Eberswalde Crater

Learning to read the fluvial system

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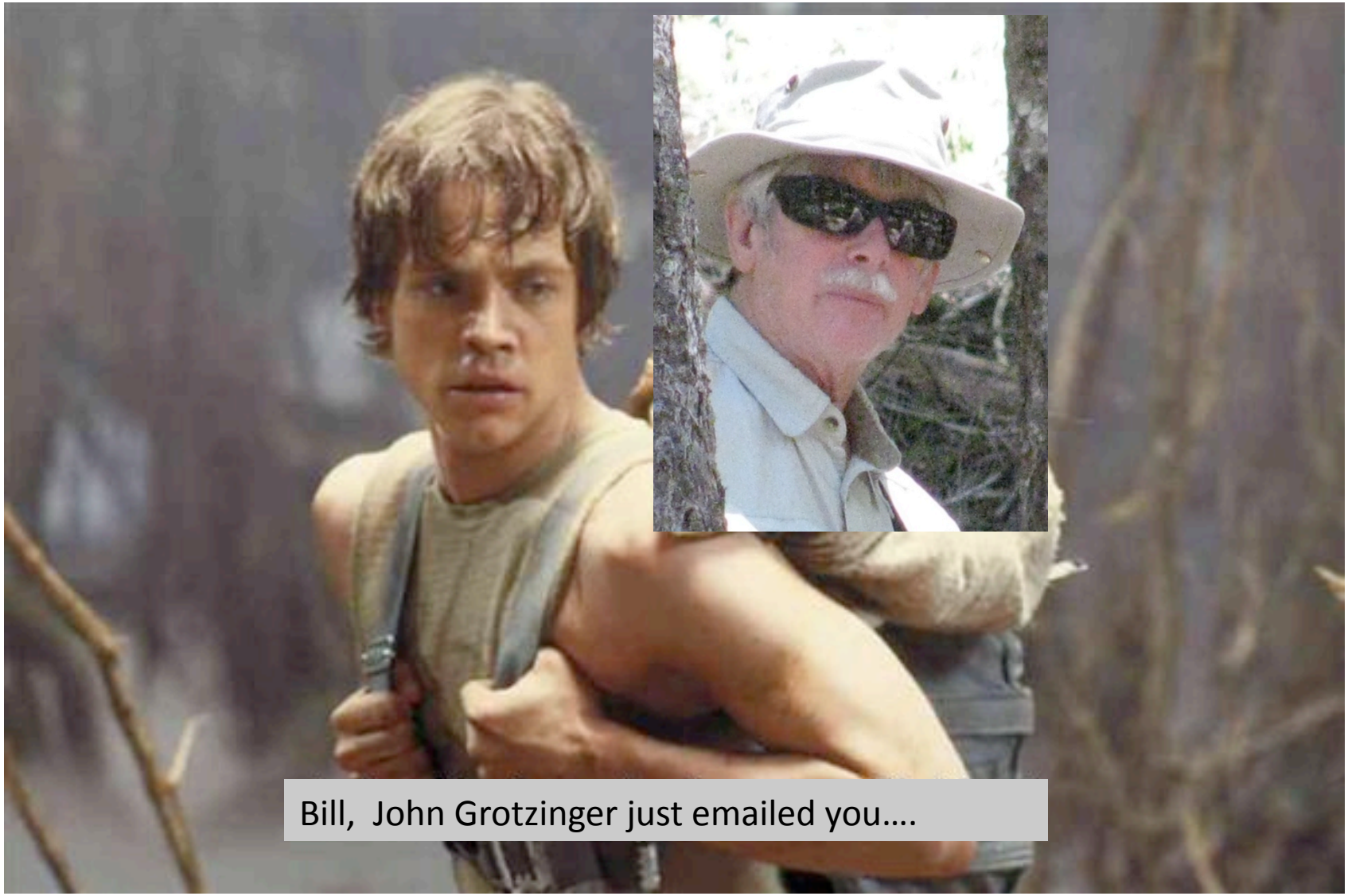


With guidance from Melissa Rice, Kevin Lewis, Sanjeev Gupta, Edwin Kite and Alan Howard

Eberswalde Crater:

•**A Source- to Sink site**.

what does this mean:

*well defined drainage area

*well defined deposits (and deeply exposed) derived from that known drainage area

Hence we can interpret deposit characteristics in terms of sediment production, transport and deposit processes and infer relative importance of weathering through time.

***This means deposits can be used to guide development of mechanistic models for the hydrologic (and climatic), sedimentologic and geomorphic evolution of the site**.

"Context is everything" Roger Summons, Sept 27, 2010

Significant increase in evidence of drainage channels, fans, and well-developed stratigraphy in Eberswalde

•Growing evidence that the crater did have a lake(s)

•Growing evidence that major deposit is a delta- not a erosional remnant of a terrestrial fan

•No evidence that the delta was significantly more extensive than now

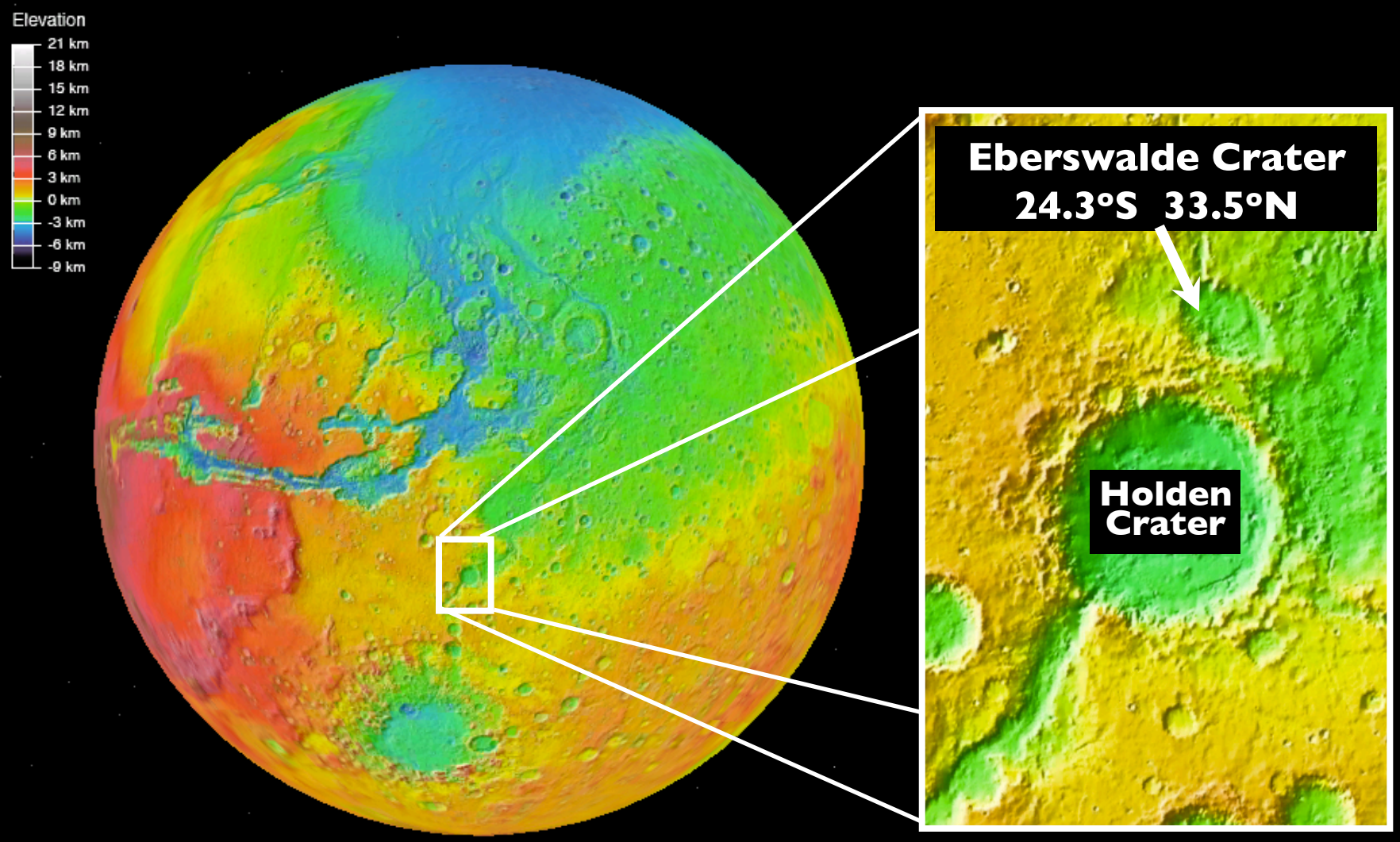
River channels provide unique and essential information:

•River channels provide the only information on rates of surface runoff but *without ground observations these observations will be order of magnitude only*

•Fluvial features occur at Gale and Holden (and many places on Mars) and *rover-based observations* should provide key observations to understand their origin and controls. This will guide interpretation of channels elsewhere but also should provide significant information about Mars climate, hydrology, and geochemistry.

•Downstream river morphologic change may indicate fluvial transition to deltaic conditions

Eberswalde Crater Location



Eberswalde post-dates 2 large impact basins, pre-dates Holden Crater, and has Holden ejecta in it (*K. Edgett*)

Notes:

Where it occurs in Eberswalde, the Holden Crater ejecta blanket would likely include materials disrupted by the Eberswalde impact and materials deposited in the earlier "Holden Basin". As you will see in Melissa Rice's presentation today, MSL would have access to this material in the Eberswalde landing ellipse.

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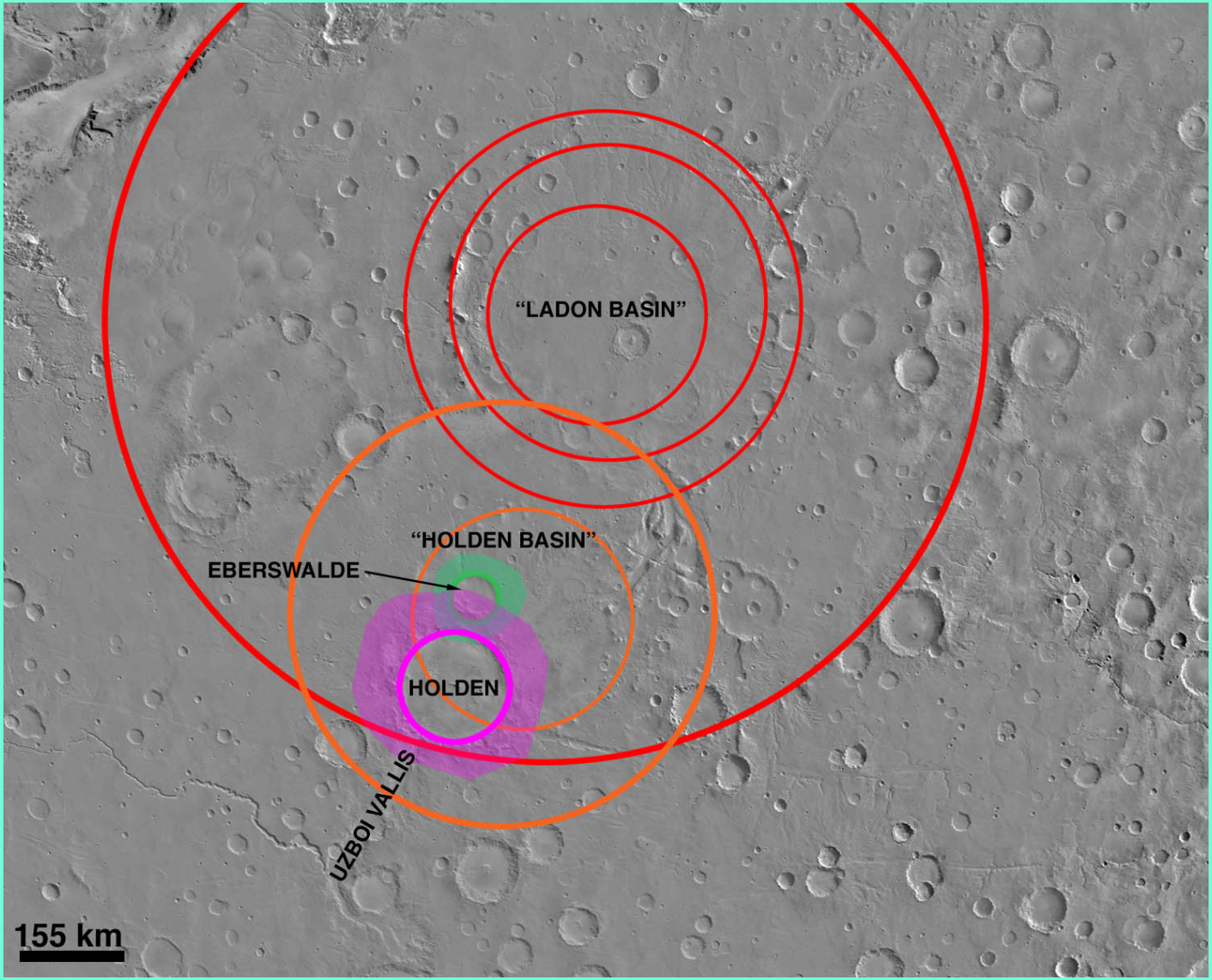


1)A large, multi-ringed impact basin (informally named "Ladon Basin") formed.

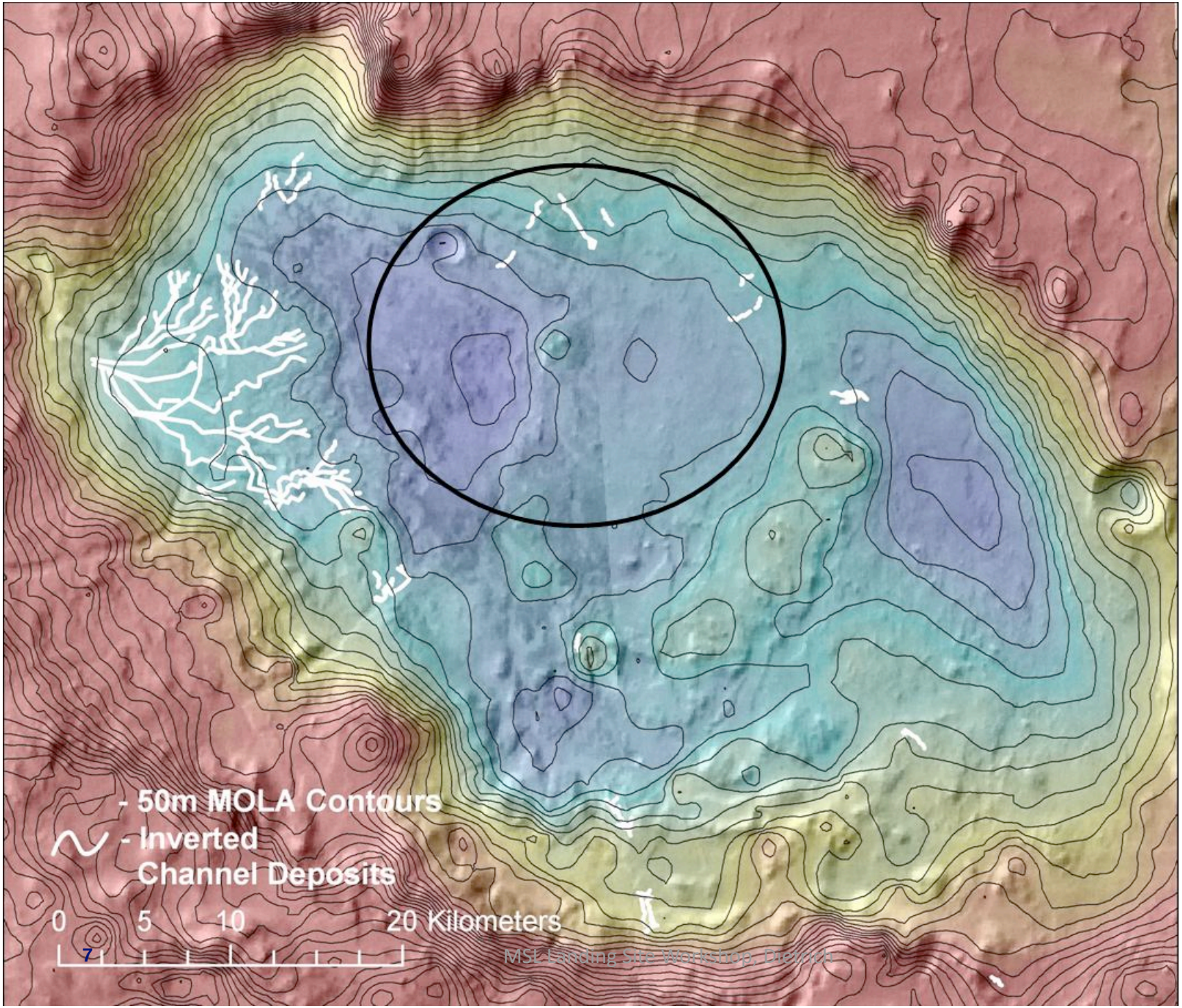
2)While "Ladon Basin" was undergoing modification(erosion, in-filling, and cratering), a new, smaller multi-ringed basin formed (informally named "Holden Basin").

3)Some time later, one of the many craters that superposed the eroding and in-filling "Holden Basin" was Eberswalde.

4)Still later, Holden Crater formed and some of its ejecta went into Eberswalde.

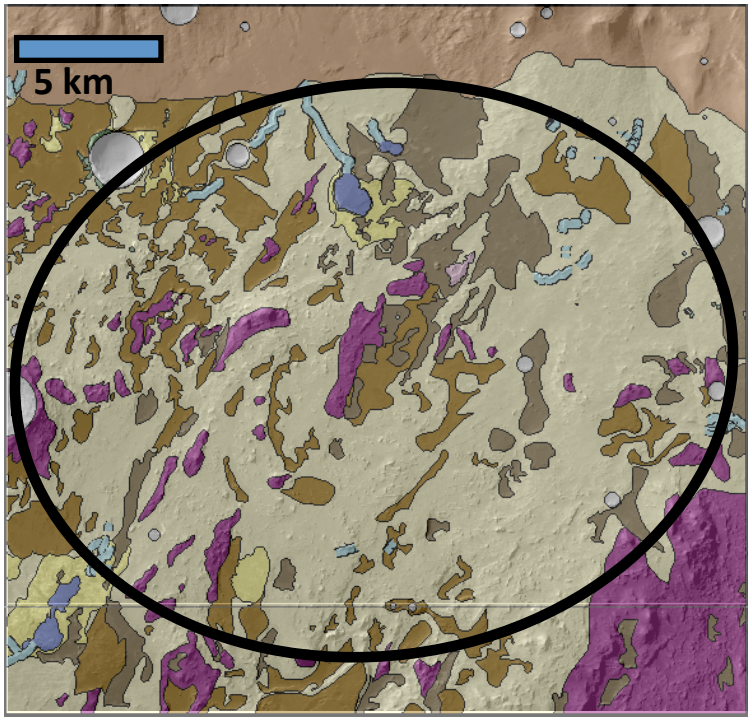
5)Even later, Uzboi Vallis entered Holden and there was a catastrophic flood.

6)Meanwhile, the delta in Eberswalde was forming.


- 50m MOLA Contours
- Inverted
Channel Deposits
0
5
10
20 Kilometers

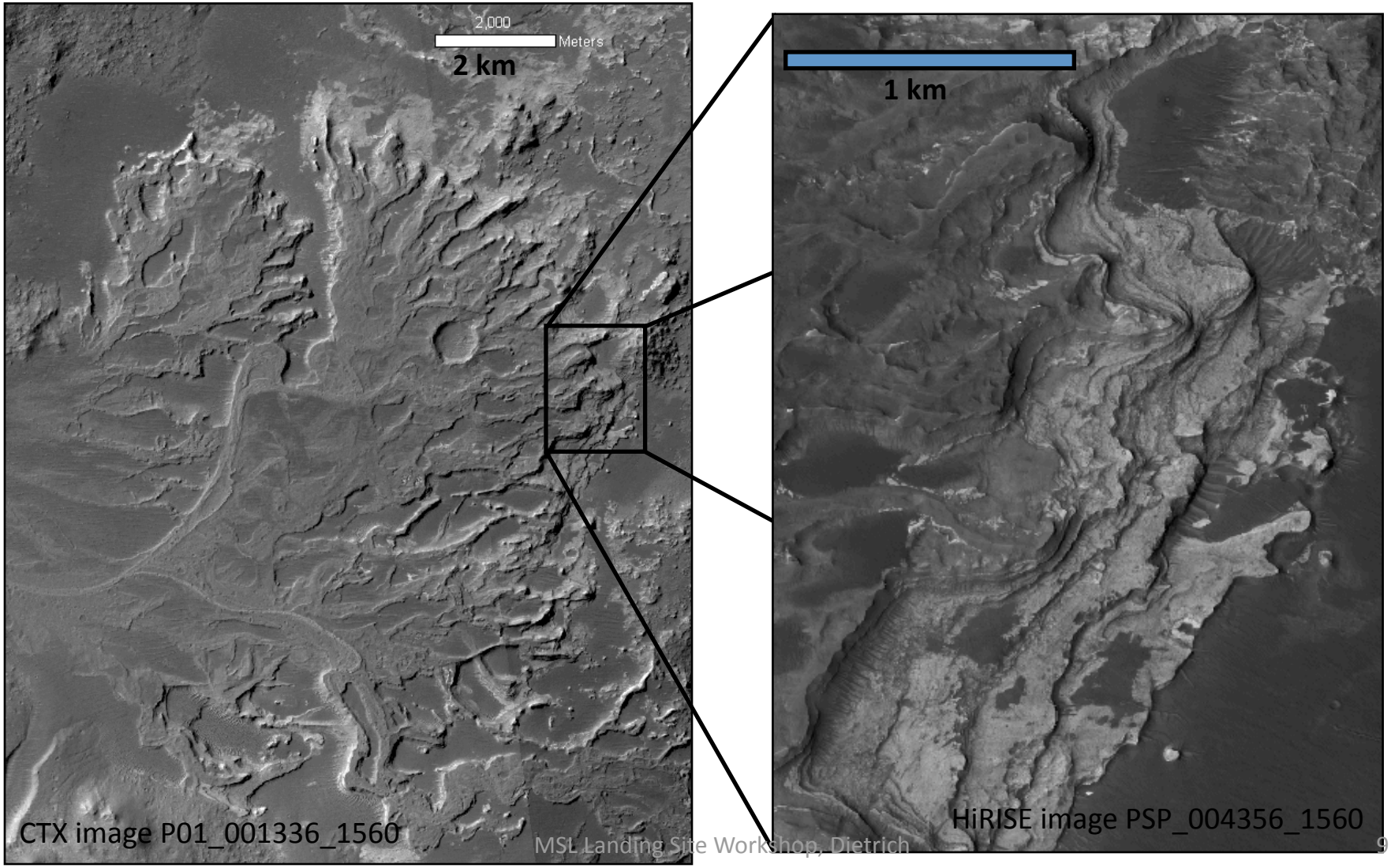
Geologic mapping of Ellipse

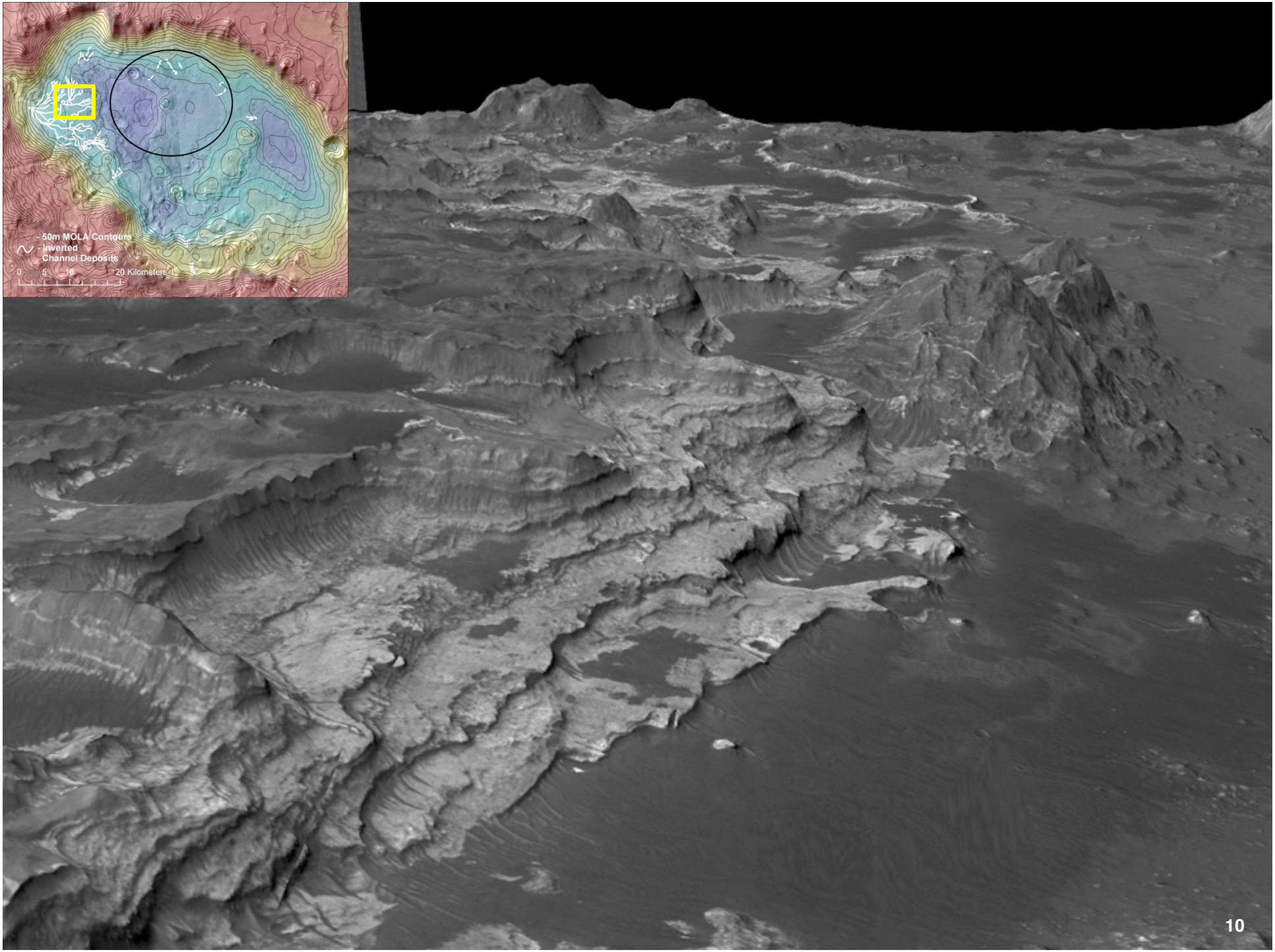
New Geomorphic Unit Map
Rice *et al.* (2010)

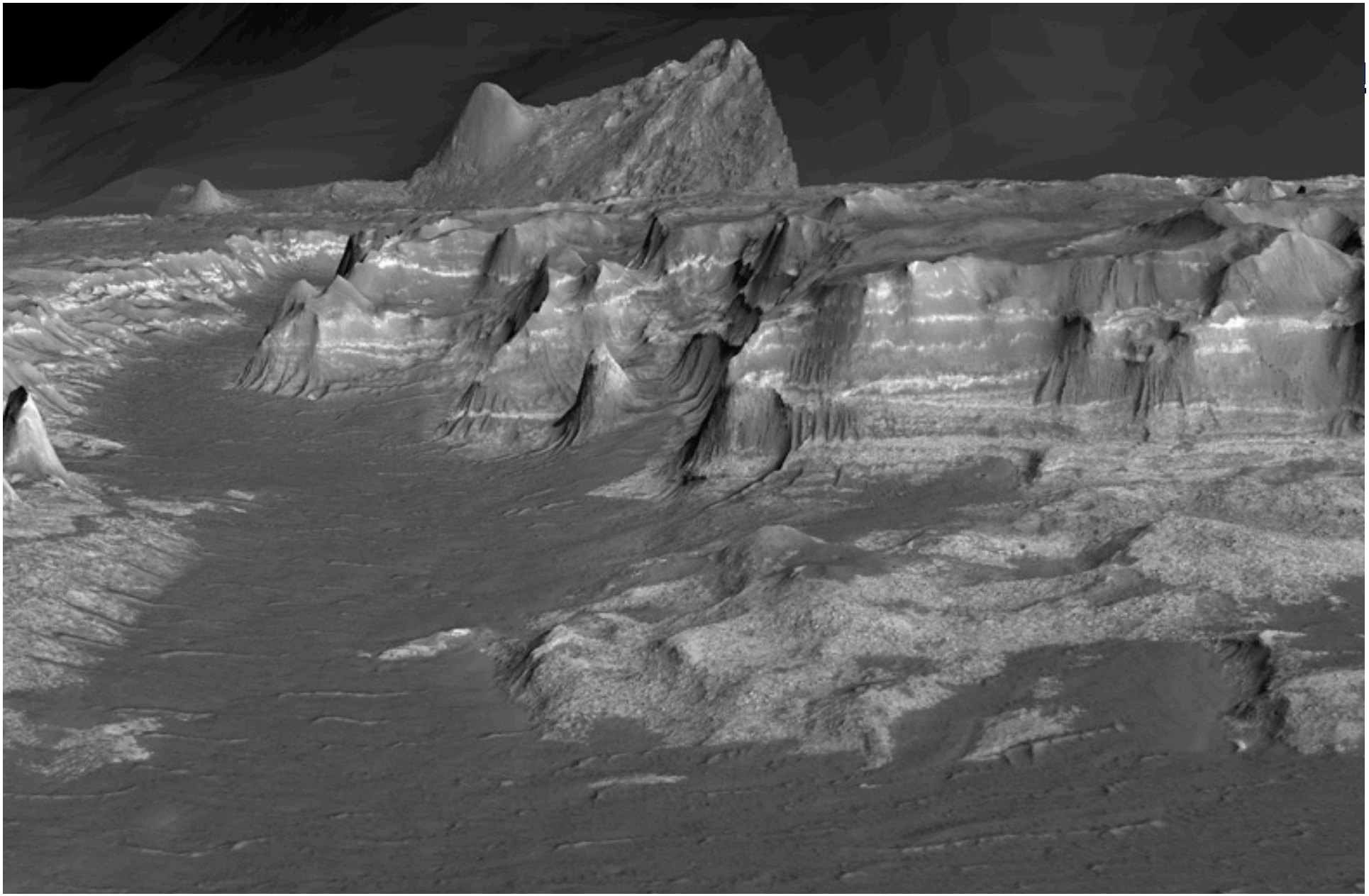


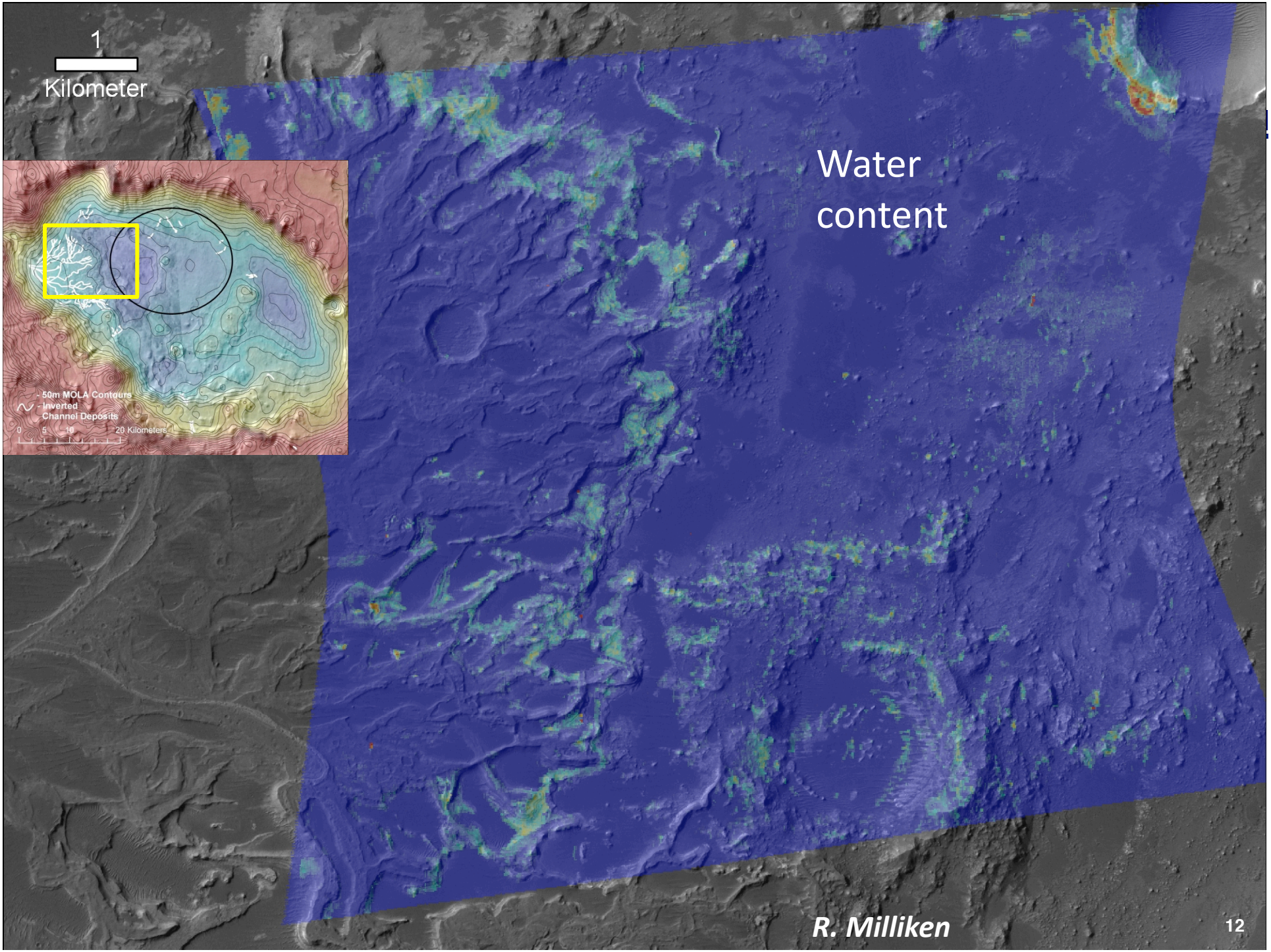
- Mass wasting deposits
- Aeolian bedforms
- Mantling unit
- Layered lobate features
- Sinuous ridges
- Layered light-toned unit
- Fractured light-toned unit
- Discontinuous light-toned unit
- Brecciated ridge-forming unit

Eberswalde “Delta”: The opportunity

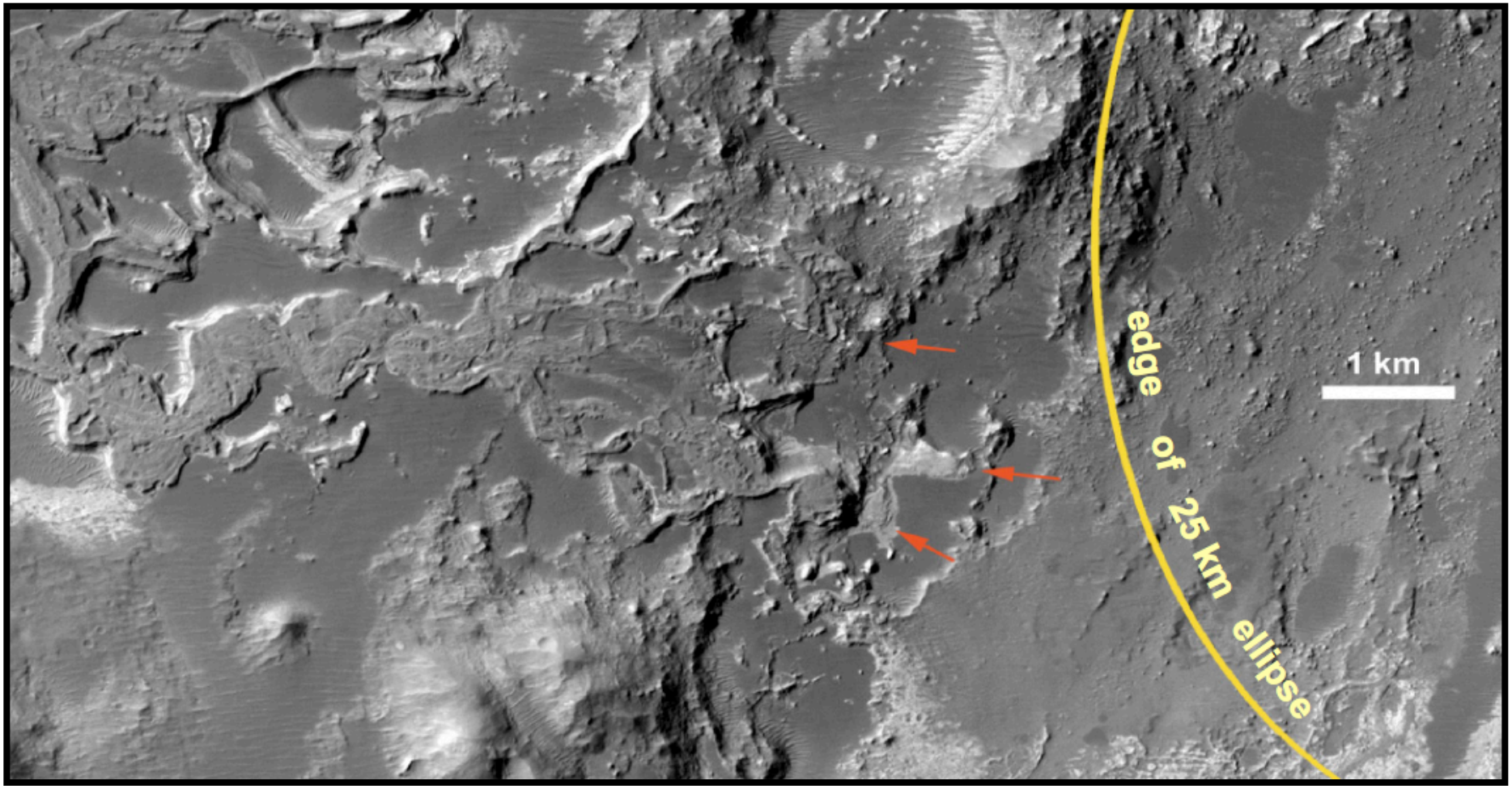



- 50m MOLA Contours
- Inverted
Channel Deposits
0 5 10 20 Kilometers

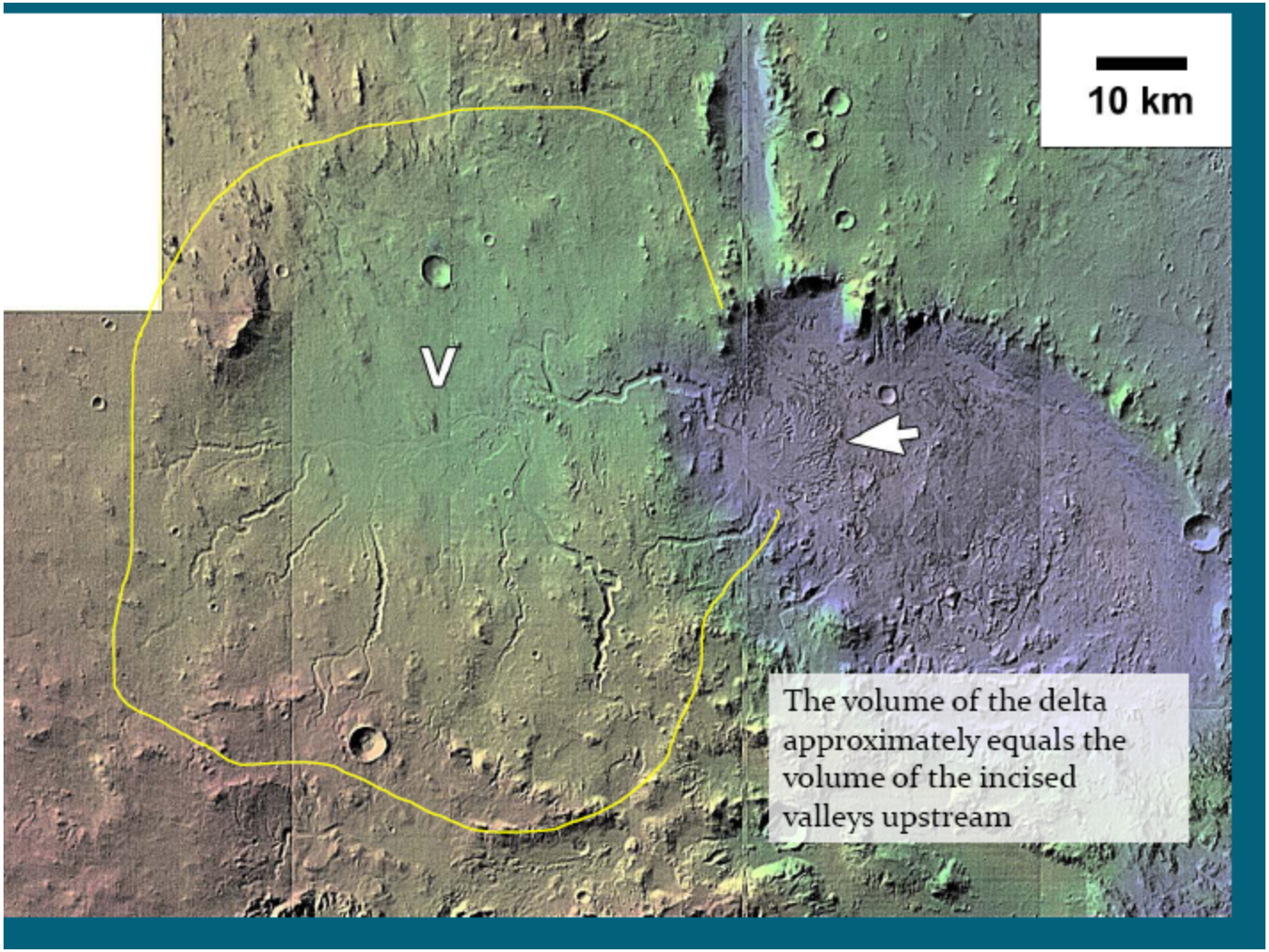


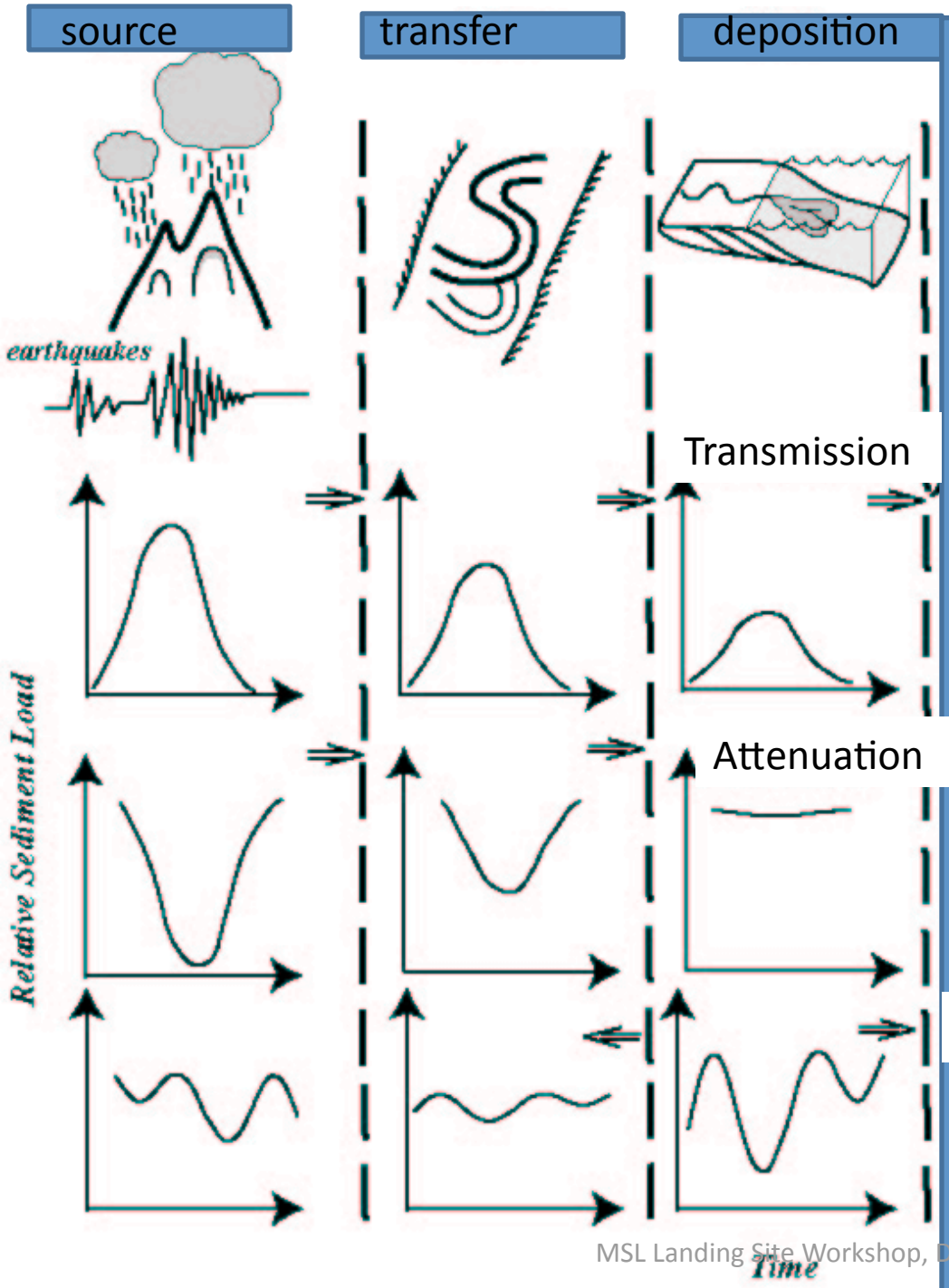

1
Kilometer
Water
content
- 50m MOLA Contours
- Inverted
Channel Deposits
0 5 10 20 Kilometers
R. Milliken

closest delta deposits to landing site:
1-2 km from edge of ellipse



From Jim Rice's 3rd Landing Site Workshop Presentation

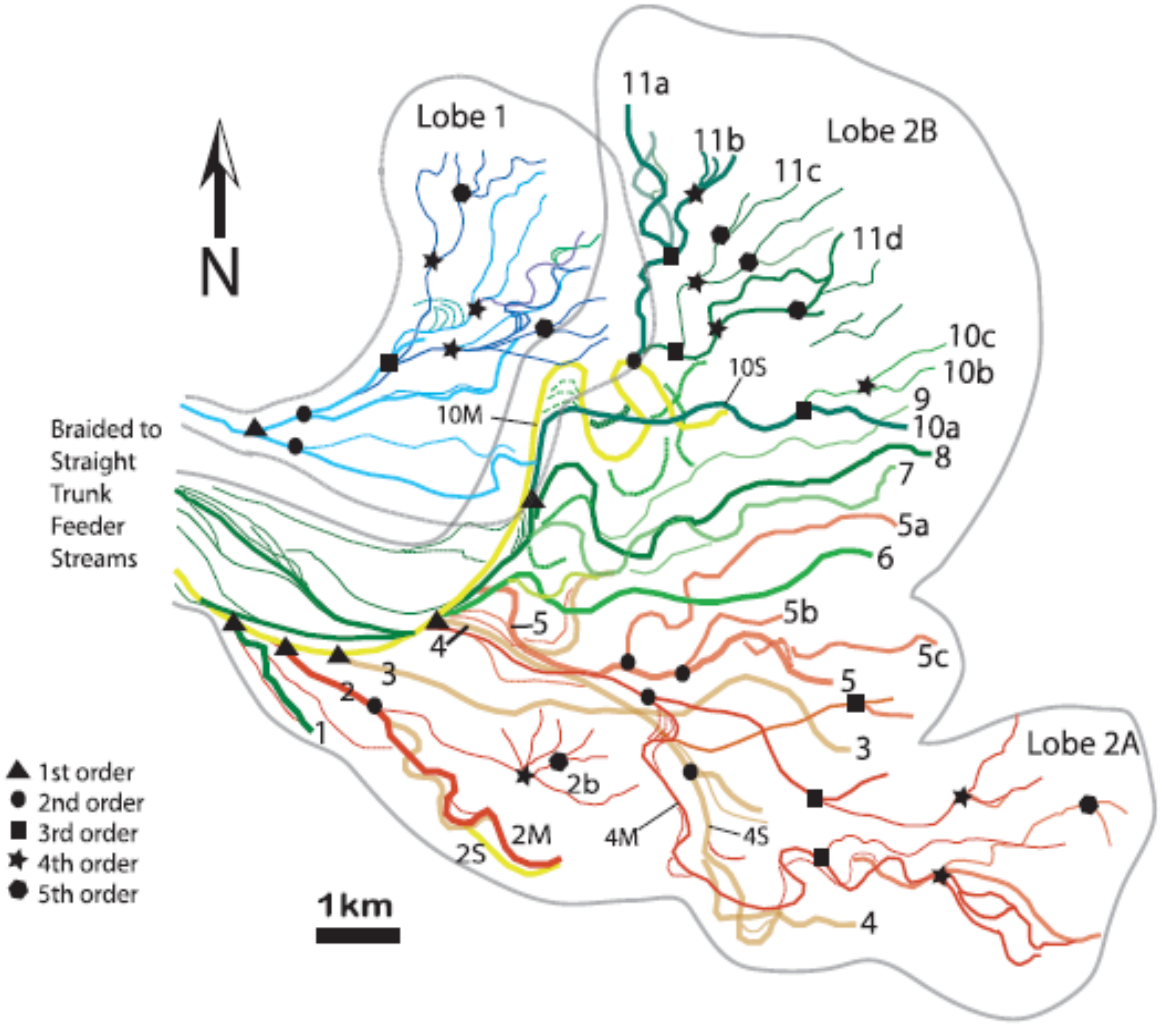

10 km
V
The volume of the delta approximately equals the volume of the incised valleys upstream



Source to Sink Sediment Signal

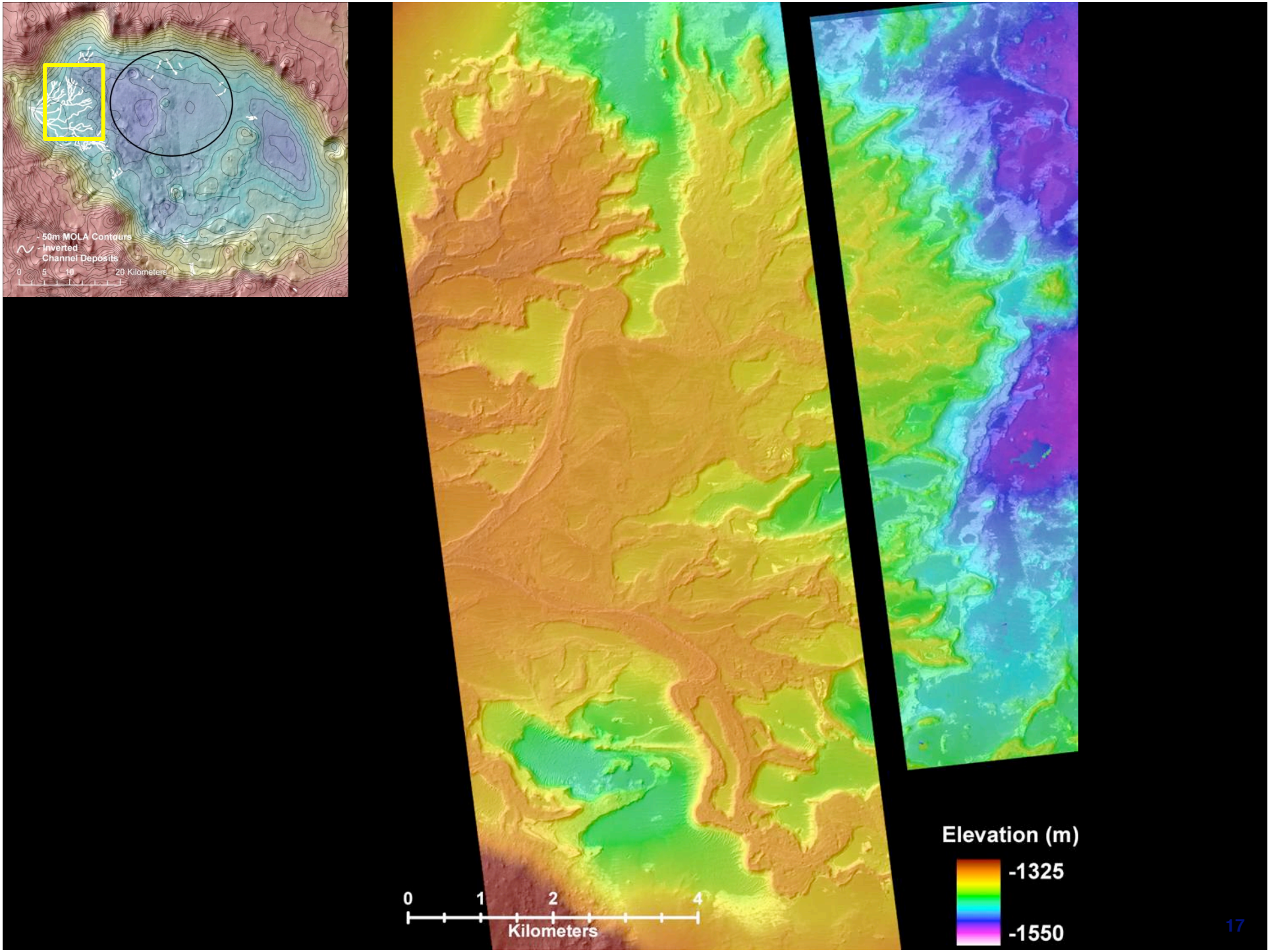
Eberswalde offers a closed basin in which sediment source dynamics, perhaps driven by hydrologic/ climatic variation, may be recorded in the stratigraphic record of the terminal deposit

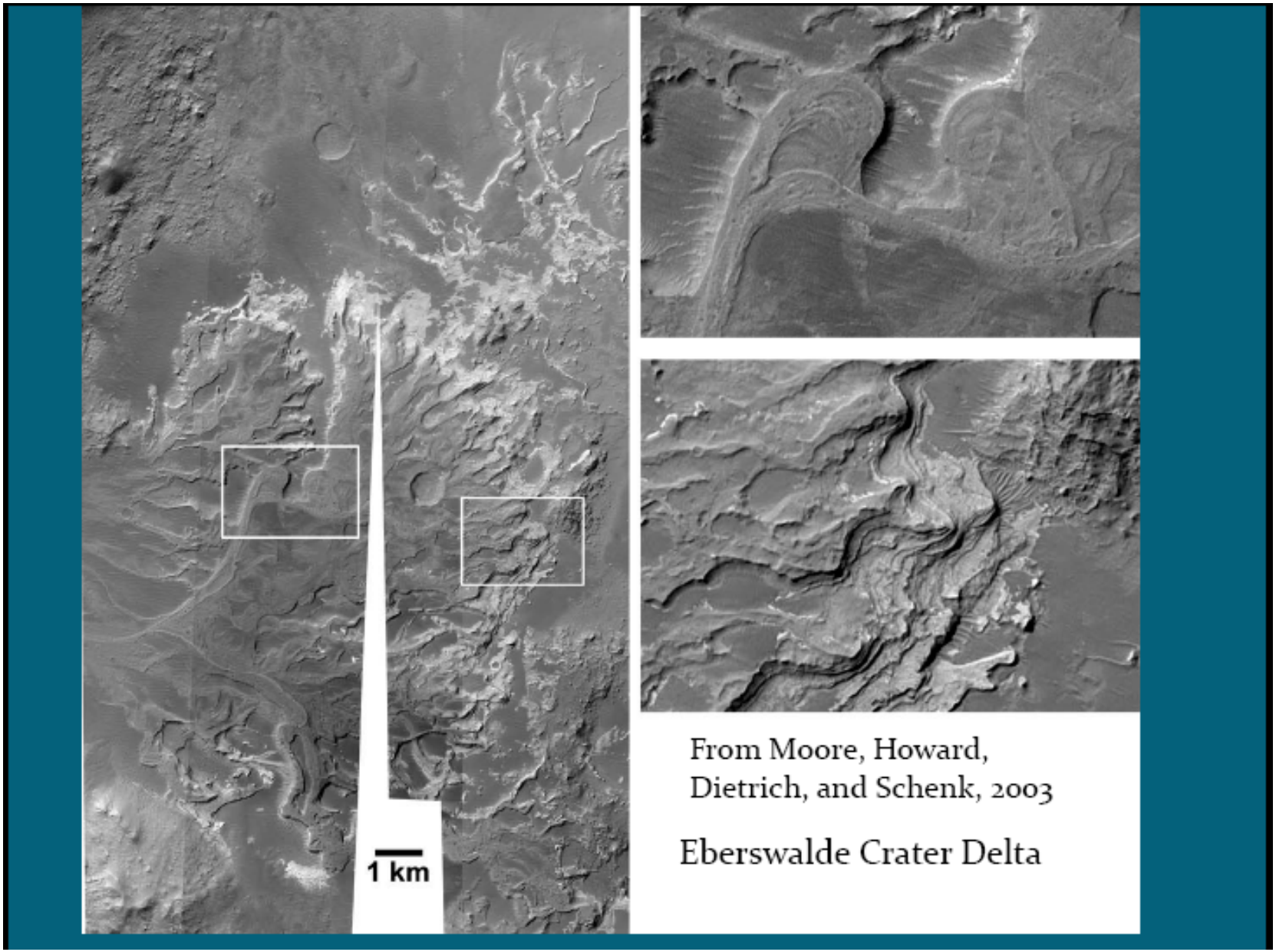
No subsidence in Eberswalde delta

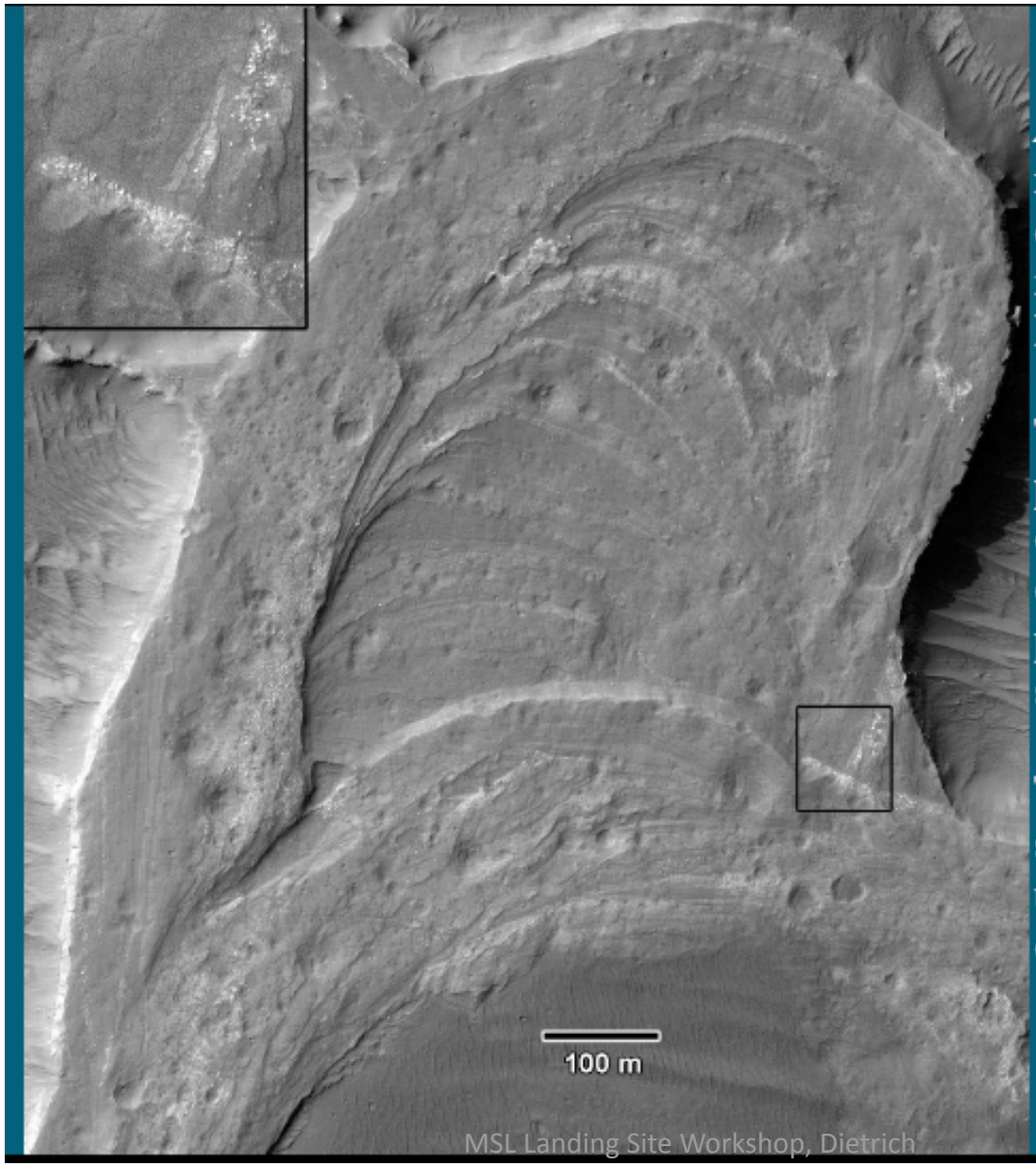


The delta is compose of several distinct lobes.

Bhattacharya et al. 2005


- 50m MOLA Contours
- Inverted Channel Deposits
0 5 10 20 Kilometers
0 1 2 4
Kilometers
Elevation (m)
-1325
-1550

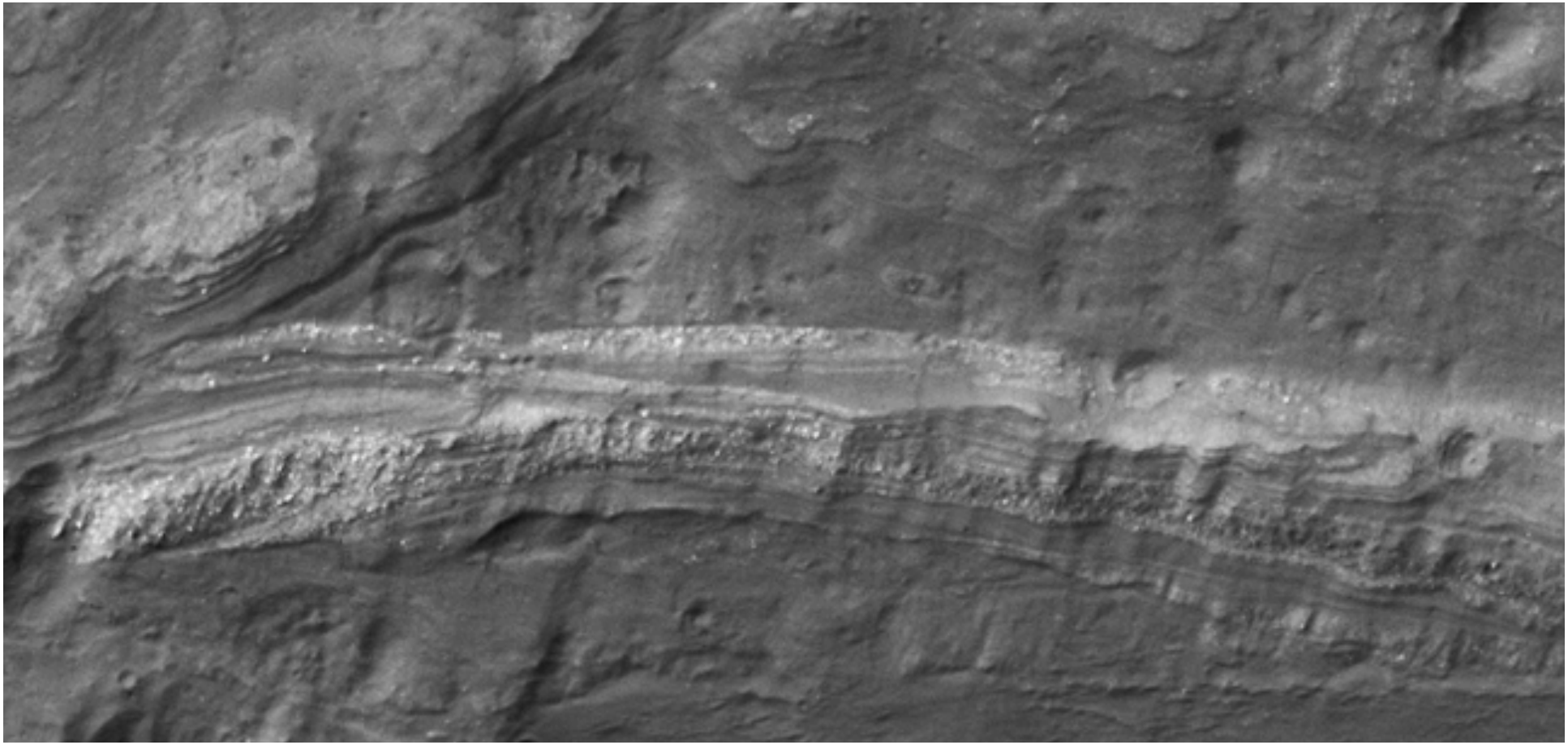

1 km
From Moore, Howard, Dietrich, and Schenk, 2003
Eberswalde Crater Delta



A HiRISE image of a meander loop that enlarged while aggrading, followed by cutoff of the loop.

The parallel scars are not point bars, but successive channel beds exposed by eolian erosion of finer point bar and overbank sediments.

The inset shows meter-scale boulders transported across the delta.



River channels can be used to estimate surface discharge of water:

$Q = W\ H\ V$

Width can be estimated remotely– not without uncertainty (canyon width may be much wider than the channel that cut it)

H (depth) is often guessed on assumed W/H ratio.

V (velocity) is calculated (with large uncertainty)

Often Q is estimated from terrestrial correlations with width, meander wavelength or drainage area (large uncertainty)

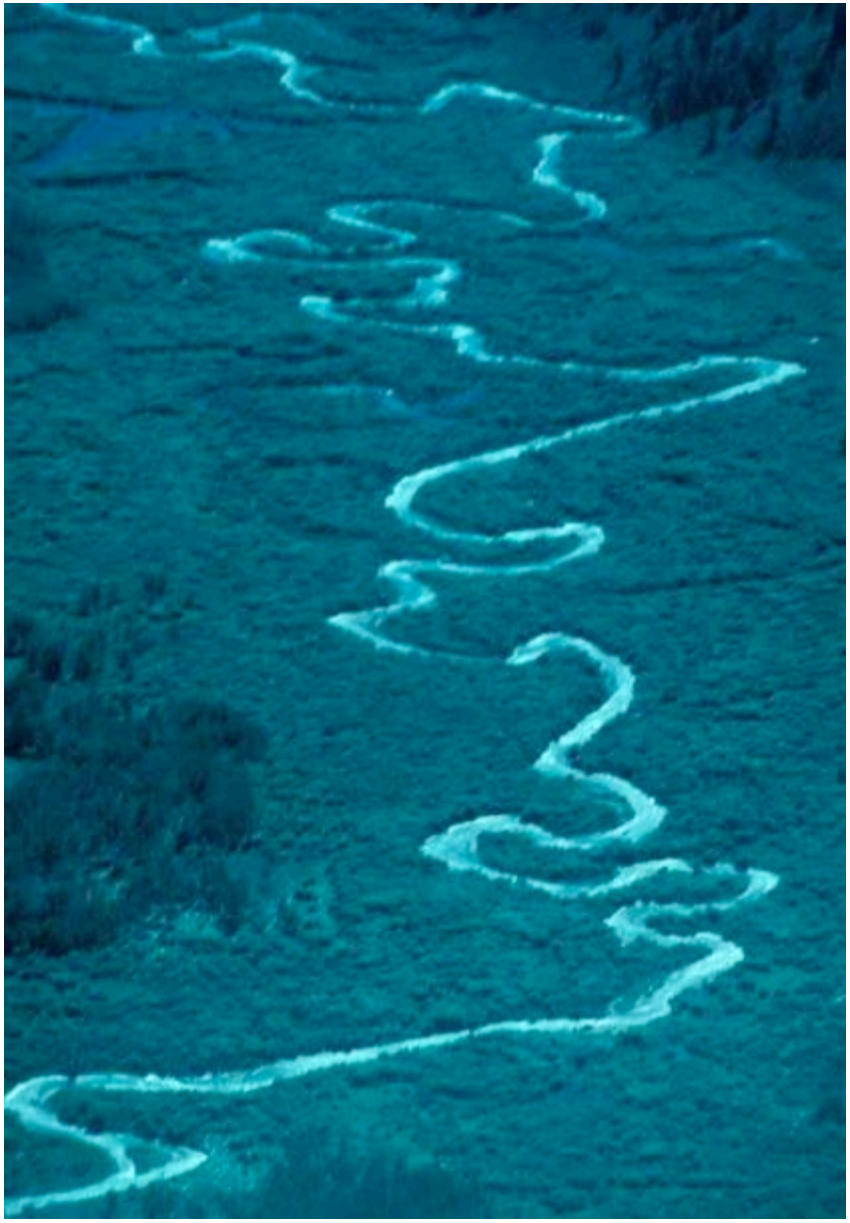
Discharge estimates for Eberswalde main channel:

"bankfull discharge" m3/s	reference	
700 (300-1600)	Moore et al. 2003	
410 (240-950)	Jerolmack et al. 2004	
550	Irwin et al. 2005	1 cm/d

Rover-based observations that would greatly reduce discharge uncertainty:
River bed grain-size, bedforms (dunes, bars), and direct observation of channel depth.

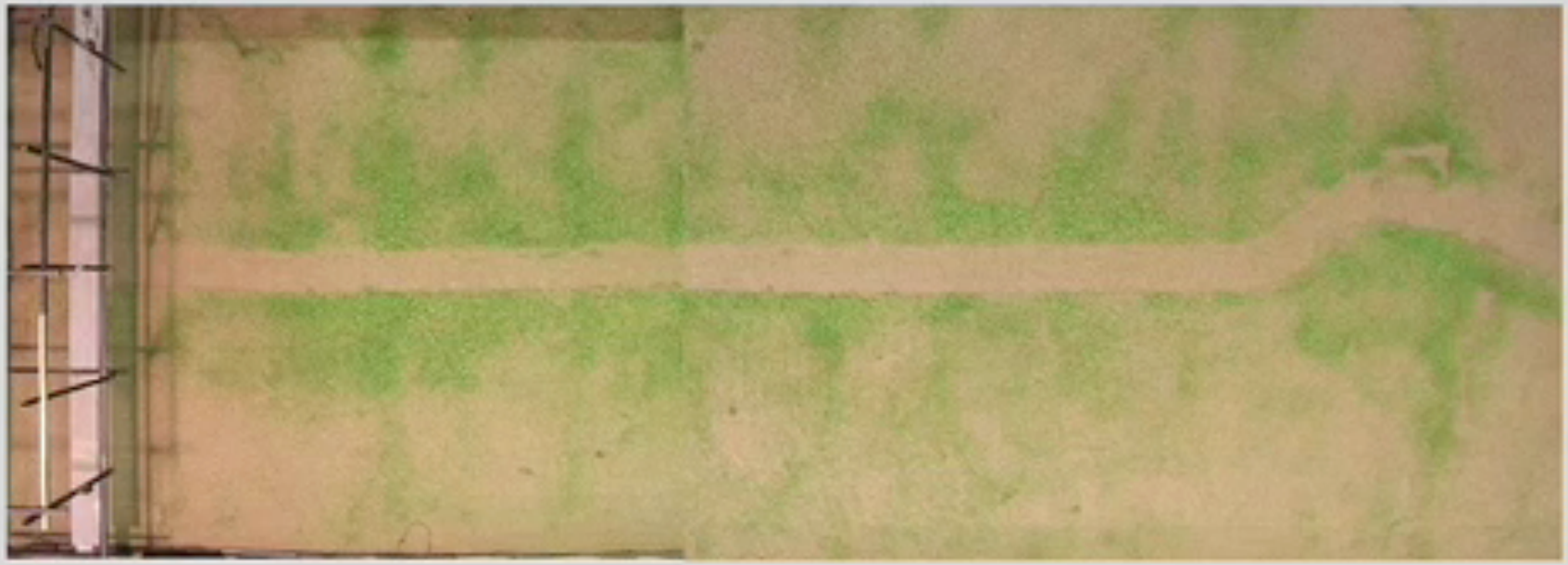
Duration and frequency of flows are much more difficult to estimate.

Observations on layering and sorting would reveal sediment transport processes and guide estimates of rates of deliver to delta



Meandering River (high bank strength)

Braided River (low bank strength)



Meanders need bank strength. And it must be able to lose strength (and become erodible on the outside bank) and gain strength (once deposited in the inside bank)

Source of strength can not be determine by remote sensing .

1.Mud (silt and clay): this has implications for weathering in the source area- and duration of "wet climate"

2.Cement: has implications for Mars climate, mineralology, geochemistry, hydrology and site evolution

3.Ice: would imply a condition of free running water in a frozen environment, with major implications for Mars climate history.

Braudrick and Dietrich, PNAS, 2009

Quinn River, Nevada

Allan Howard
Devon Burr
Rebecca Williams

General view, showing scroll bars and some abandoned loops


Exposed Point bar deposits

Interstratified sand and mud on point bar surface

Mud (silt and clay) is easily transported, but once it deposits and dewaters it gains strength and resists re-entrainment, and it provides strength when the river cuts bank in on these deposits, slowing erosion and allowing meandering to develop

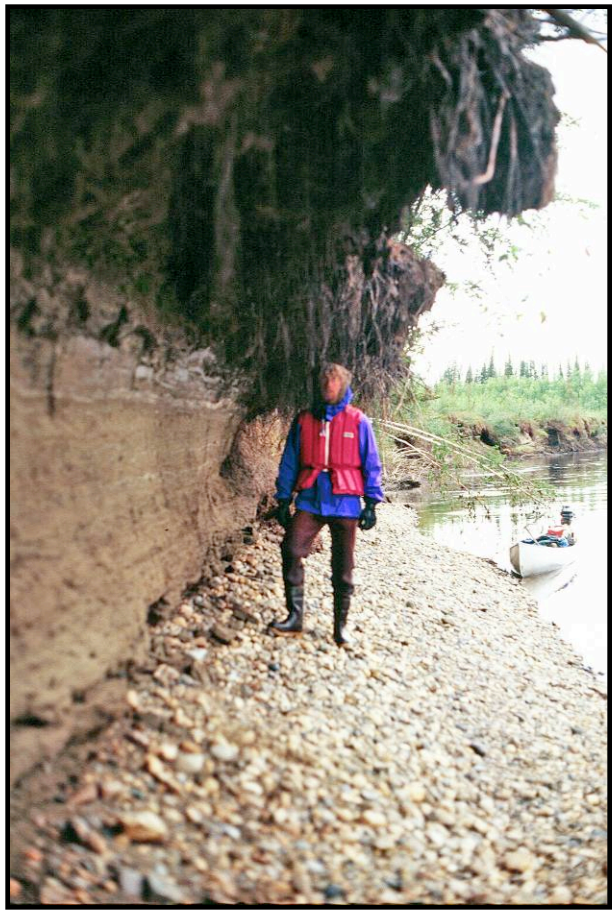
Yana River, Siberia 67 deg N, Landsat 7,4,2

Fig. 7. Meandering river in the zone of continuous permafrost in the taiga of northern Alaska.

Channels cut against permafrost strengthen banks and deposit sediment on the inside bank into which the permafrost progressively advances.

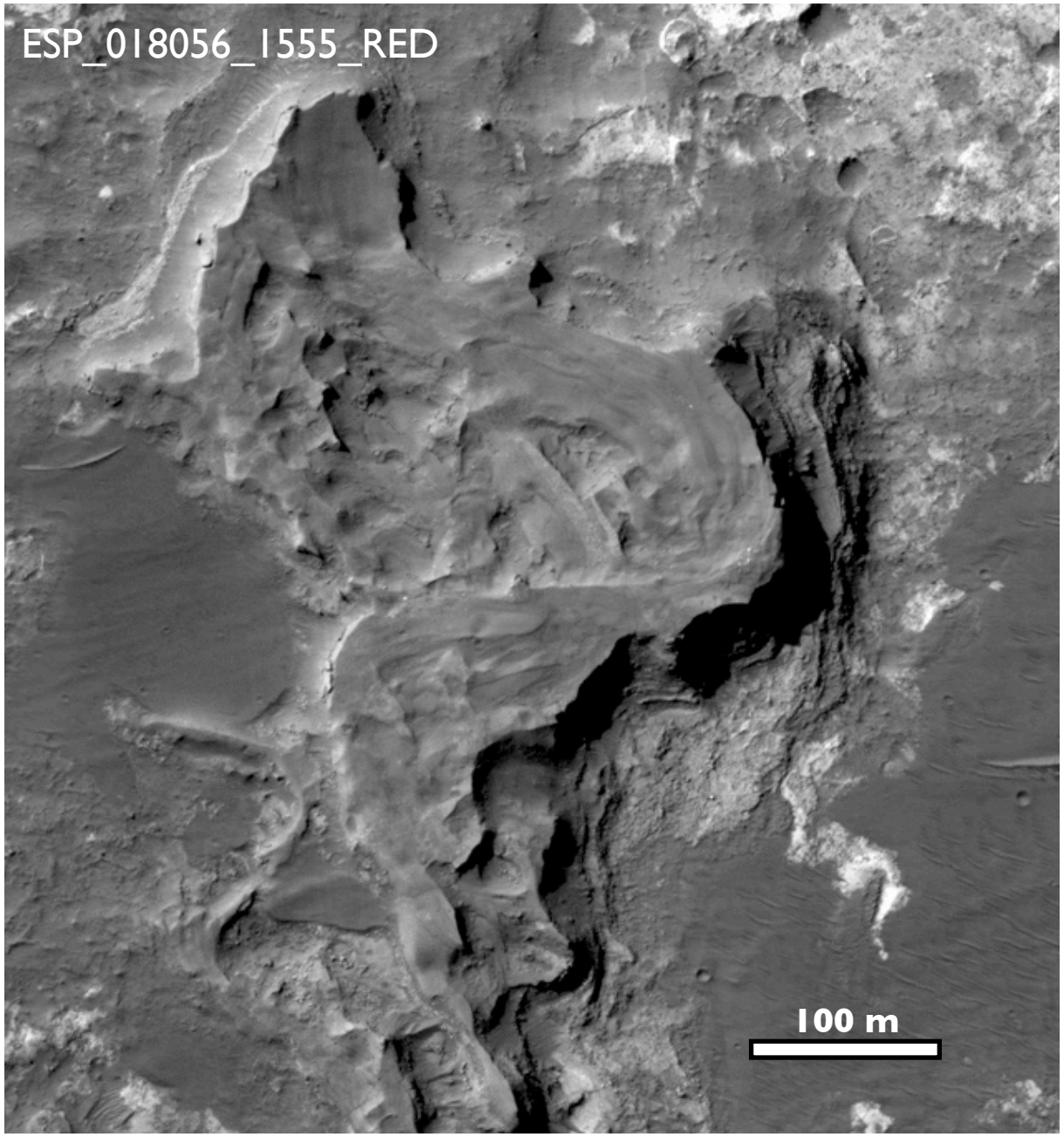
Permafrost for bank cohesion – thermal control

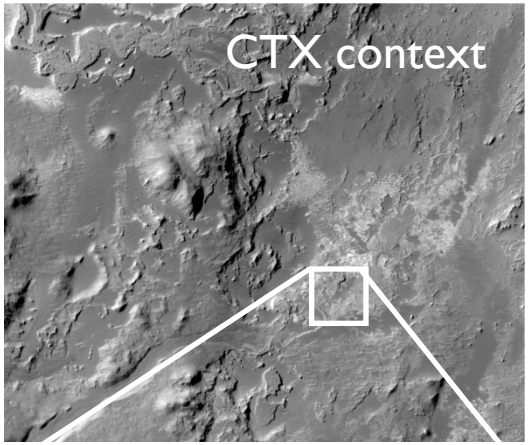
Yukon River - 2009

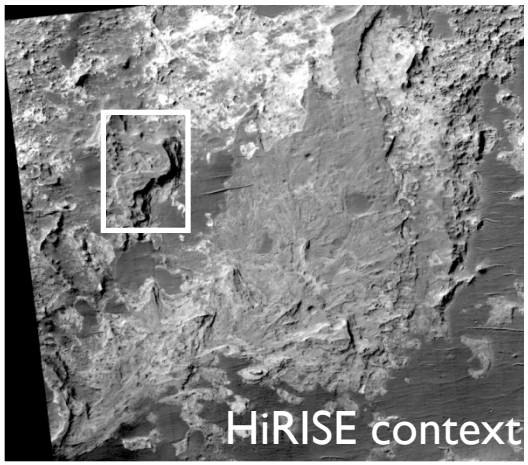


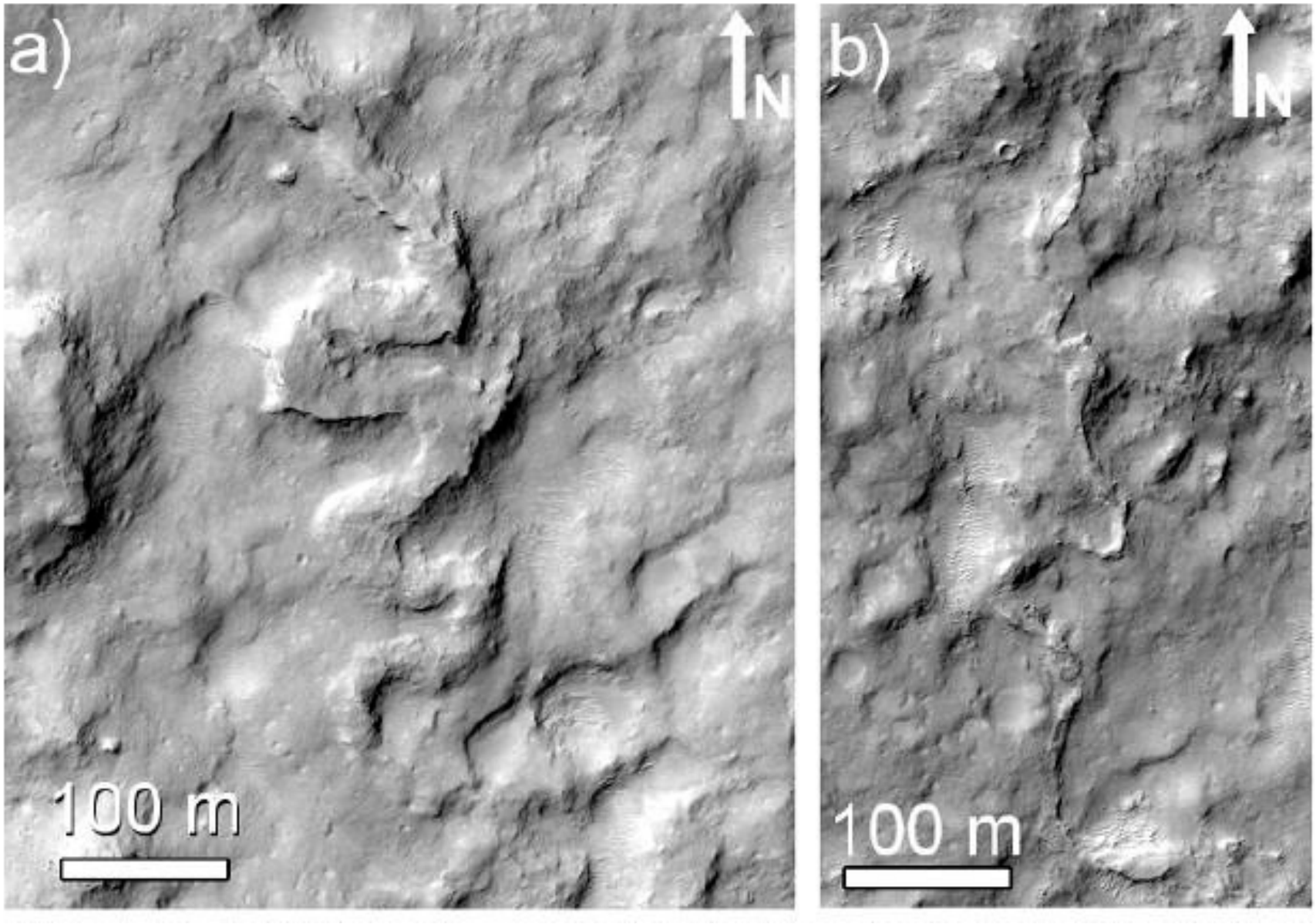
Beaver Creek - 2002

To permit continued meandering and cutoffs, ice would have to reform on point bars, which appears to be happening here, as evidenced by ice-wedge polygons

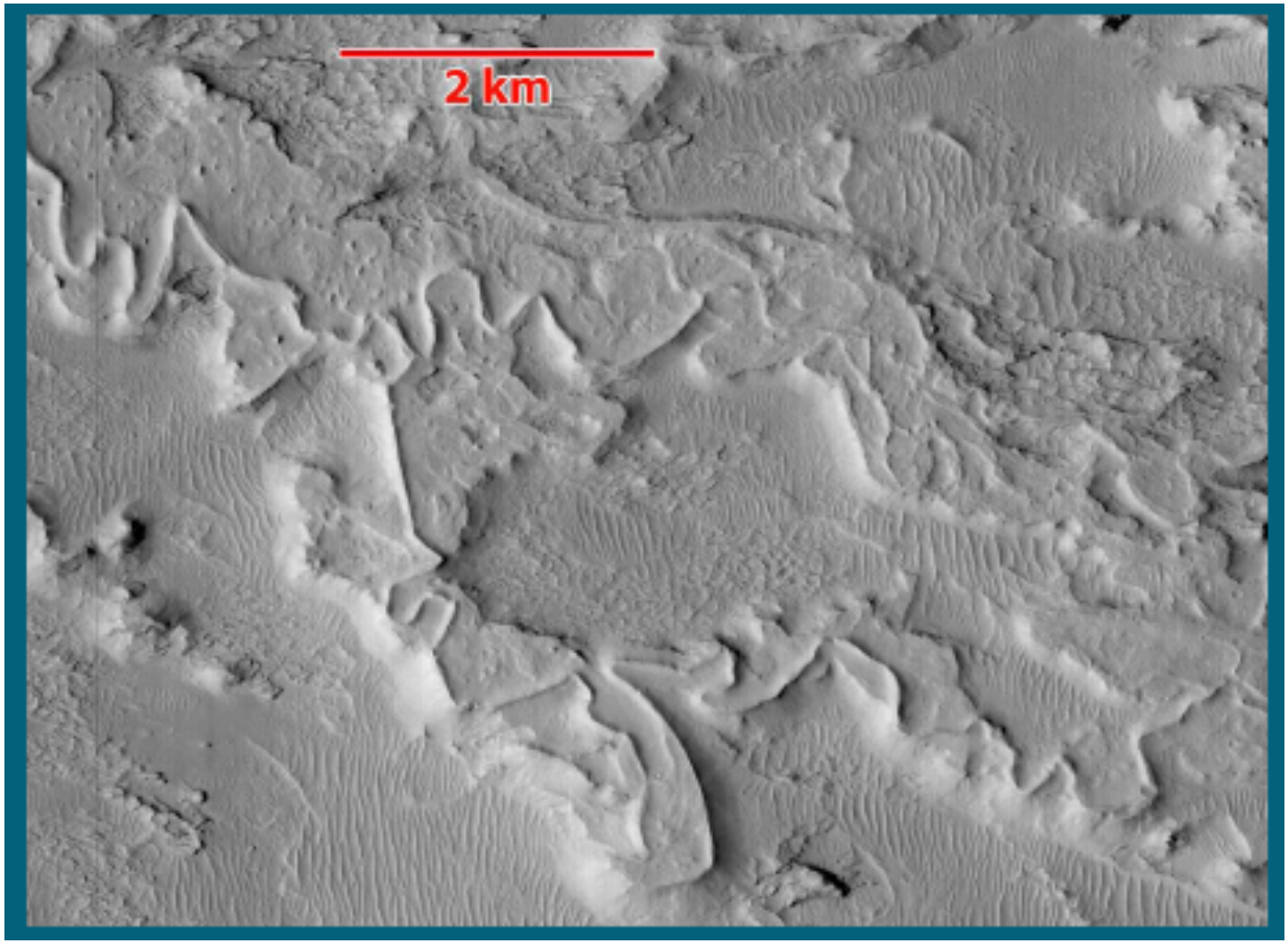

ESP_018056_1555_RED
100 m


CTX context


HiRISE context

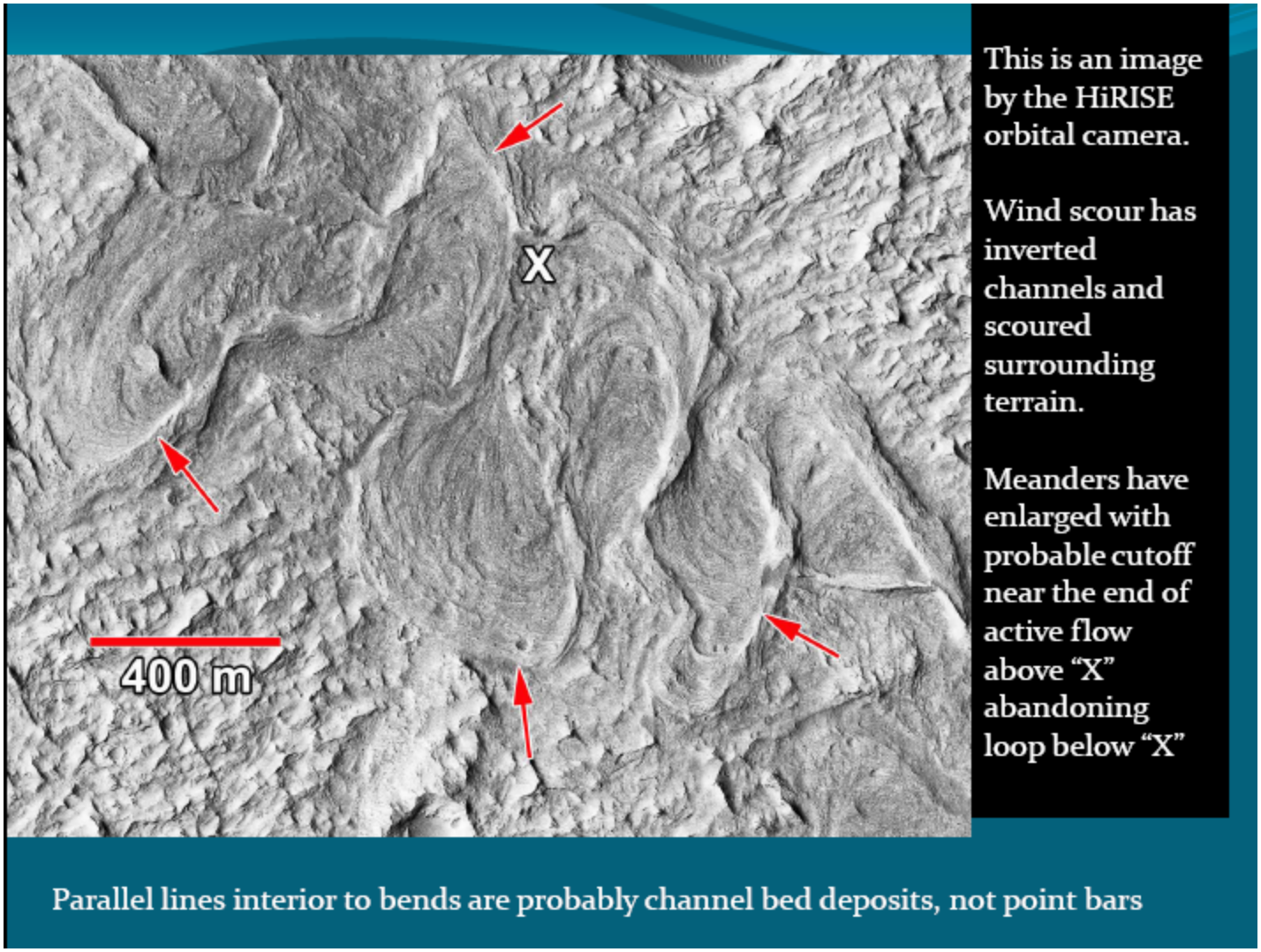


Gale Crater, within the landing ellipse, Anderson and Bell (2010)

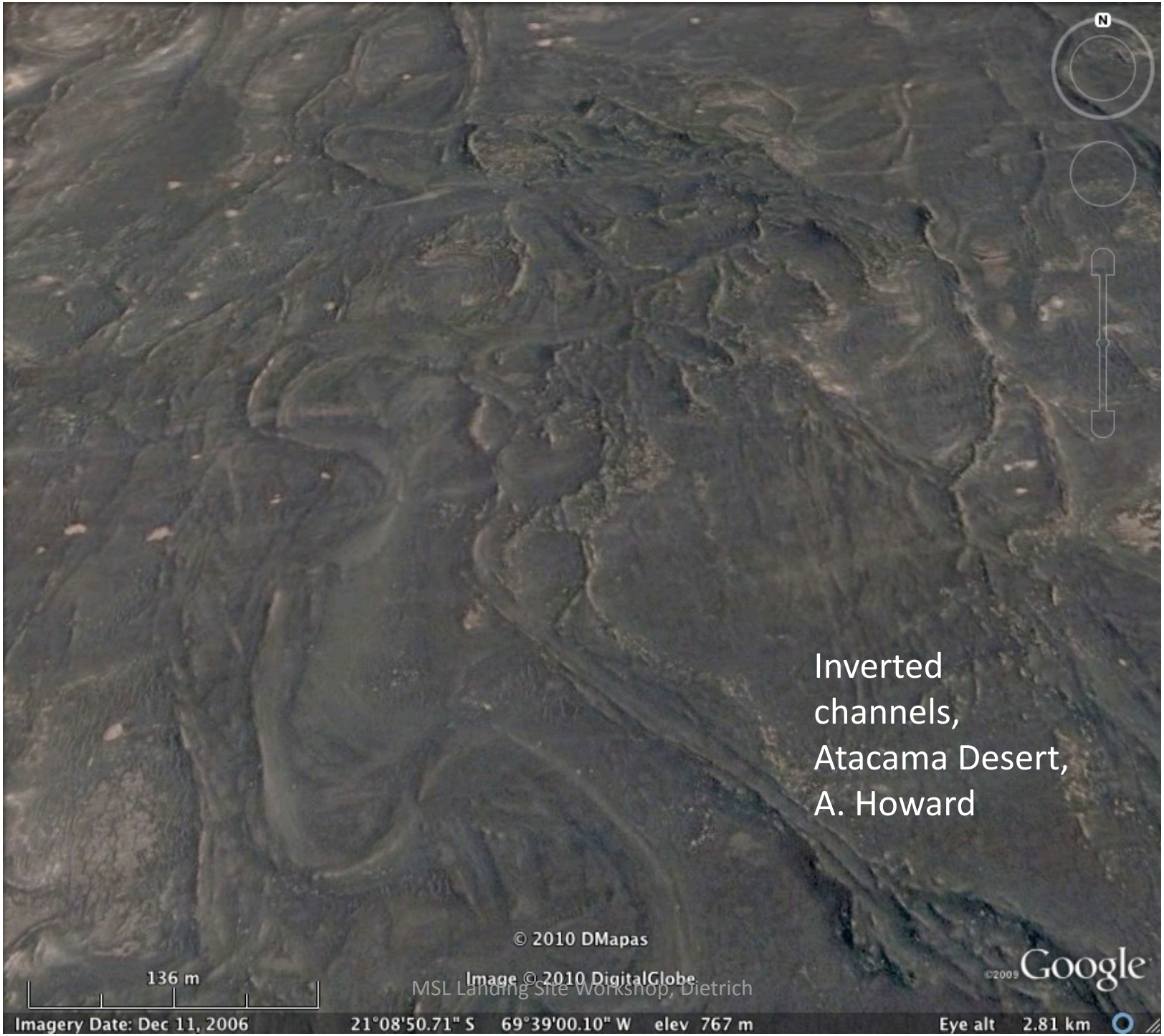


The surrounding flat-topped ridges exhibit scroll bars and cutoff loops. This implies the channels formed by sustained or repeated discharges that allowed extensive channel migration.

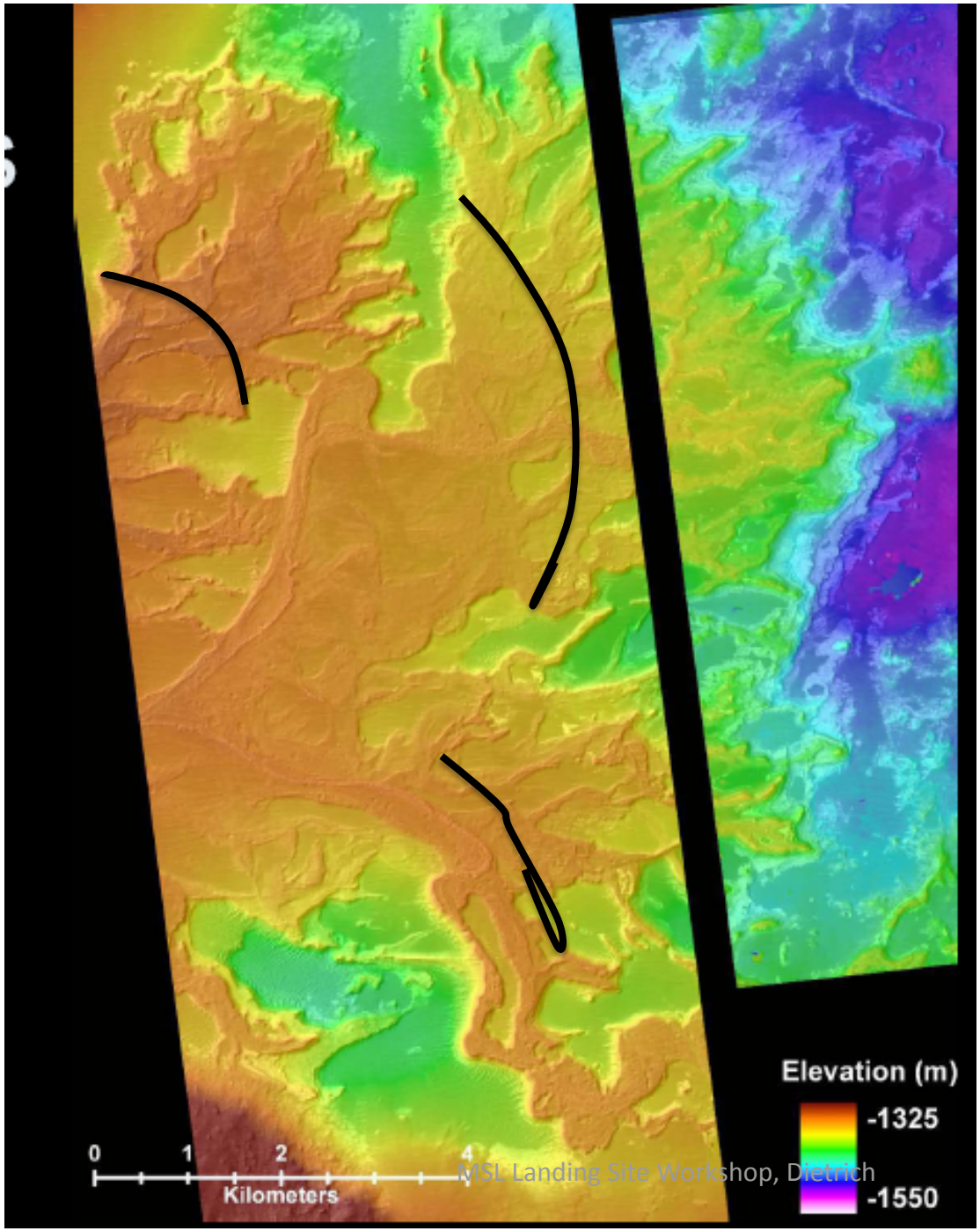
Aeolis/Zephyria Plana Burr et al. 2010


X
400 m
This is an image by the HiRISE orbital camera.
Wind scour has inverted channels and scoured surrounding terrain.
Meanders have enlarged with probable cutoff near the end of active flow above "X" abandoning loop below "X"
Parallel lines interior to bends are probably channel bed deposits, not point bars

Aeolis

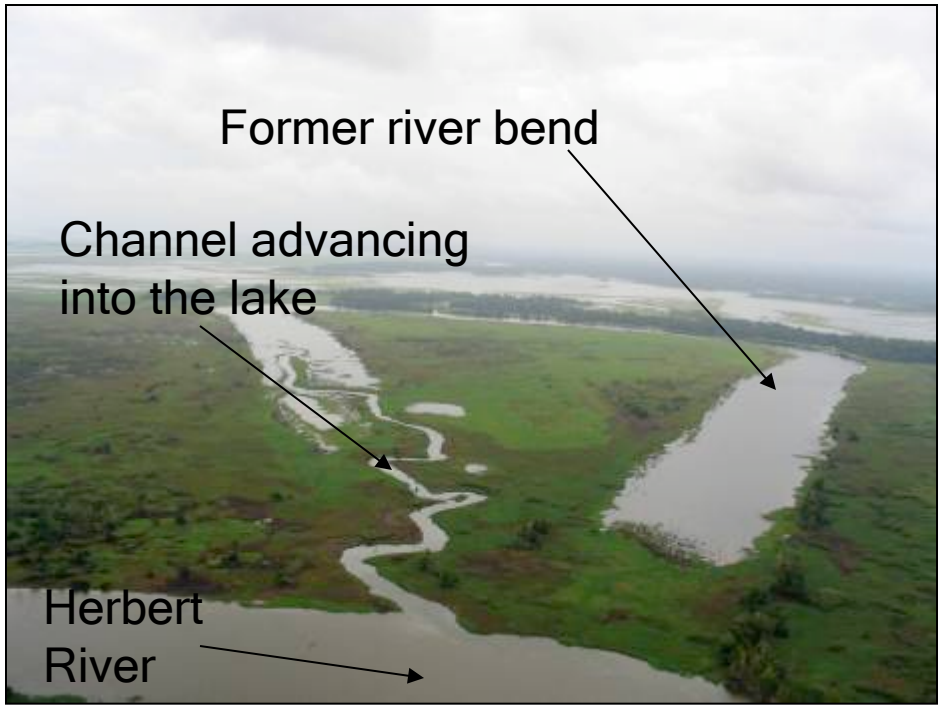


Inverted channels, Atacama Desert, A. Howard



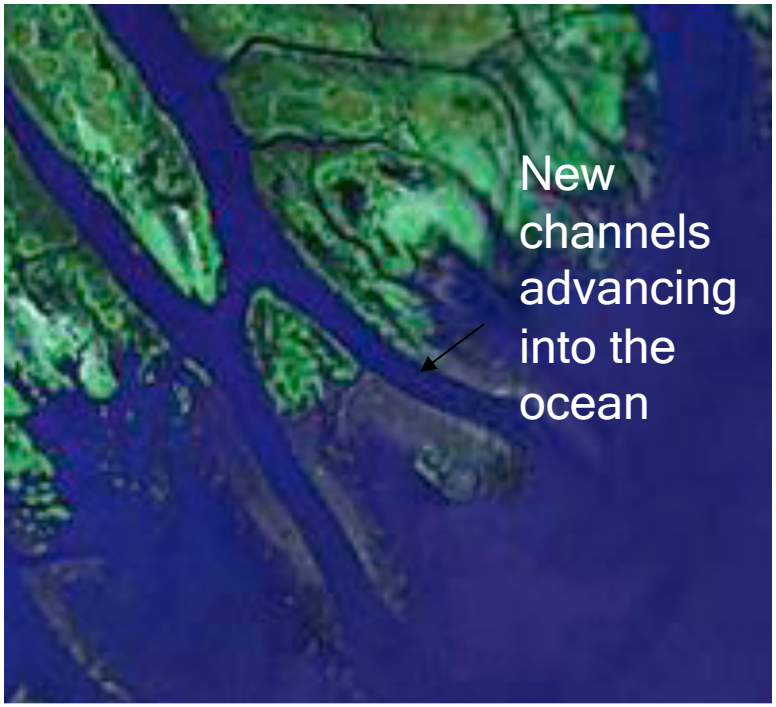
Significant and systematic downstream change in change morphology

As sediment-laden rivers enter lakes and oceans they typically build distinct channels..

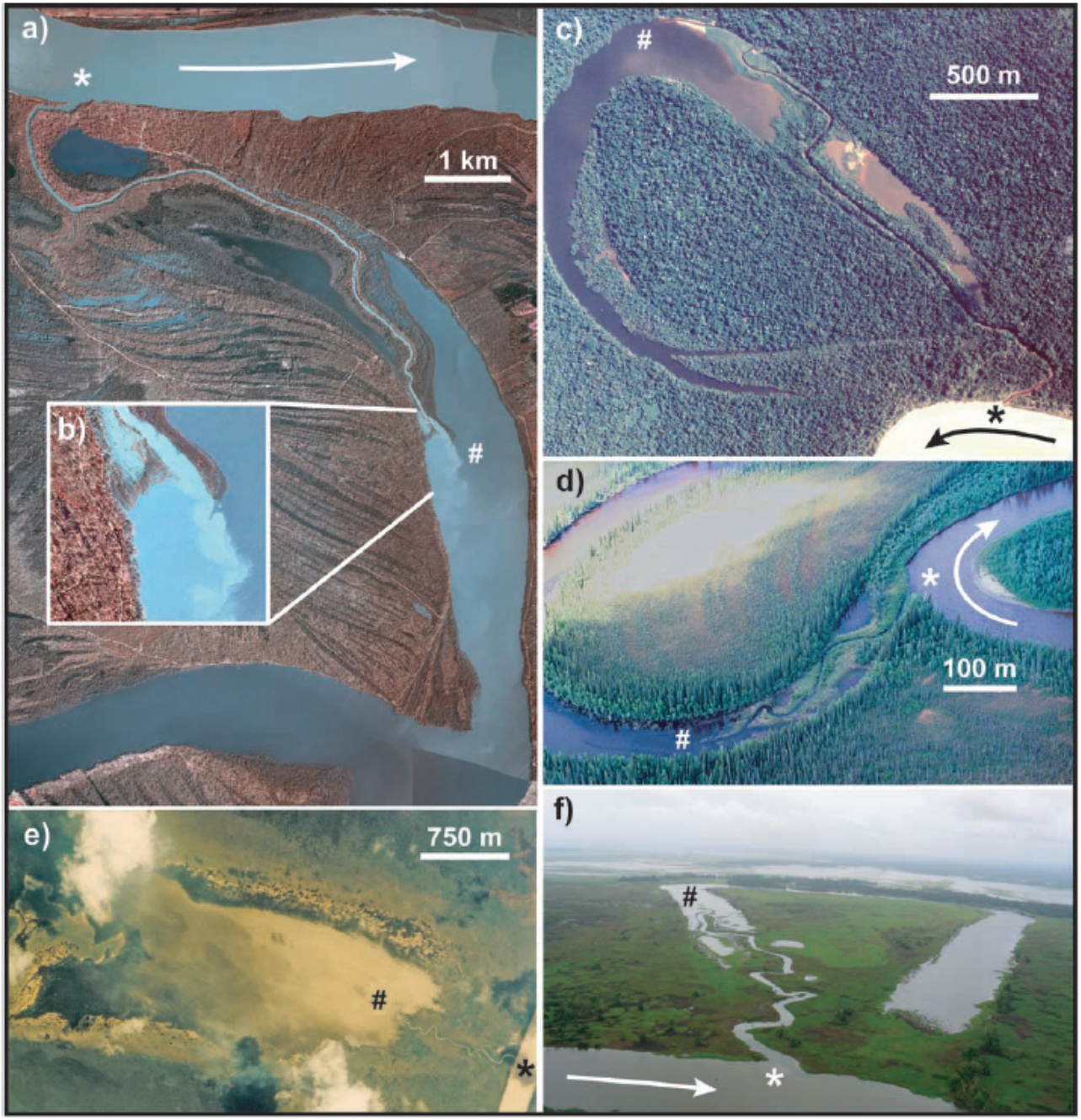


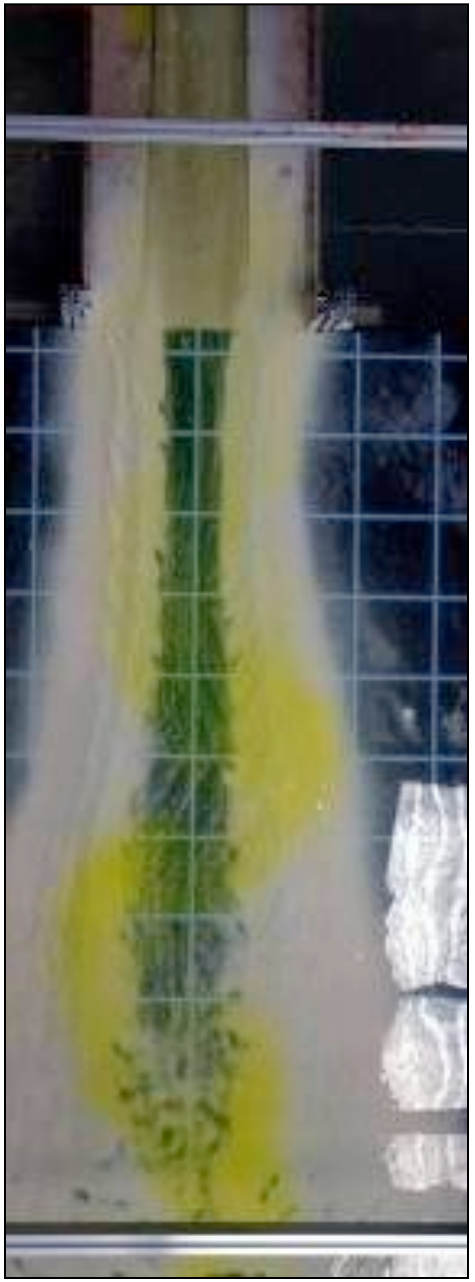
Herbert River, Papua New Guinea

(Dietrich)

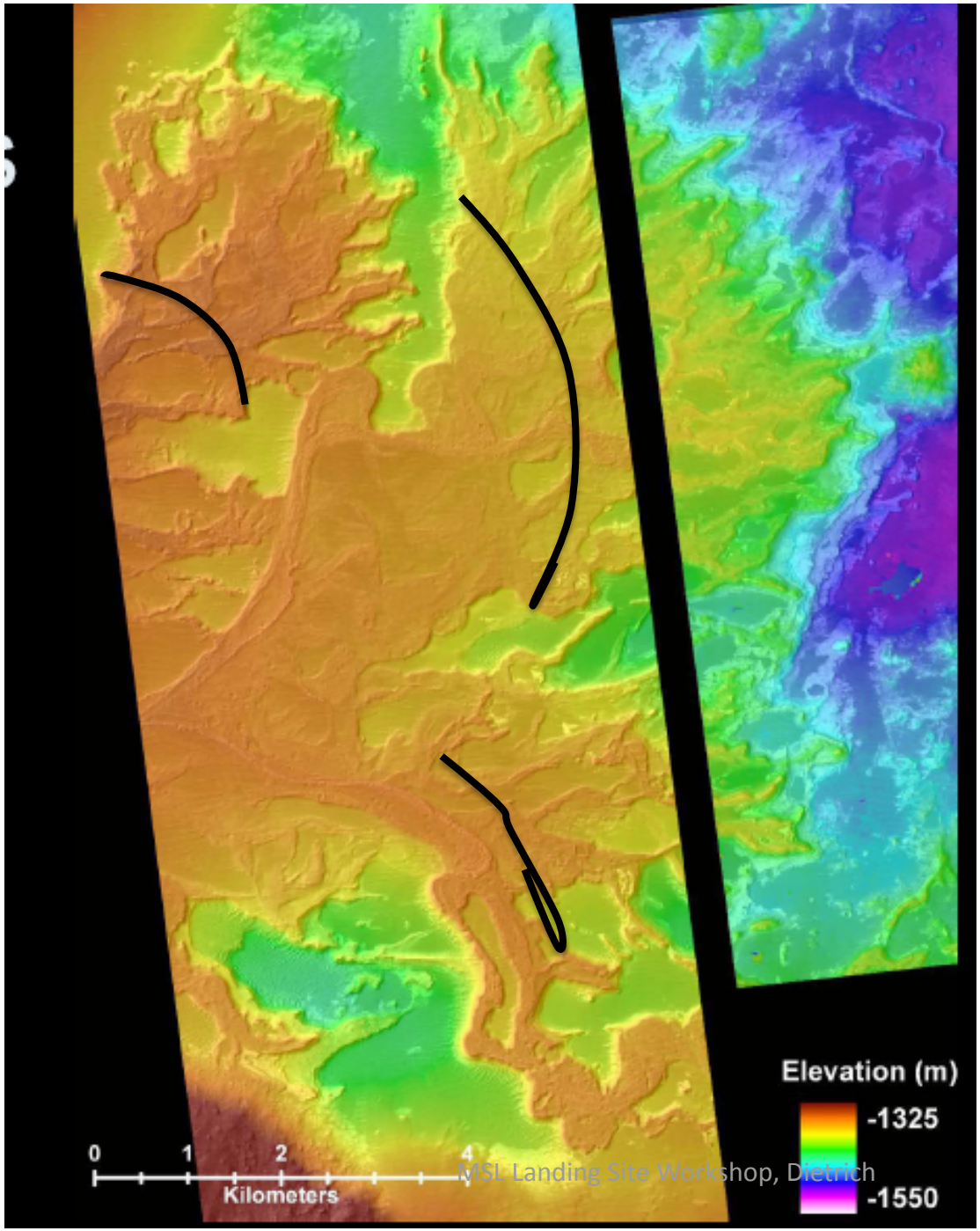


Wax Lake delta, Louisiana, USA
(Google Earth)

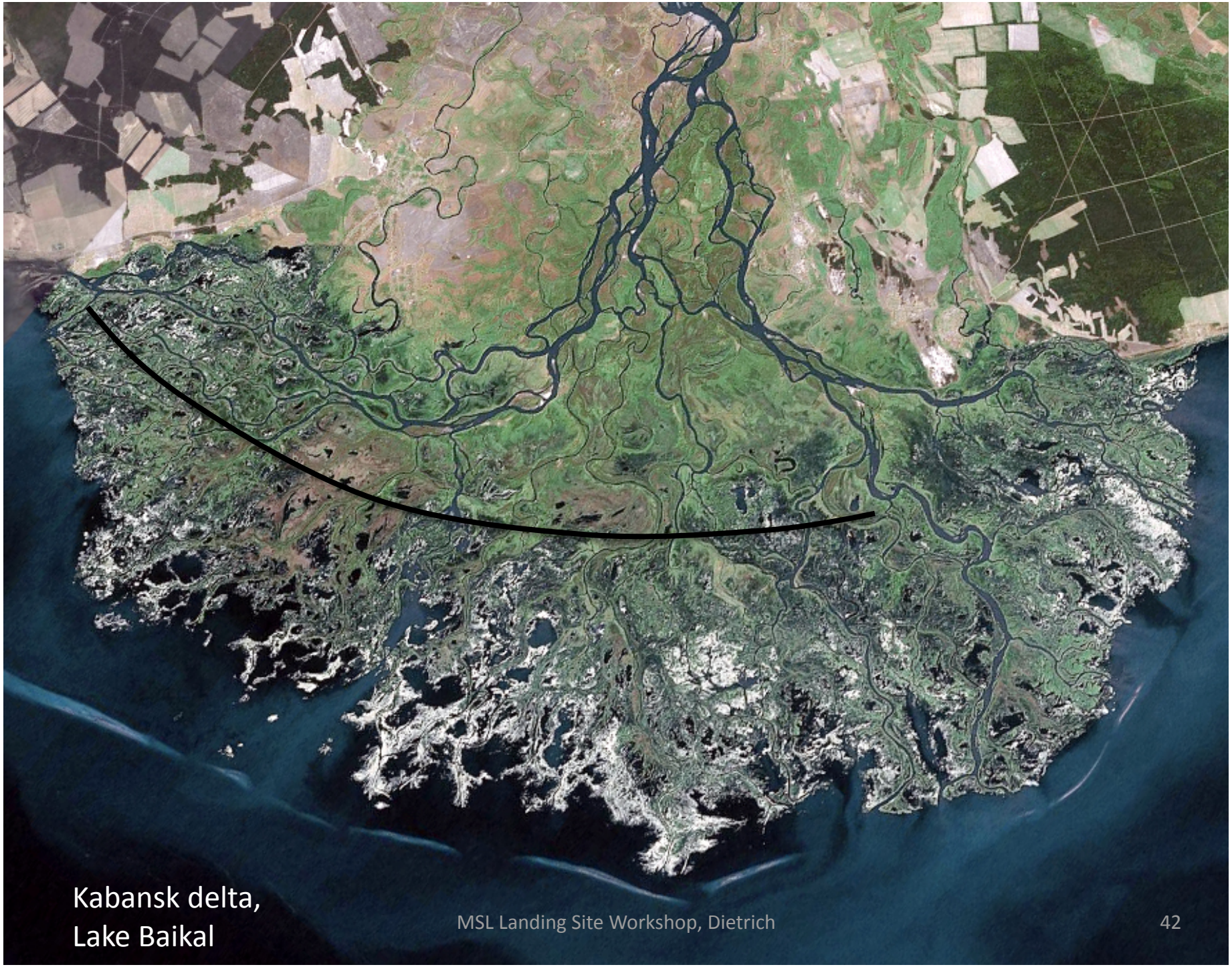




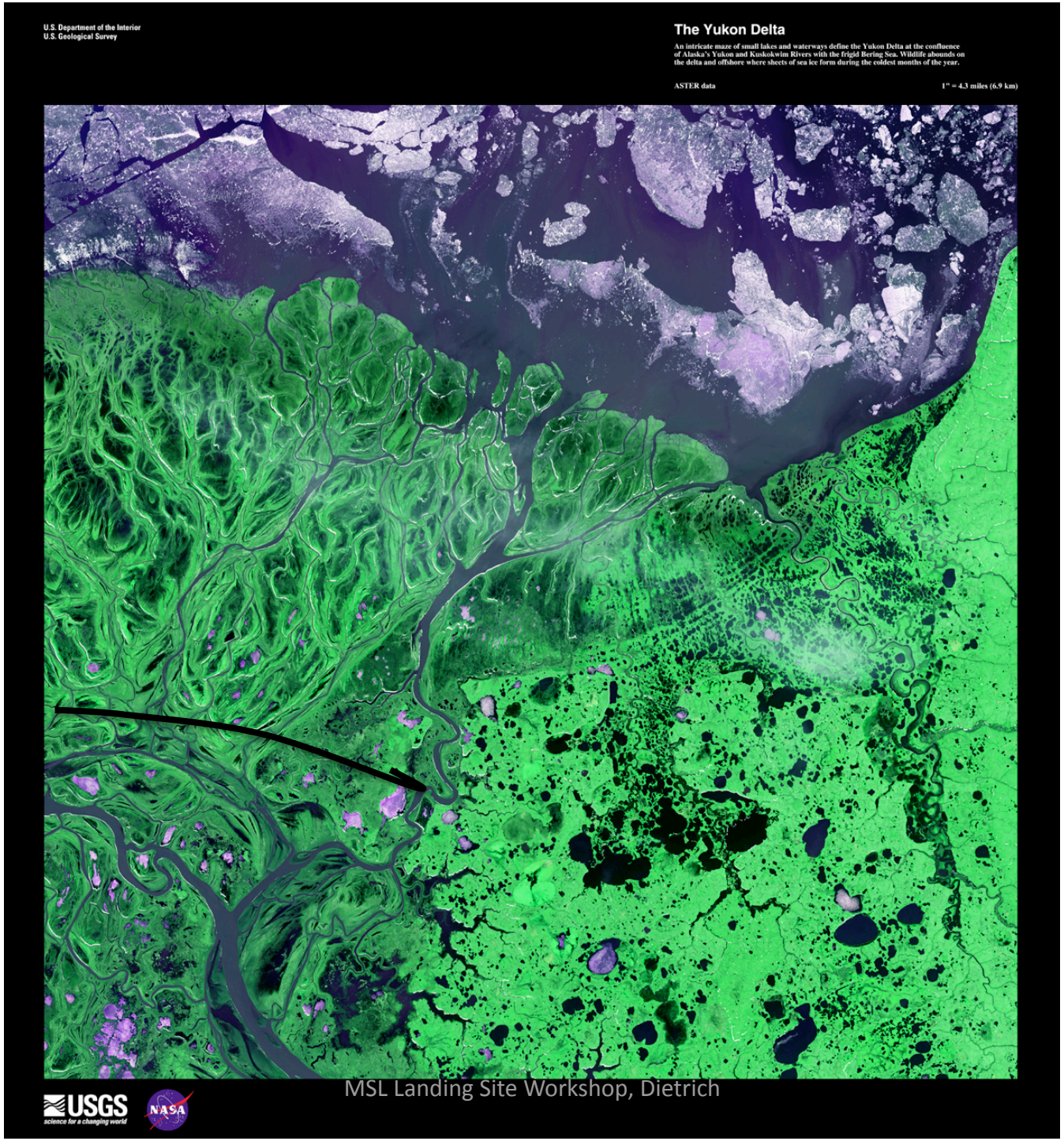
Rowland et al. 2009



Significant and systematic downstream change in change morphology



Kabansk delta,
Lake Baikal


U.S. Department of the Interior
U.S. Geological Survey
The Yukon Delta
An intricate maze of small lakes and waterways define the Yukon Delta at the confluence of Alaska's Yukon and Kuskokwim Rivers with the frigid Bering Sea. Wildlife abounds on the delta and offshore where sheets of sea ice form during the coldest months of the year.
ASTER data
1" = 4.3 miles (6.9 km)
USGS
science for a changing world
NASA

Great Slave Lake, Yukon

Eberswalde Crater

Source to sink observations enable much deeper understanding of mechanisms, timing, duration of processes and can be used to build constrained models

Increasing evidence that the major deposit is a delta and Eberswalde was at times occupied by a lake.

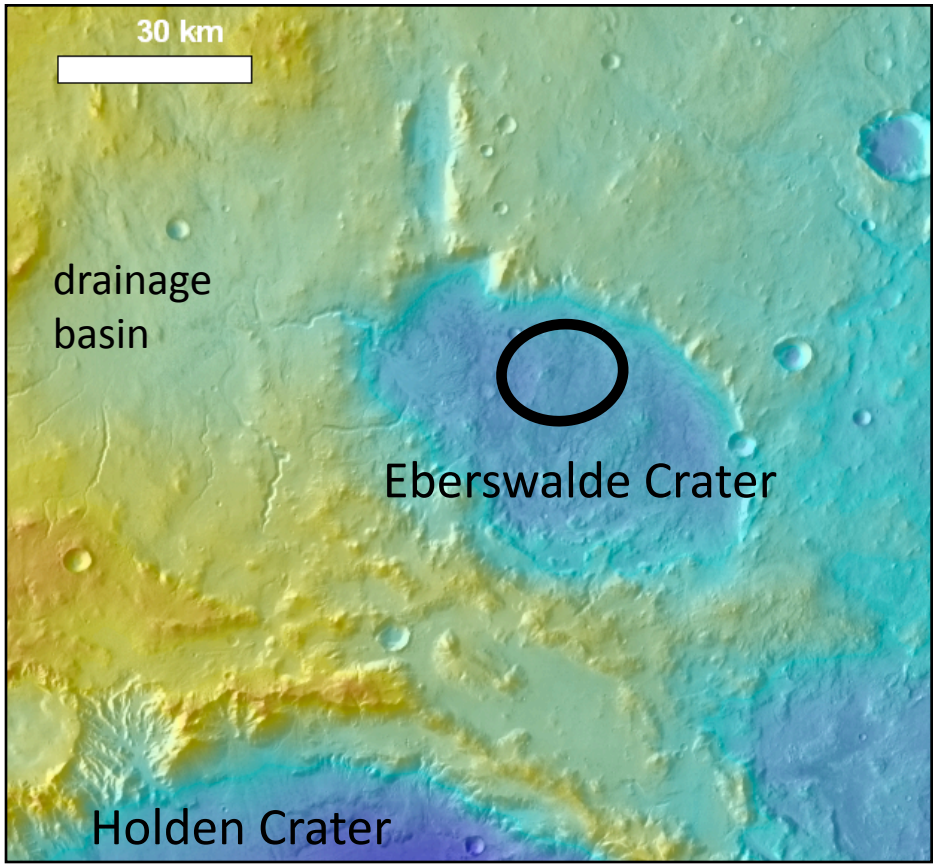
Downstream variation in channel morphology may be indicative of transition into lake environment.

Rover-based observations in fluvial channels can: 1) significantly improve estimates of water discharge, and 2) reveal processes controlling meandering, which would then provide unique information on climate, hydrology, weathering and geochemistry of Mars, which has implications for understanding habitability!

Topography and Thermal Inertia

MOLA

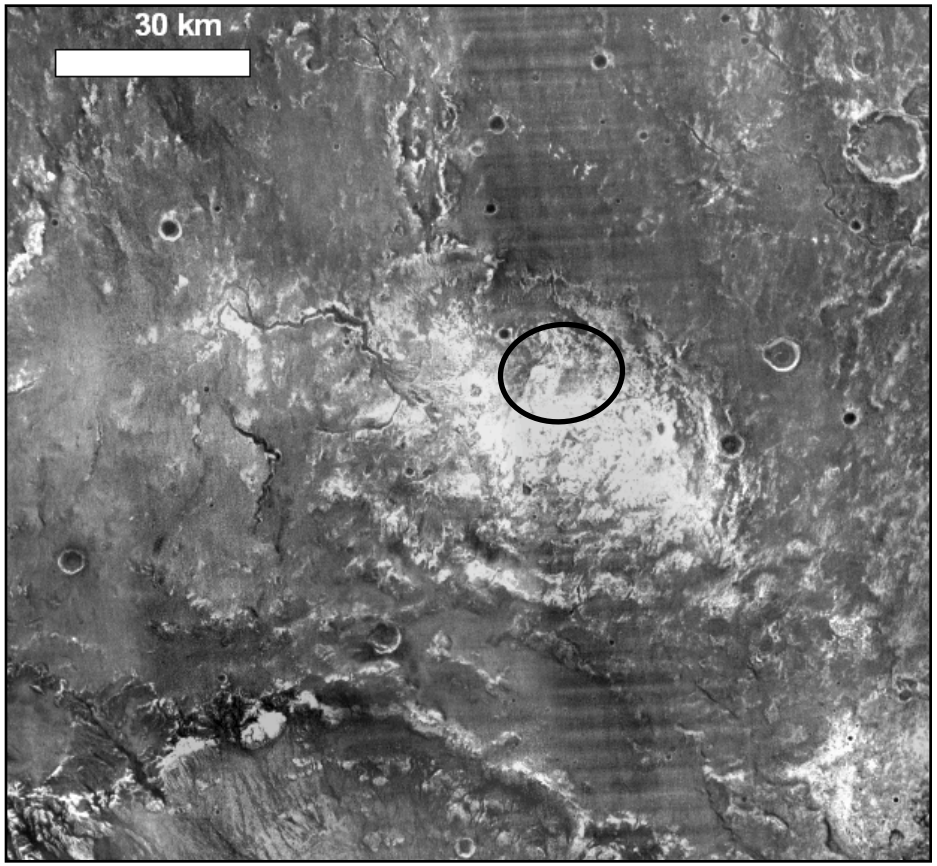
Image Credit: MOLA team / NASA Goddard Spaceflight Center



-3160 m 1776 m

THEMIS Thermal Inertia

Image Credit: Fergason et al. (2006) and the THEMIS Team



80 Thermal Inertia J m-2 K-1 s-1/2 525