3.0 Unambiguous evidence of concentration of flows in a basin.
- ✧ 4.0 Use of Complete Suite of Athena Science Instrument Payload to Test Hypotheses (Formation & Processes)

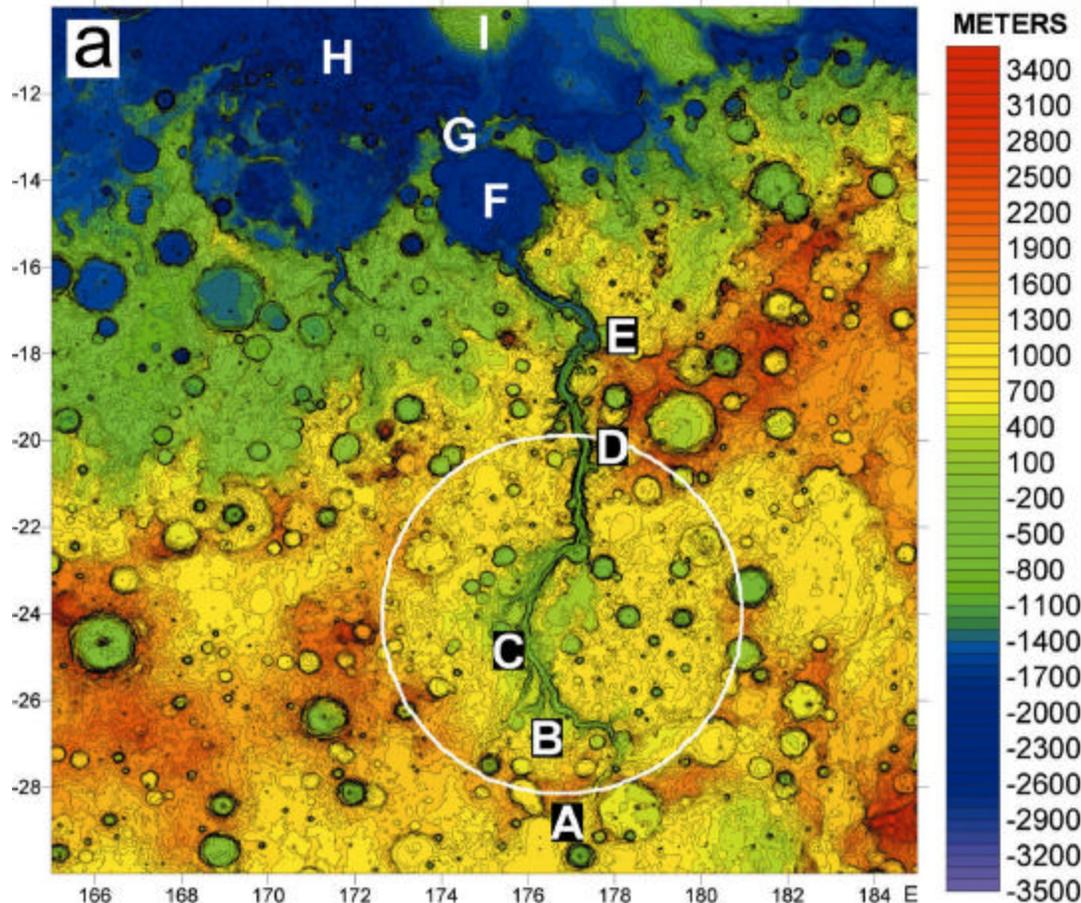


What Makes Gusev an Outstanding MER A Site

- ☆ Gusev has the “right stuff” to provide the information we seek on Mars about:
 - The hydrogeology over long geological periods and its changes through time (**long, episodic, interaction between Ma’adim & Gusev**)
 - The climate changes (**lakes record changes: variations in discharges & grain-size, chemistry, mineralogy & morphology of deposits**)
 - The pre-biotic to biotic potential (**abundant ponding water**)
 - The fossilization potential (**lakes favor fossilization processes**)



1.0: Unambiguous evidence of the past presence of water

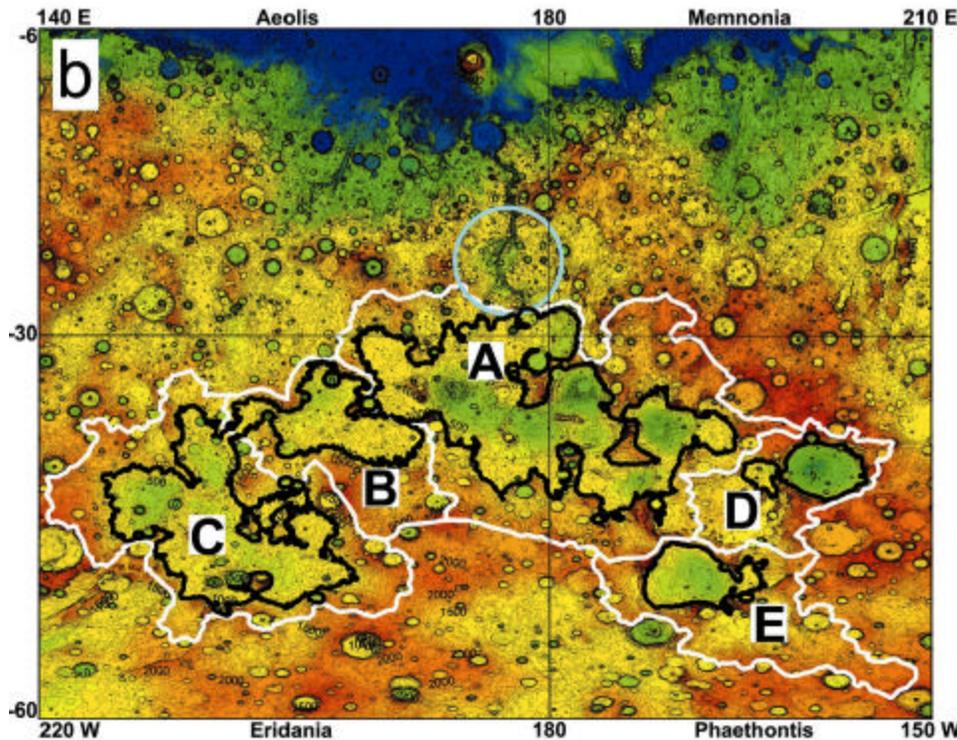


Map: Irwin et al., 2002
(submitted)

- One of the largest channel systems on Mars;
- Vast watershed eroding highland terrain and a variety of geological units;
- System of terraces showing episodic activity.
- Flow concentrating in Gusev (receptable);
- Several sources suggested for the water through time:
 - *Runoffs and outflows*
 - *Groundwater*
 - *Hydrothermal*
 - *Glacial*



1.0: Unambiguous evidence of the past presence of water

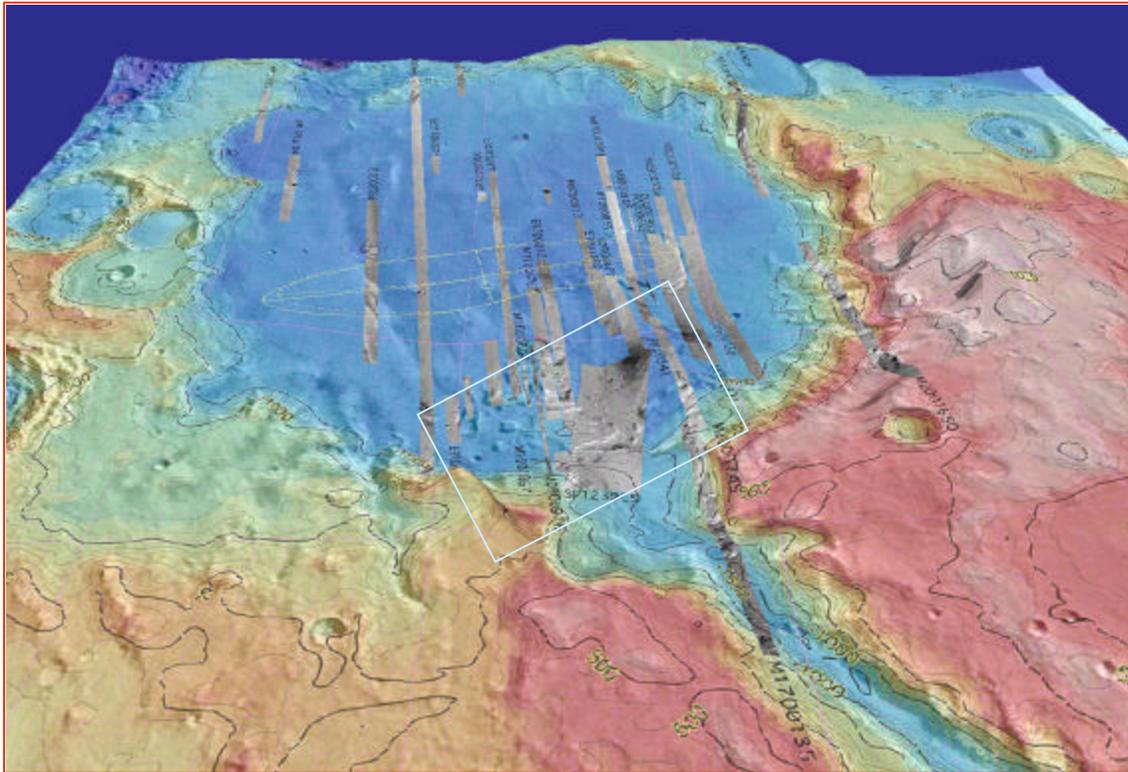


**Lake basin at the head of
Ma'adim Vallis?**

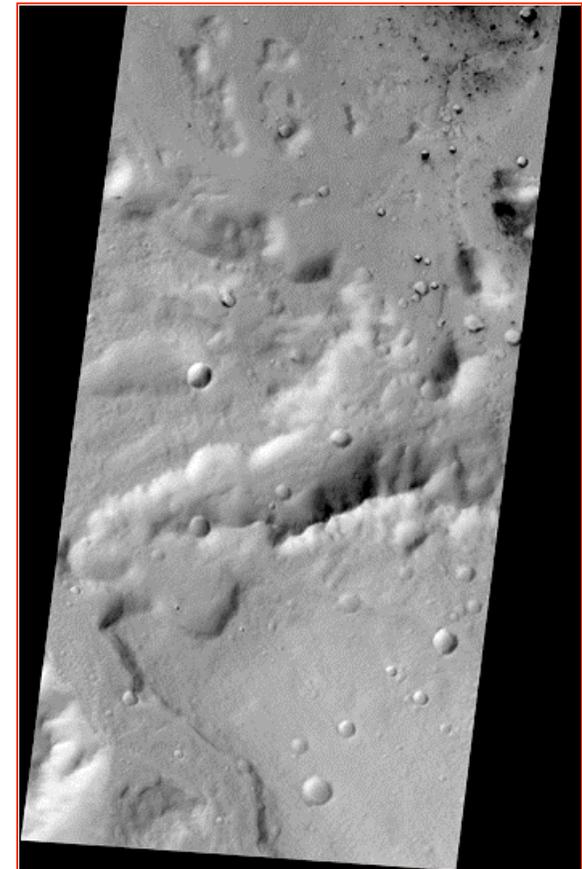
Map: Irwin et al., 2002
(*submitted*)



2.0 Unambiguous evidence of long term fluvio-lacustrine interaction (Gusev and Ma'adim).

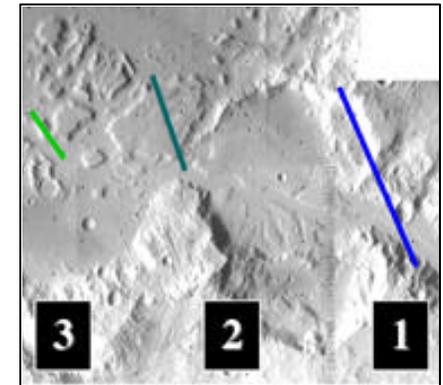
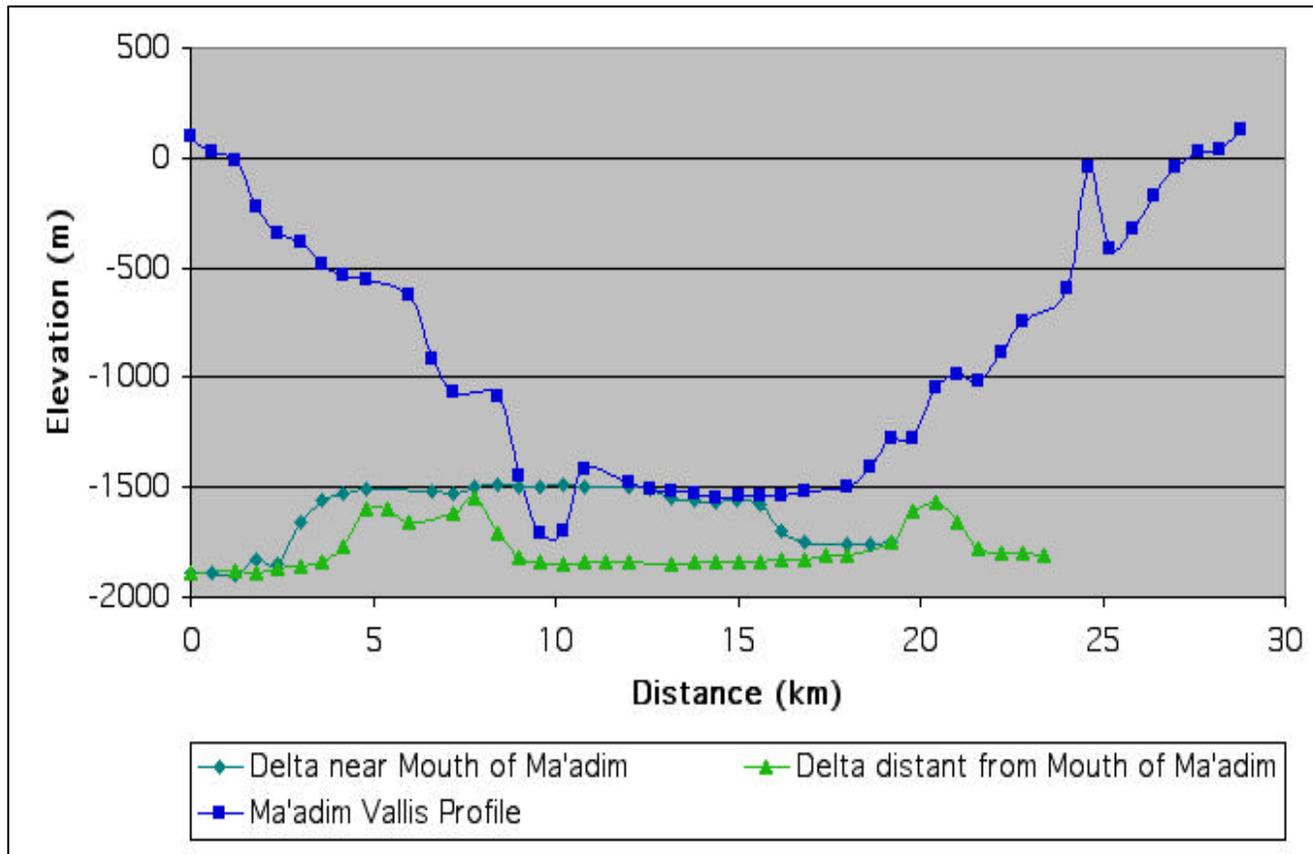


Delta of Ma'adim in Gusev





2.0 Unambiguous evidence of long term fluvio-lacustrine interaction (Gusev and Ma'adim).



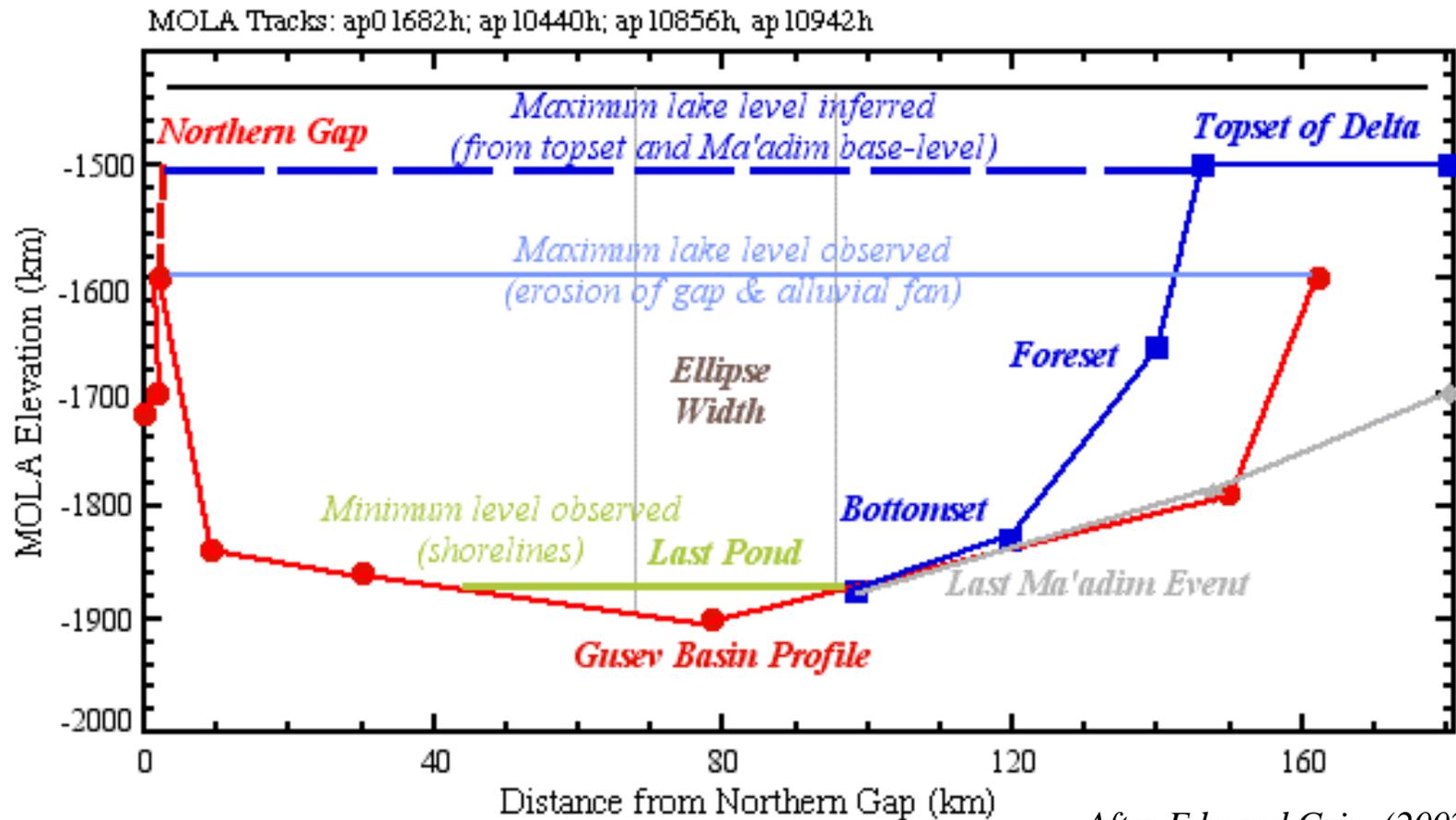


3.0: Unambiguous evidence of concentration of flows in a basin.

- MOLA Bathymetry
- MOC
 - Layers identified
 - Variable thickness
 - Variable albedo
 - Possible Playas & Evaporites (THEMIS?)
 - Shorelines and Lacustrine Terraces
- THEMIS
 - Mineralogy?
 - See results from *Phil Christensen*



3.1: Gusev Bathymetry from MOLA



After Edmond Grin, (2002)



Conclusions from Bathymetry

- Combined MOC and MOLA show:
 - Maximum lake depth inferred from topset: ~ 410m
 - Maximum lake depth observed from gap: ~ 310 m
 - The depth of last pond was at least: 35 m
- Landing Ellipse located in the deepest point of the lake
 - Whenever a lake, water ponded there
 - Site of longest residence time for water
 - Best location for evaporites

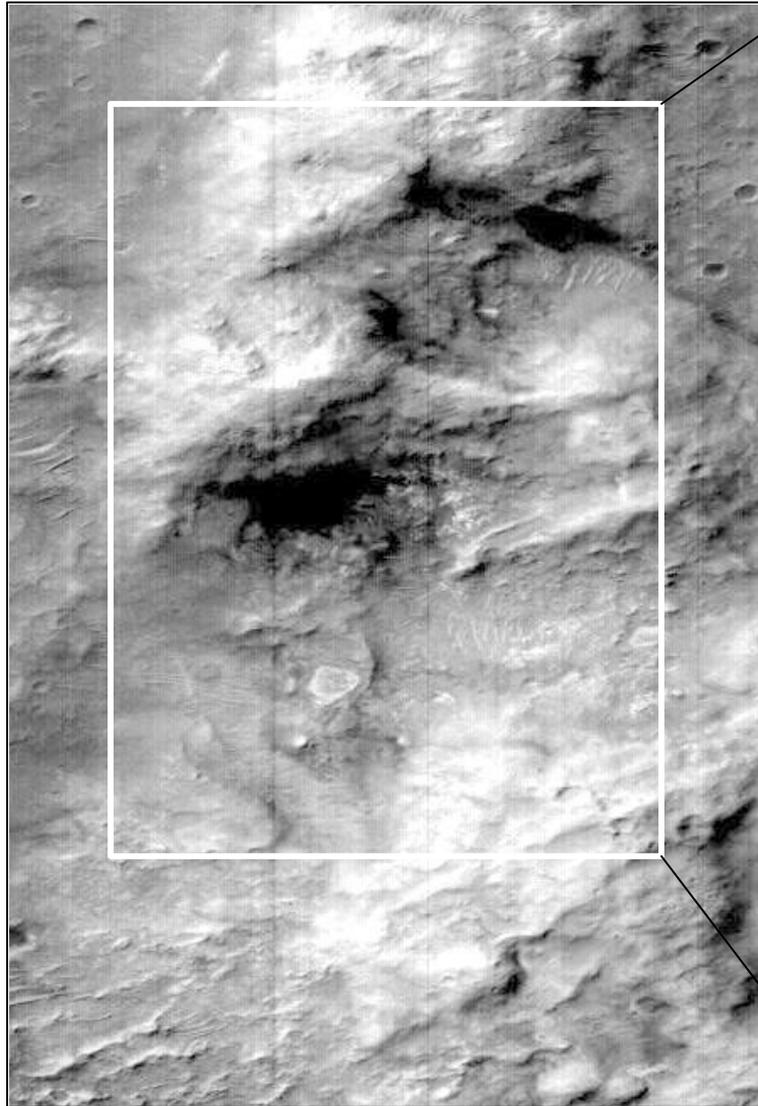


3.2: Flow Concentration in the Basin: Evidence from MOC

- Layers observed in central region of ellipse.
 - 40-m high hill shows many layers (last stage ~35m water depth. Island?) and abundant thin-layering in the basin.
- Candidate playas and evaporites in location where they are expected to be observed.
- Lake presence is also shown by:
 - Terraced Shorelines
 - Residual Shoreline Ridges

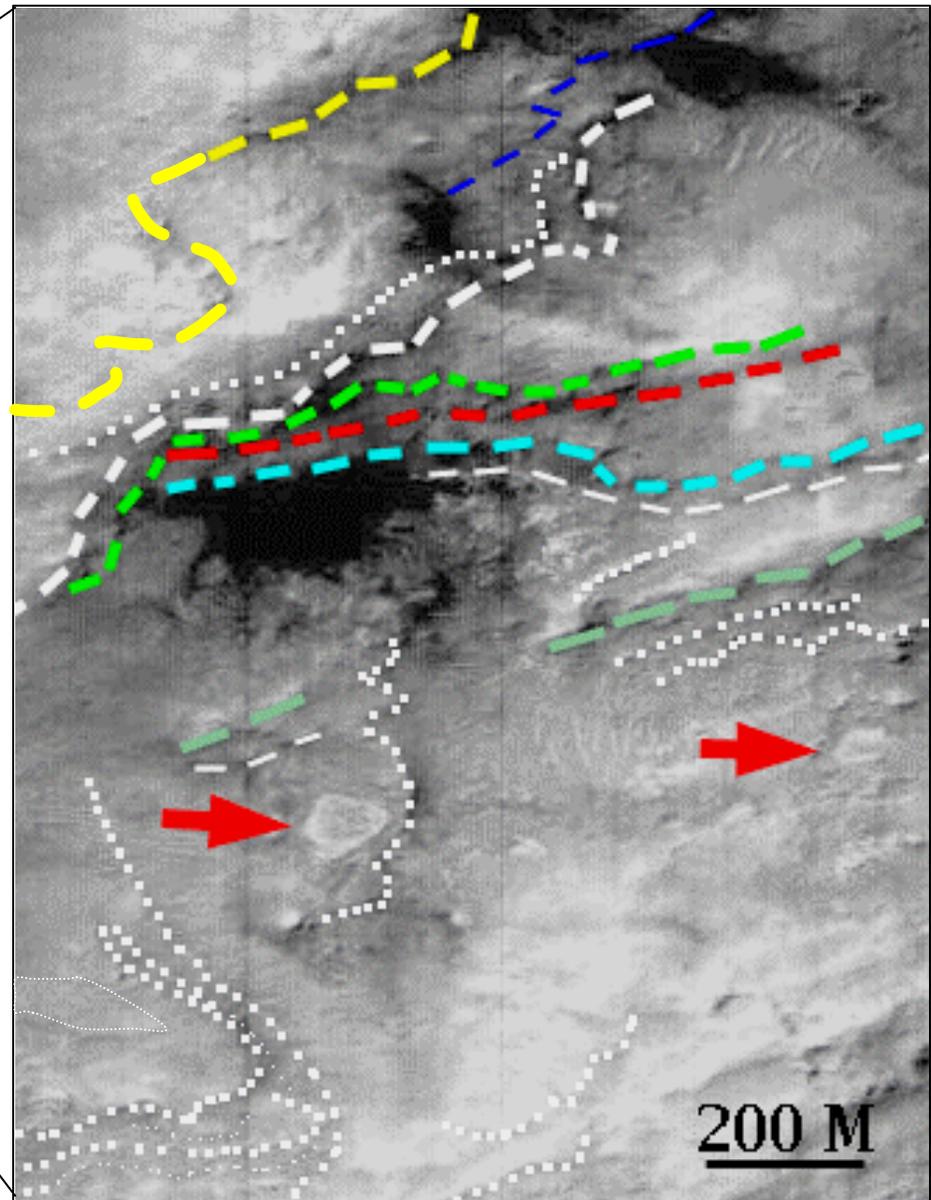
Layers

(Near center ellipse)



March 26-28, 2002

E03-00012



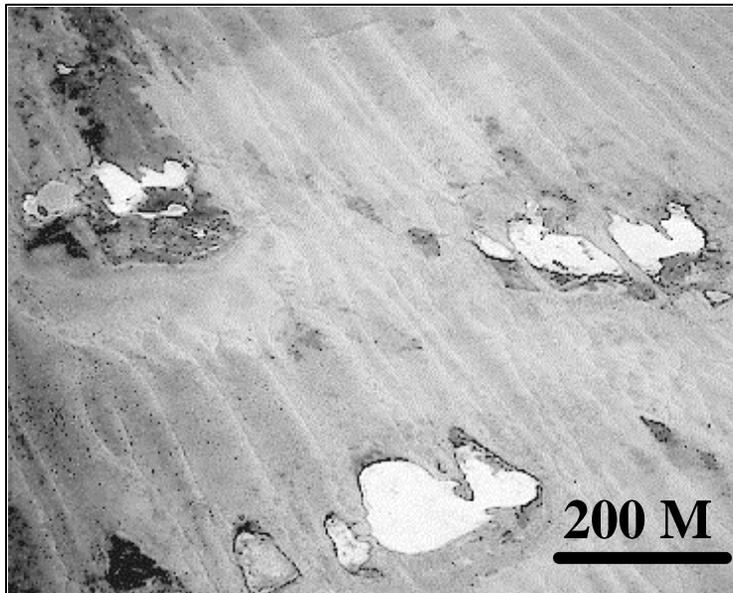
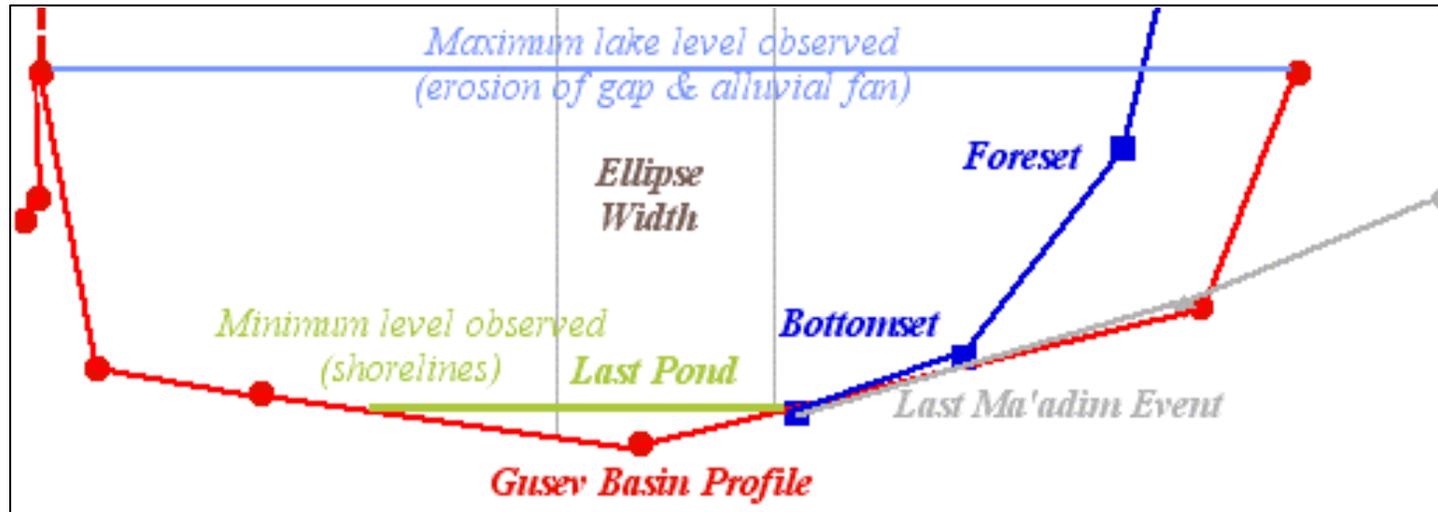
Gusev MER A

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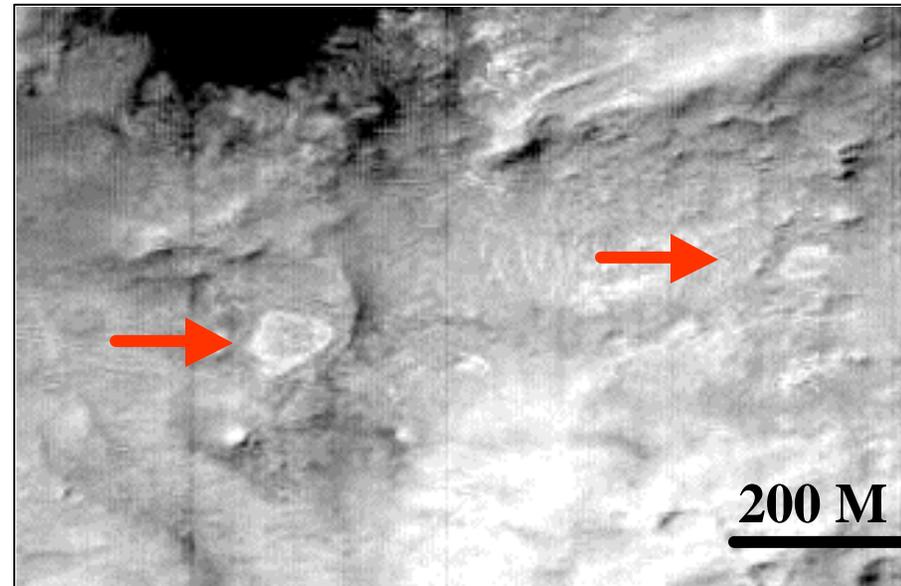
Playa & Evaporites?

E03-00012

(Near center ellipse)



March 26-28, 2002



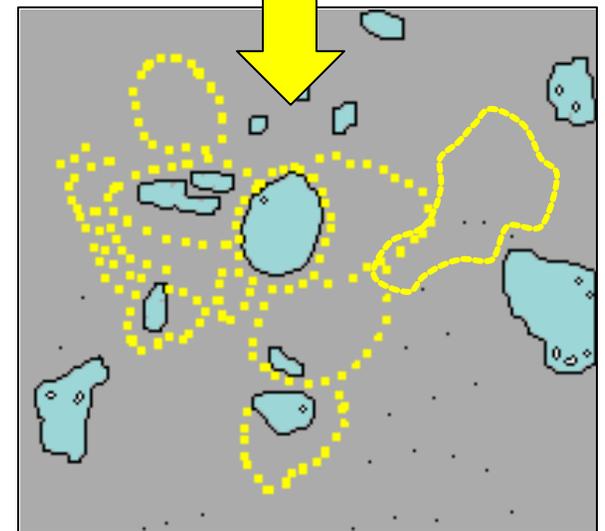
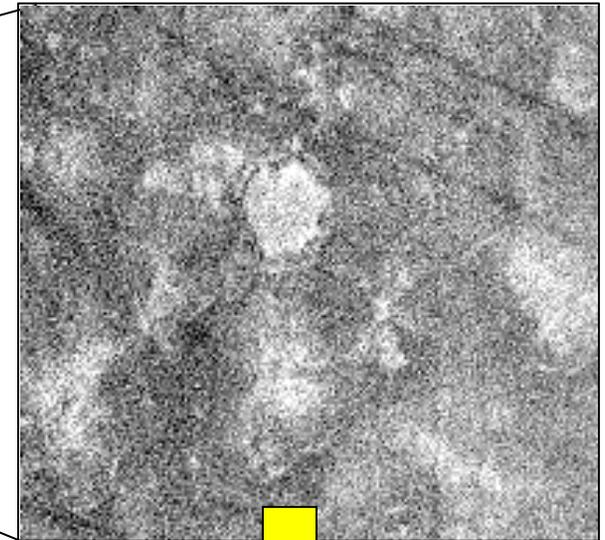
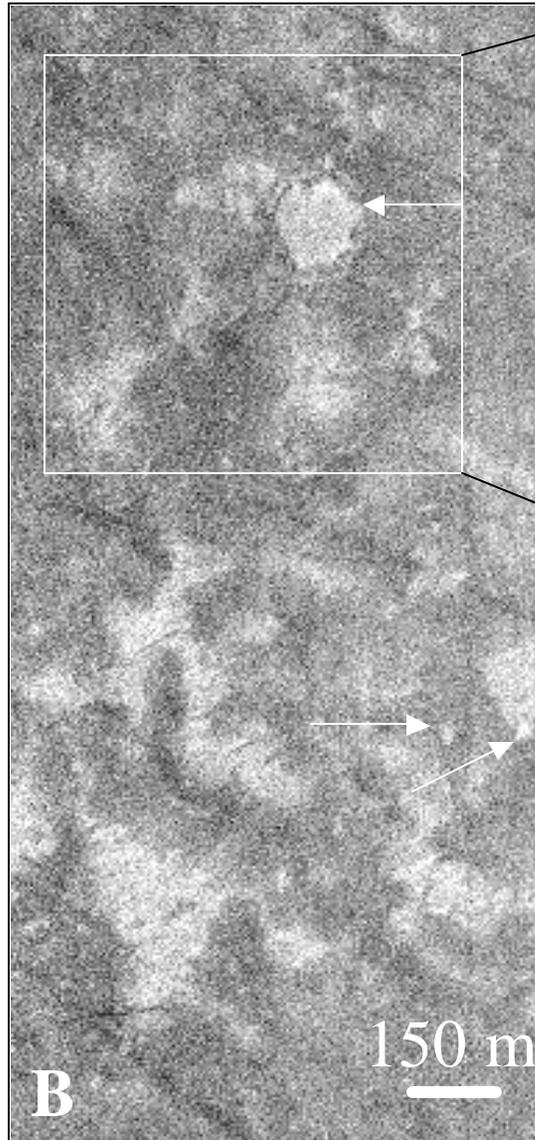
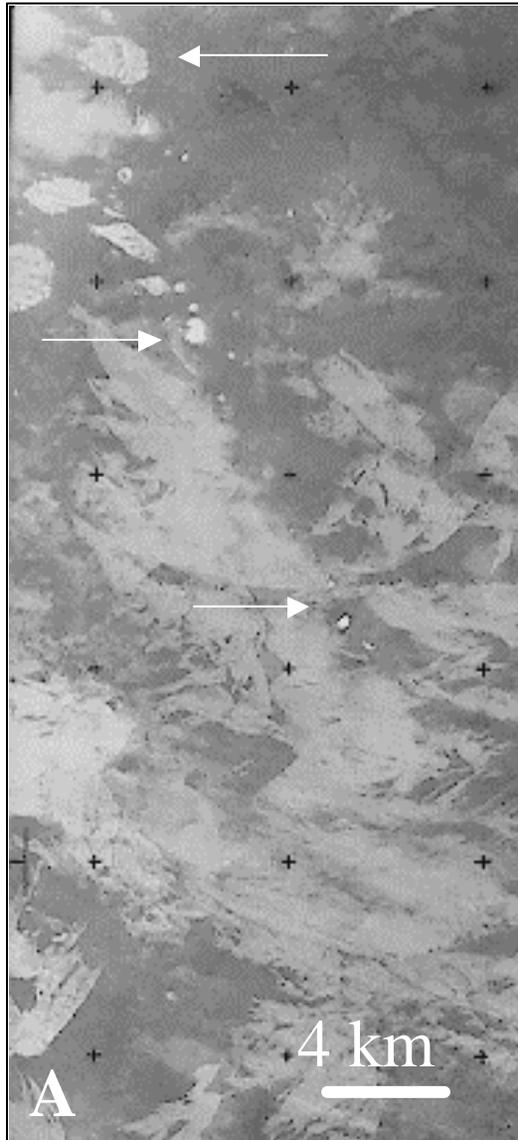
Gusev MER A

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Playa & Evaporites?

E12-02629

(Near center ellipse)



March 26-28, 2002

Gusev MER A

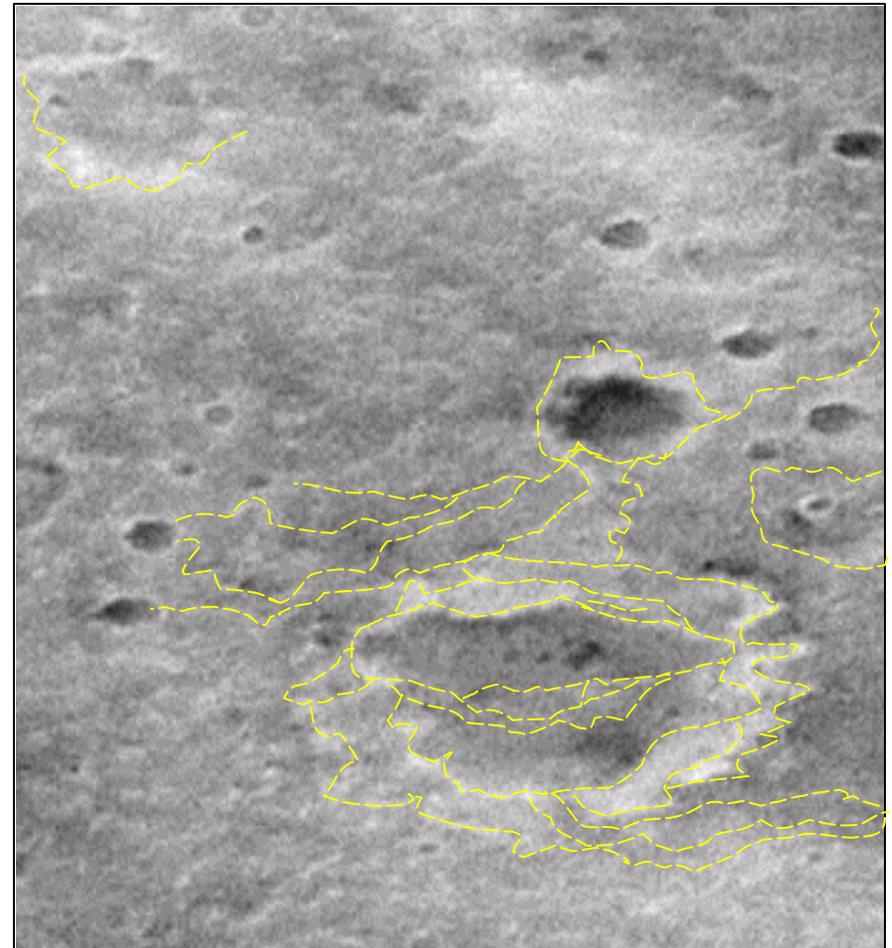
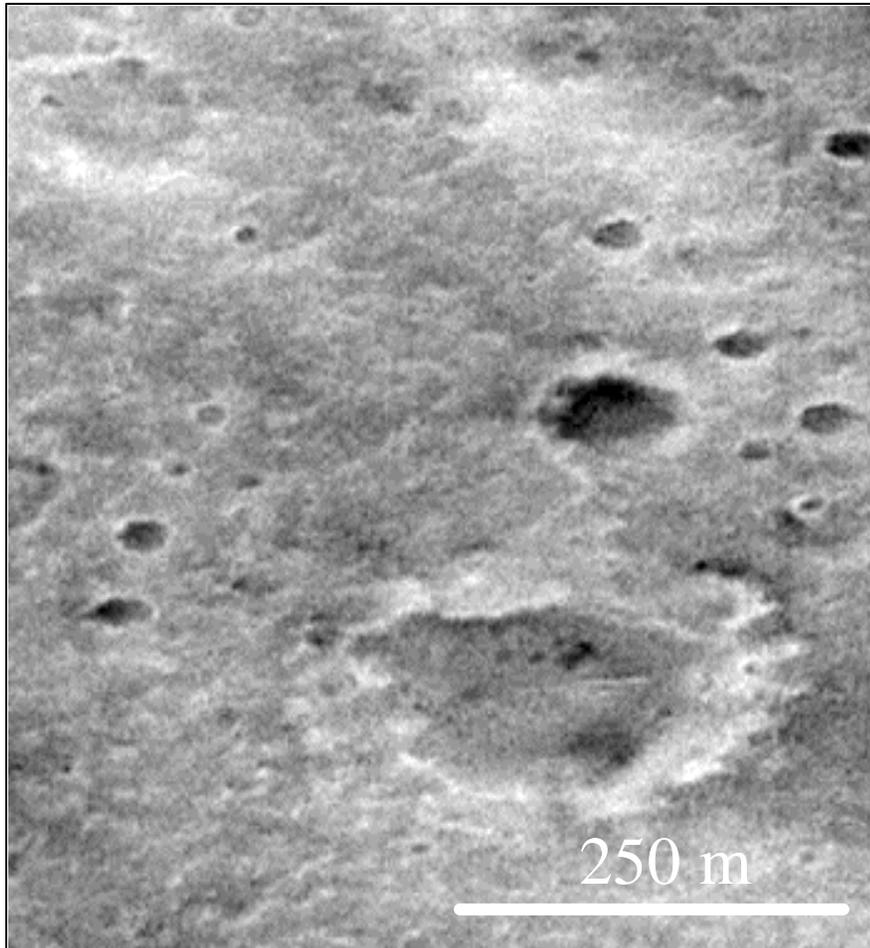
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Layers

E13-01593

(Playas & Evaporites?)

(Near center ellipse)

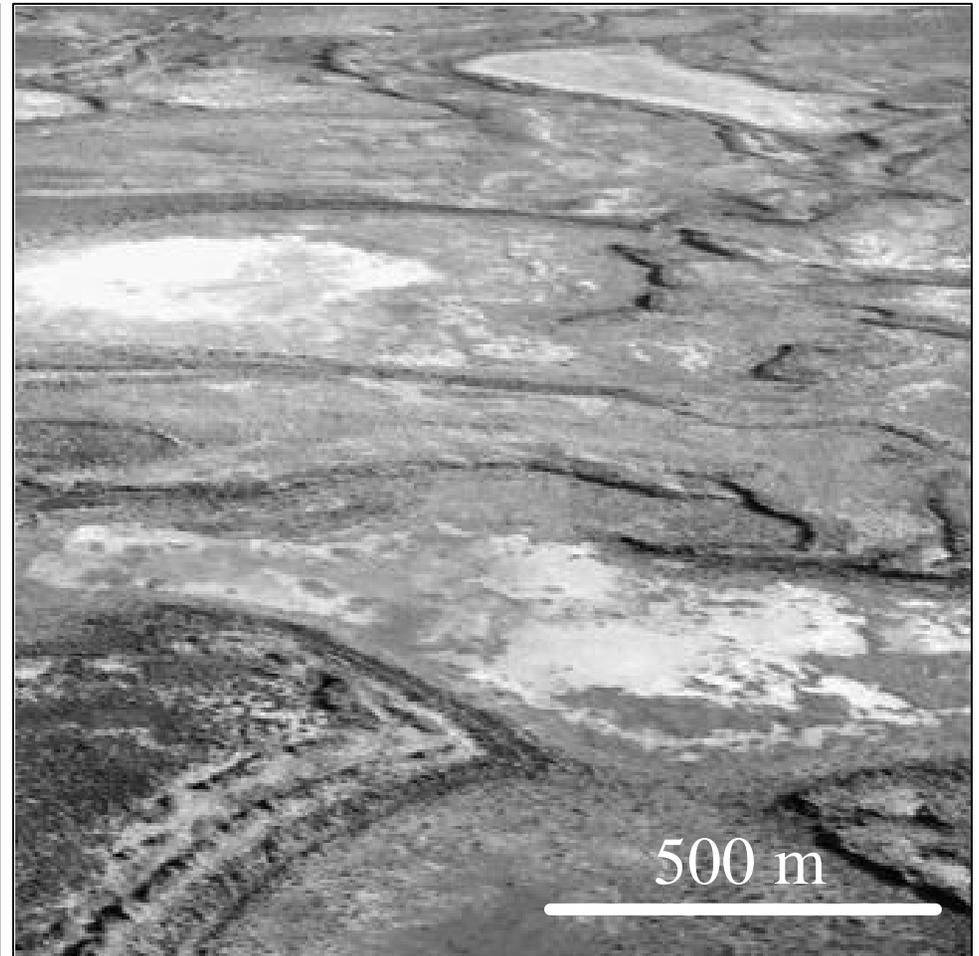
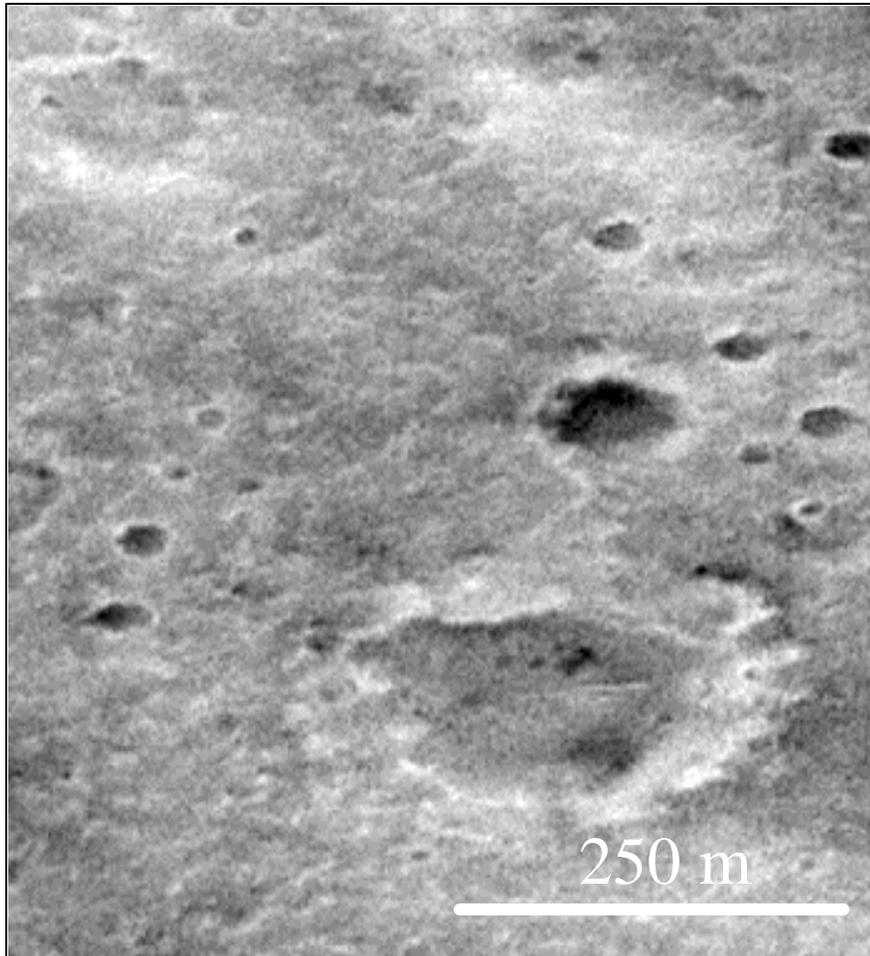


Layers

(Playas & Evaporites?)

(Near center ellipse)

E13-01593



March 26-28, 2002

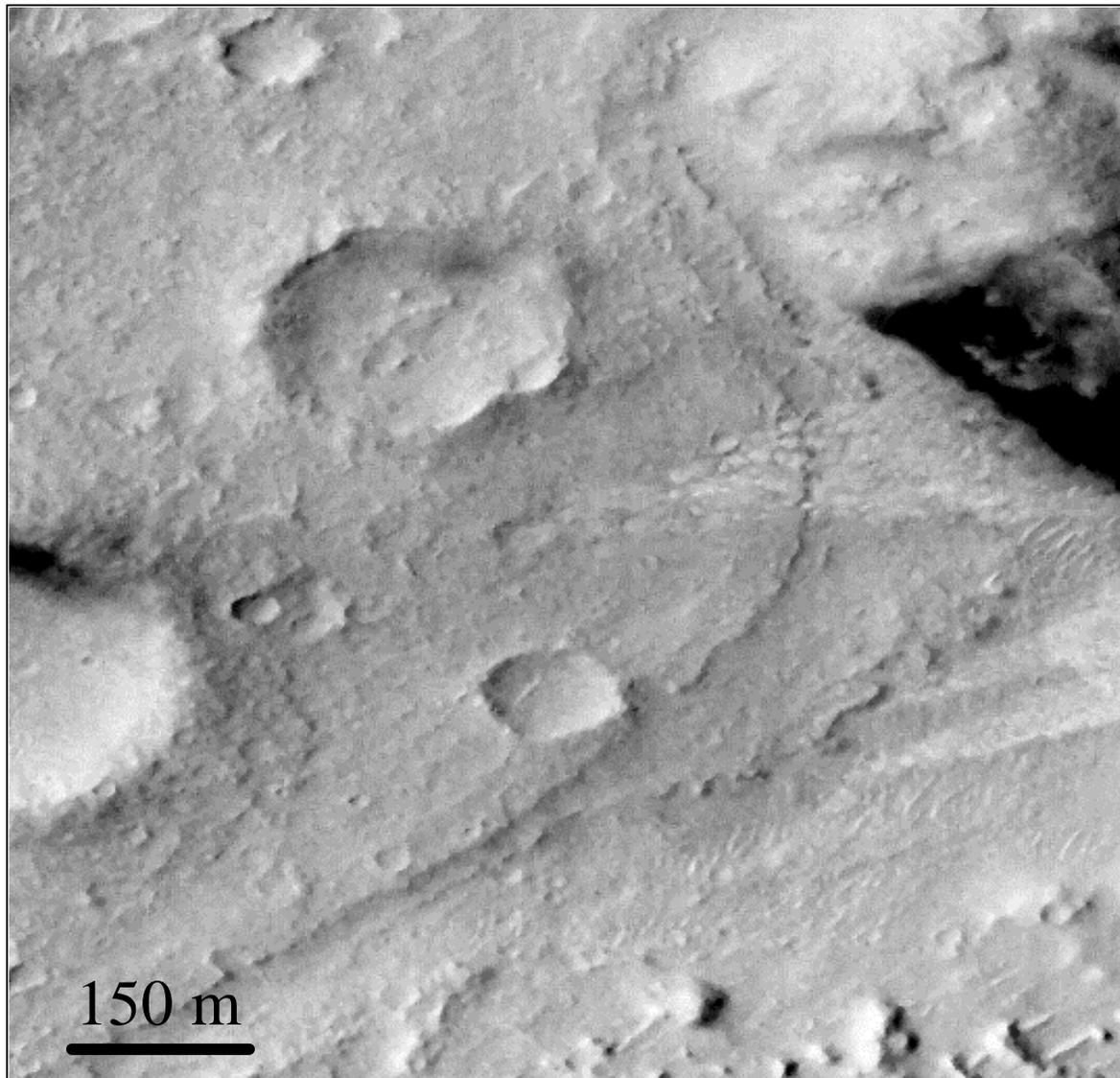
Gusev MER A

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Terraced Shorelines

E05-00471

(Eastern Margin of Ellipse)



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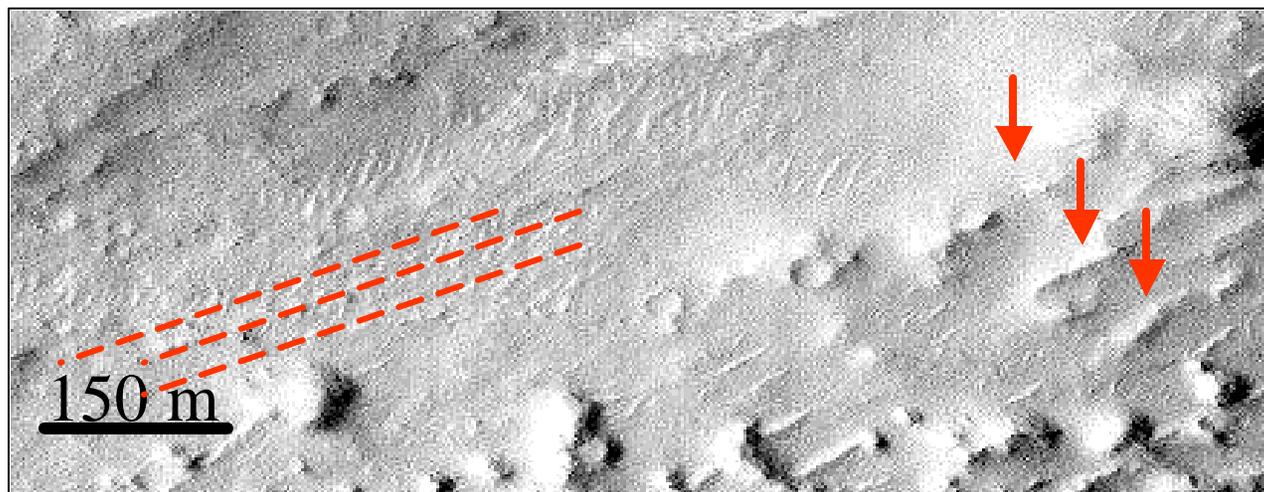
Gusev MER A

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Residual Shoreline Ridges

E05-00471

(Eastern Margin of Ellipse)





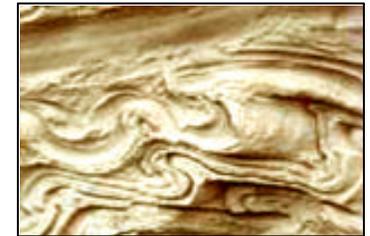
3.3 Conclusion on MGS Evidence

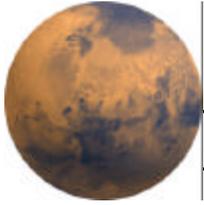
- Observations and measurements are consistent with the hypothesis of a series of lakes in Gusev.
- Presence of aqueous sedimentary layers definitely confirmed in the ellipse. Spectacular in central region.
- Presence of playas likely (THEMIS?). Deposits, albedo, erosion of material, and location in basin consistent with such hypothesis.



4.0 Examples of Testable Hypotheses by MER in Gusev with the Athena Science Payload

- ✘ Was there a series of lakes in Gusev?
 - ☺ Are sedimentary deposits aqueous in origin?
 - ☺ Were there episodes of ice-covered lakes?
 - ☺ Do sedimentary deposits reveal the relative duration of lake episodes and possibly climate changes?
- ✘ Was there variability in Ma'adim Vallis' regime?
- ✘ Are the bright albedo patches playas & evaporites?
- ✘ Was the environment favorable to pre-biotic and/or biotic processes and to the preservation of fossils?

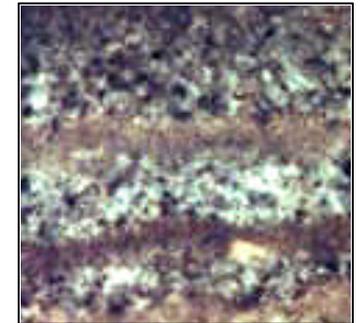
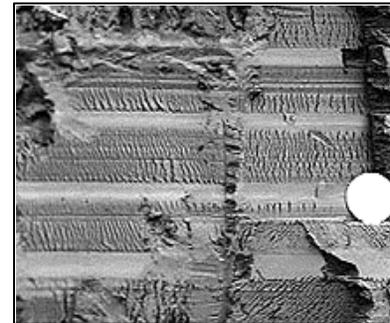




H1: Was there a series of lakes in Gusev?

- Instruments

- PanCam/Mini-TES: **Layers, varve thickness, sorting, rounding, grain-size, discontinuities in beddings, intermixing of material from different origins (i.e. dry cycles), morphology**
- MI: **thin varving, mud, clay/silt, cementation, microflame and convolution for glacial lake sediments)**
- APXS: **role of water activity**
- Mössbauer: **presence of carbonates, sulfates, nitrates in ponding environment?**
- Raman: **Aqueous minerals**
- Mini Corer: **Study sequences**



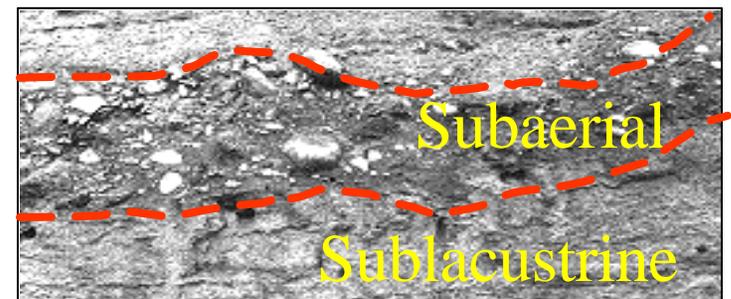
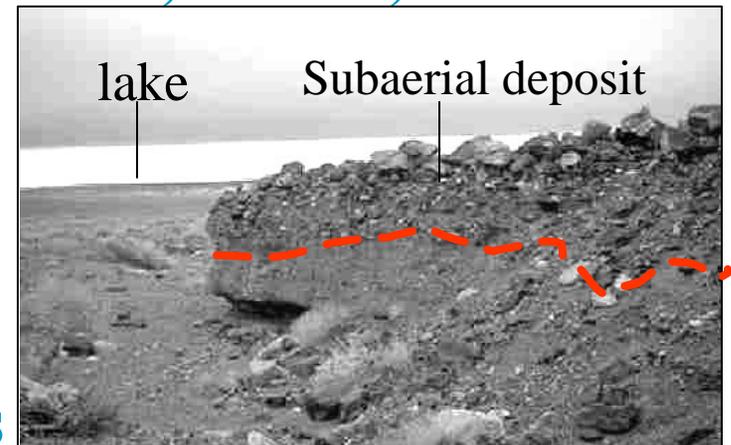


H2: Variability in Ma'adim's Regime?

✉ *Climate Change*

- Instruments

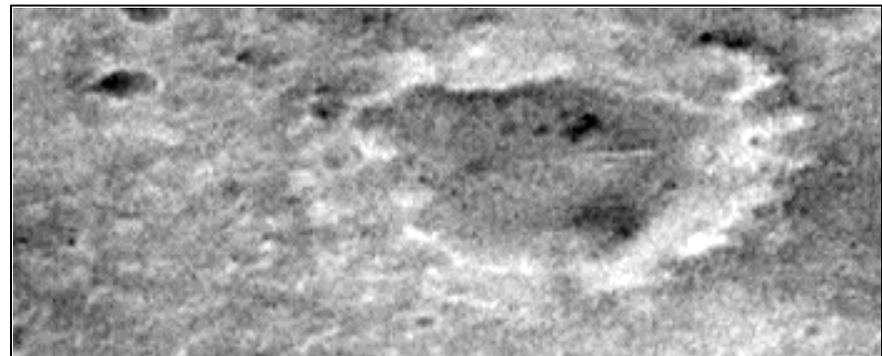
- PanCam/Mini-TES: **deposit morphology & composition, sorting of grains, angularity, roundness, matrix, lamination, varves...**
- MI: **microvarves/massive deposits**
- APXS: **Weathering processes**
- Mössbauer: **alteration of material under different climate conditions**
- Raman: **Aqueous minerals**





H3: Are the bright albedo patches playas & evaporites?

- Instruments
 - PanCam/Mini-TES: **deposit morphology (i.e., salt rings, layers) and composition, albedo,**
 - MI: **cements, grain-size and morphology as indicators of processes, precipitation, crystallization**
 - APXS: **Weathering processes**
 - Mössbauer: **role of water in mineral's formation**
 - Raman: **Aqueous minerals**

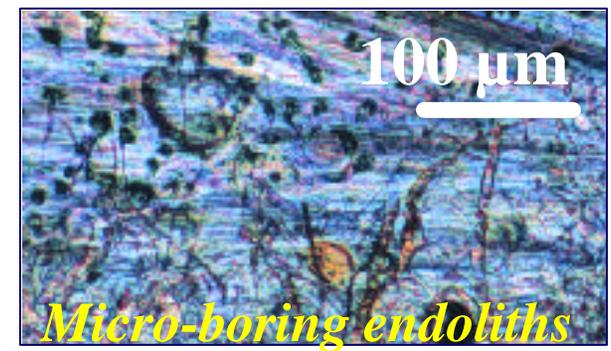
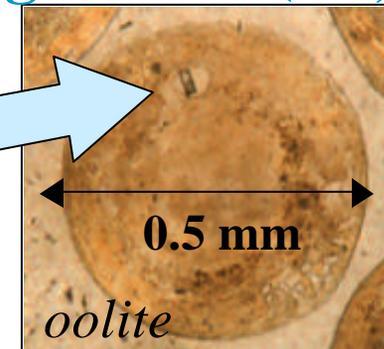




H4: Was the environment favorable to pre-biotic and/or biotic processes & preservation of fossils?

- Instruments

- PanCam/Mini-TES: **morphology of biosignatures (i.e., biokarst, biopatterns) & composition**
- **MI: i.e., microfossils, endoliths...**
- APXS: **Water activity**
- Mössbauer: **identify Fe-carbonates, sulfates, nitrates, and minerals that could preserve early environmental and biological evidence**
- Raman: **Aqueous minerals**



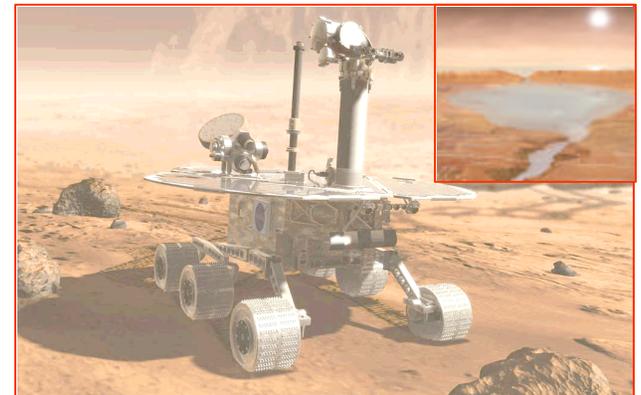


Conclusions

- **Top relevance of Gusev to the 2003 MER mission.**

- Unique primary site to document *all* science questions of MER

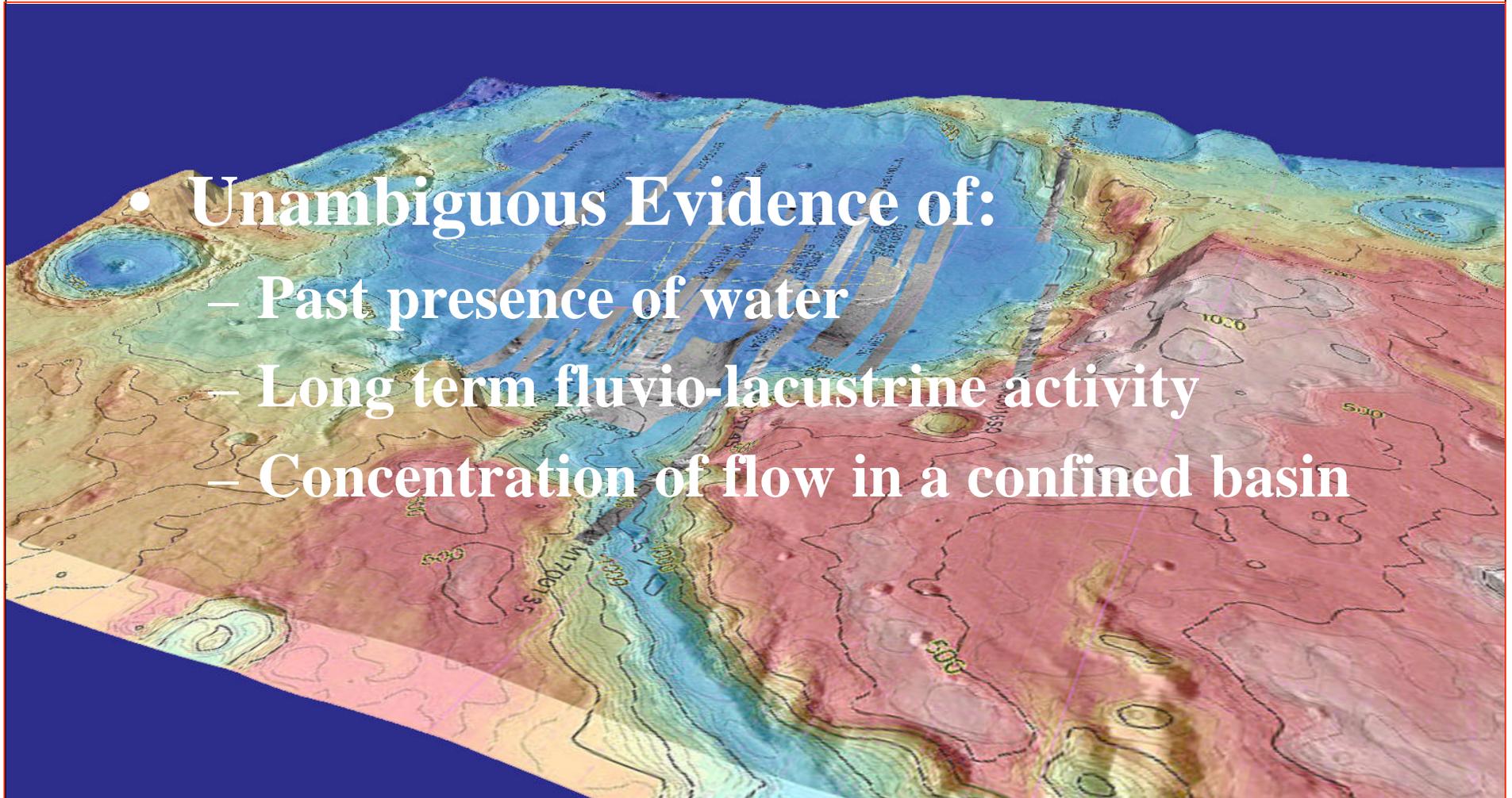
- *Water*
- *Geology & Sedimentary history*
- *Climate*
- *Life*





Conclusion: Addressing the Question of **Water**

- Unambiguous Evidence of:
 - Past presence of water
 - Long term fluvio-lacustrine activity
 - Concentration of flow in a confined basin





Conclusion:

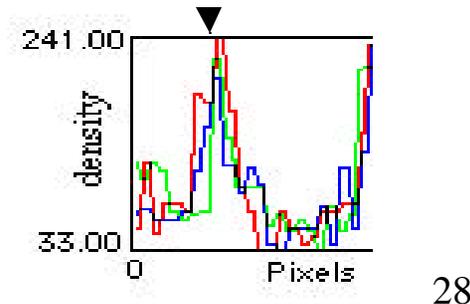
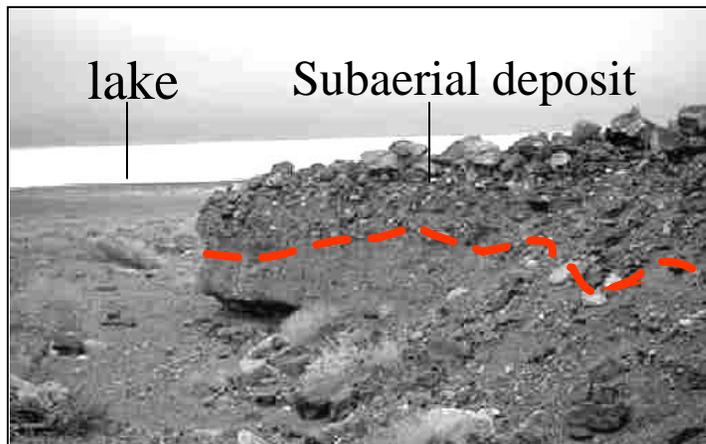
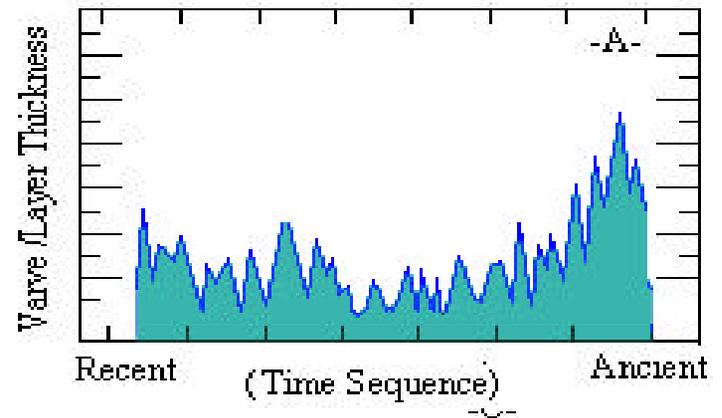
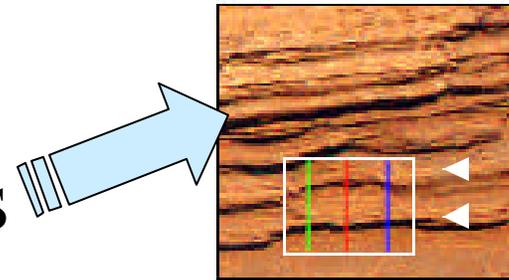
Addressing the **Geological History**

- Aqueous geology and morphology
- Rhythmites (aqueous, aeolian, volcanic -- ashes and pyroclasts from Apollinaris Patera ?), layers & varves
- Sediment mineralogy
- Flow deposit morphology and composition
- Other? (Glacial episodes?)



Conclusion: Addressing the **Climate History**

- Rhythmites, layers & varves
- Sediment mineralogy
- Flow morphology



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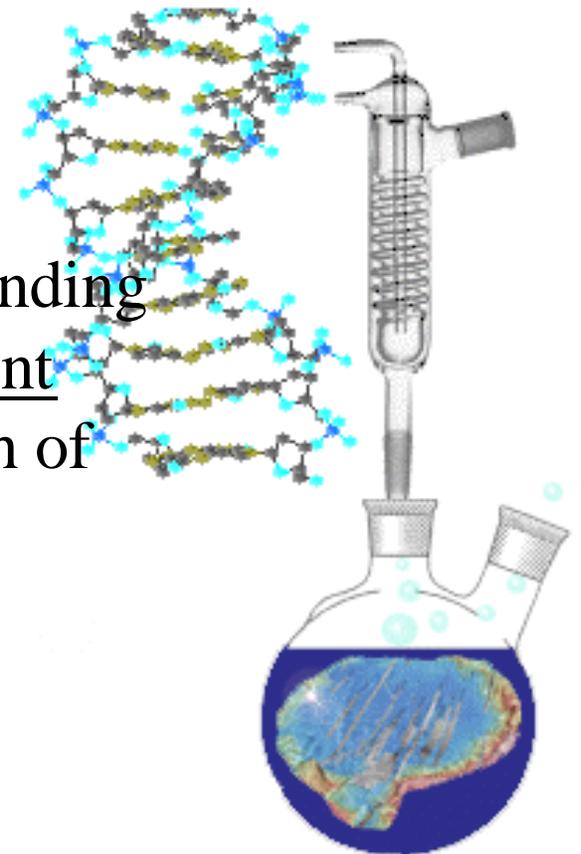
Gusev MER A

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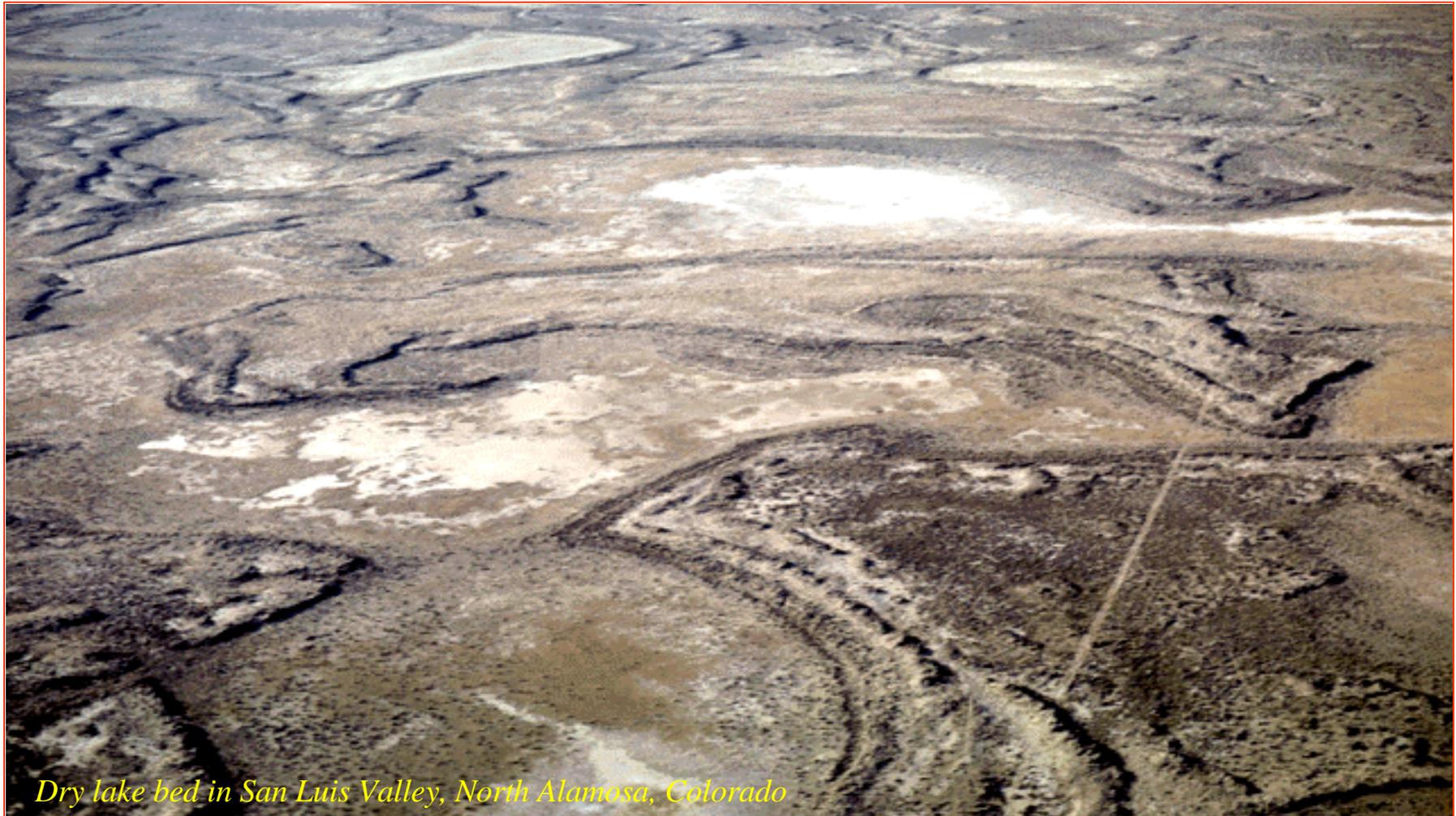
Conclusion: Addressing the Question of Life

- Long term fluvio-lacustrine history
- Concentration of flow in a confined basin
- Fossilization processes favored in lakes. Landing ellipse in distal end of delta and deepest point of the lake. Optimum location for the search of fossils (Farmer, 1995).
- Exposures and candidate-evaporites





Conclusion: Training in Terrestrial Analogs



Dry lake bed in San Luis Valley, North Alamosa, Colorado



Conclusion: Public Engagement

- **View of layered hills, possibly evaporites, ancient shores.**
- **Site of ancient calm ponding waters. Very different from VL and MPF.**
- **An exciting perspective for the search for life. Possibly the best of the four primary sites.**
- **Rivers and lakes are easily explainable to the public and fascinate children. Modeling of delta, fossil hunt.**
- **Moreover, Gusev has been (and is still) being used by public, schools & universities for projects about Mars exploration & search for life. More than 1000 websites showcase it.**
Gusev is not an anonymous site to the public and kids.

