Impact crater processes and MSL landing sites – Potential for impact hydrothermal deposits associated with a) megabreccia and b) thick hot ejecta? Potential for crater lake sediments?

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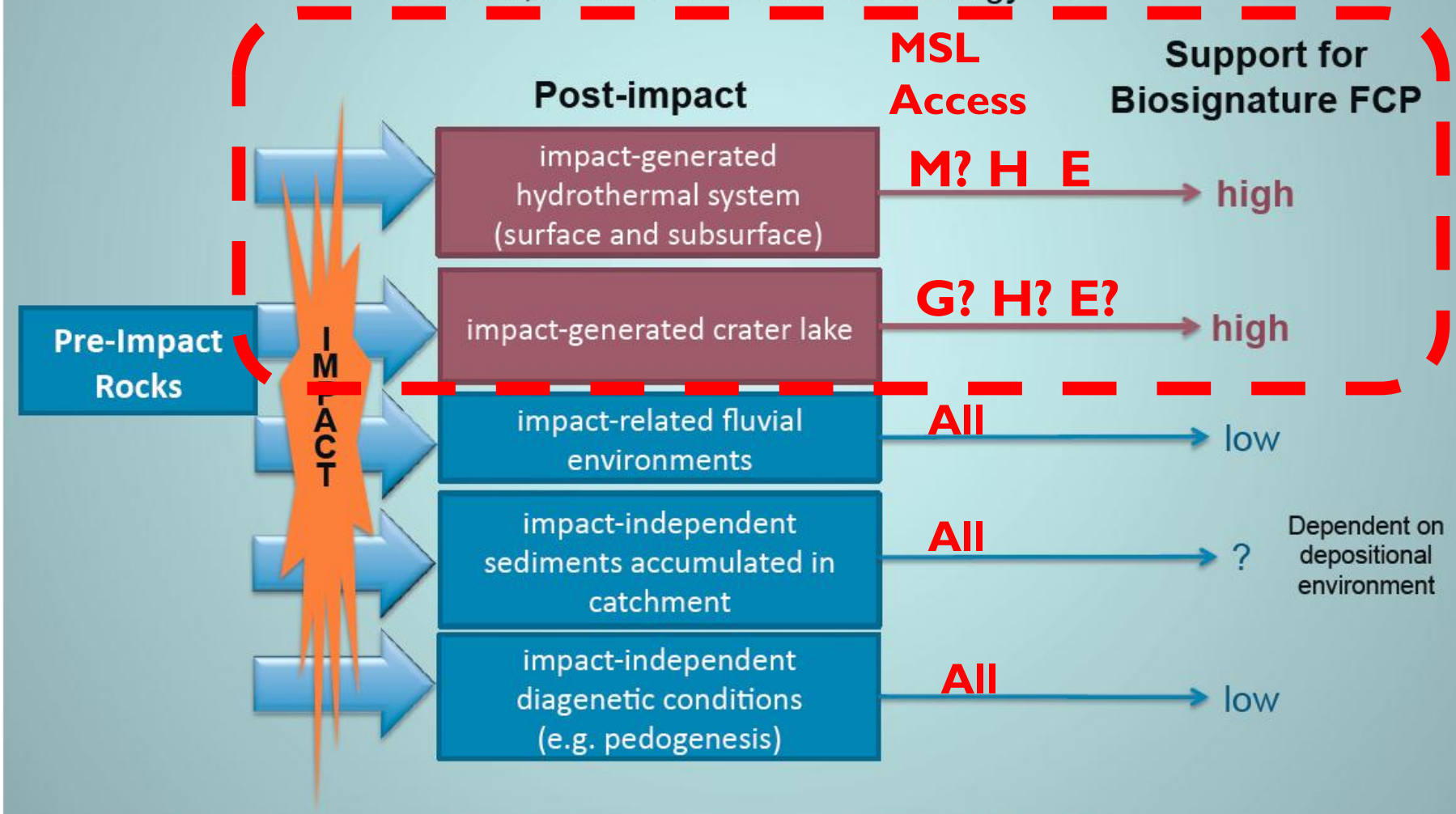
Landing site craters – Large!

- Gale Crater – 155 km diameter
- Holden Crater – 154 km
- Oyama Crater (Mawrth) – 107 km
- Eberswalde Crater – 65 km

- Terrestrial analogs
  - Chicxulub, Mexico – 150 km diameter
    - Impact melt-bearing breccias in ejecta with hydrothermal clay deposits
  - Vredefort, S.A. – 160 km
    - Deeply eroded with pseudotachylyte dikes
  - Manicouagan, Canada – 80 km
    - Megabreccia, and hydrothermal alteration - smectite etc.
  - Ries, Germany – 24 km
    - Melt-bearing breccias in ejecta (suevite) – limited hydrothermal alteration

Evaluation of support for biosignature formation, concentration, and preservation (FCP) for impact-related rocks

Impacts provide heat that can linger for 1000's to 10,000's years (more?)
→Water, chemical and thermal energy flux



Clays - Impact hydrothermal origin?

- Gale
  - Ellipse – Fe/Mg clay (possible hydrothermal debris from crater wall)
  - Mound – Fe-rich smectite clay (unlikely to be impact related)
- Mawrth
  - Ellipse – Fe-rich smectite clay, Al-rich clay (possible hydrothermal alteration from eroded Oyama impact melt layer)
- Holden
  - Crater rim wall and landing site fan – Fe/Mg clay and (mixed layer clays suggest possible impact hydrothermal materials)
  - Ellipse - Fe/Mg clay (possible hydrothermal debris from crater wall and megabreccia)
  - Go-to sites – Fe/Mg clay, Megabreccia
- Eberswalde
  - Crater rim wall above L.S. fan – Fe/Mg clay
  - Ellipse - Fe/Mg clay (possible hydrothermal deposits from crater wall or from megabreccia)
  - Go-to delta - Fe/Mg clay (mixed layer clays suggest possible transported impact hydrothermal materials)

Impact generated crater lake deposits?

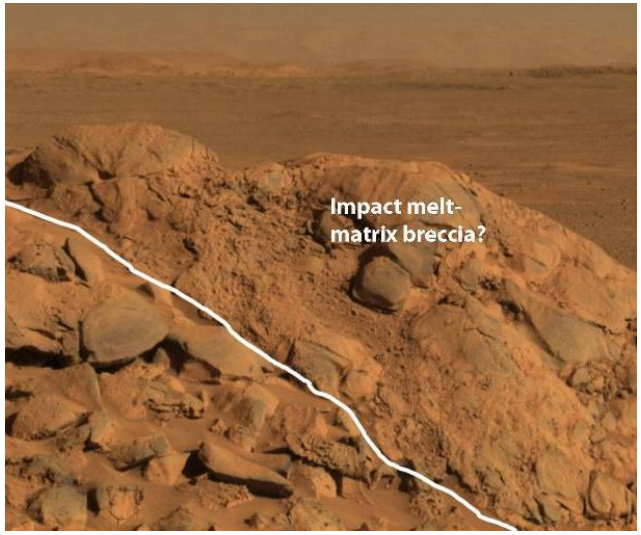
- Early post-impact lake deposits with connections to deep acquifers and impact hydrothermal systems
  - Eberswalde:
    - Ellipse (layered material?) Go-to sites (base of delta?)
  - Holden:
    - Ellipse and go-to sites (layered material)
  - Gale:
    - Northern ellipse (fractured and cemented layers)
    - Go-to sites (layered material at base of mound?)
  - Mawrth:
    - None

Ejecta blankets and impact melt

- Large impact craters and basins
  - Proximal - impact melt sheets covered with melt-bearing breccia (e.g., Sudbury), substantial heat for hydrothermal processes - Mawrth (Oyama ejecta)
  - Distal – melt-bearing breccia (suevite) - Eberswalde (Holden ejecta)
  - No thick hot ejecta in Gale or Holden sites

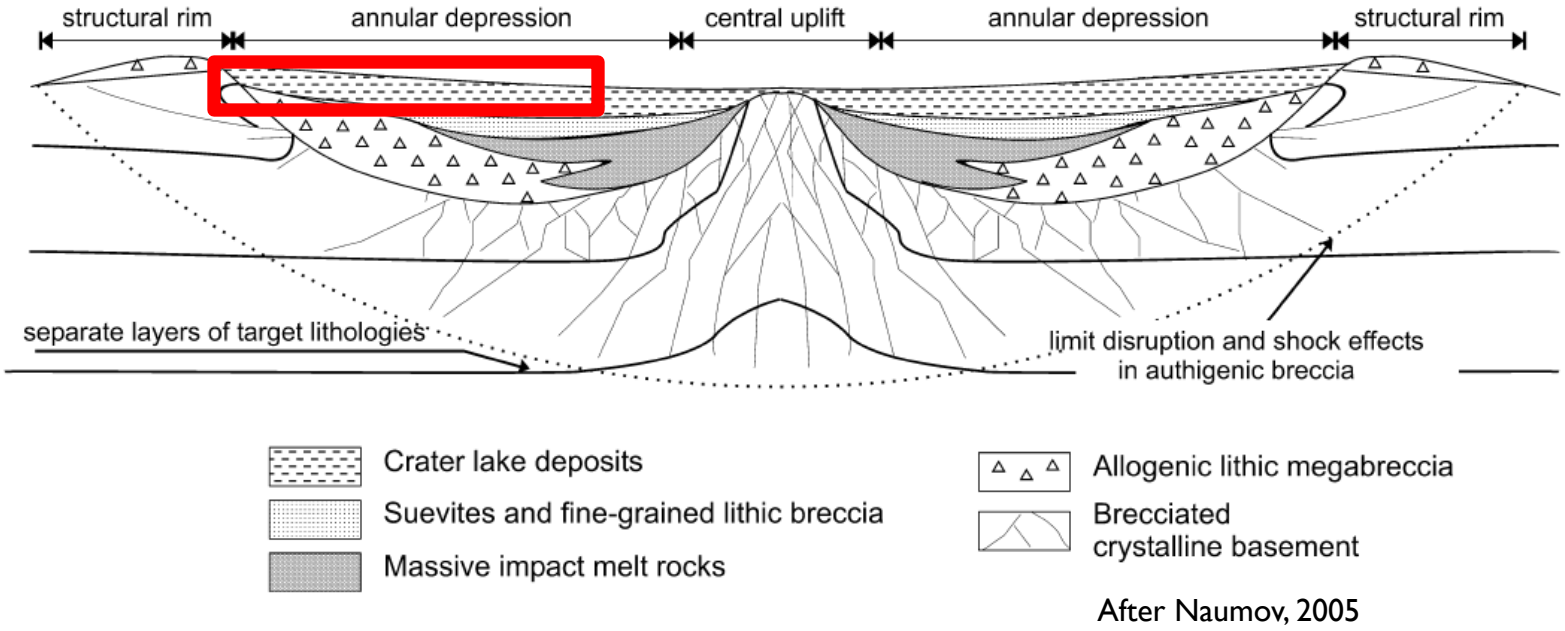
- General characteristics of ejecta blankets
  - Highly shocked melt-bearing breccia(suevite), often in upper layer of ejecta. Can contain degassing pipes and accretionary lapilli
  - Minimally shocked material, consisting of excavated lithologies, ballistic emplacement, often lower layer of ejecta
  - Shocked rocks and even melts can also preserve organics. Example – organic material is preserved in terrestrial impactites, including loess-like targets (Shultz and Harris, 2010)
  - Contributions to surficial materials – soils and dust – especially early soils (paleosols?)

Haughton Crater – brecciated ejecta block



MER-A Spirit - Possible flow-textured impact melt deposit – Similar to Holden ejecta in Eberswalde?

Gale Crater – Megabreccia, transported altered rim materials, and lake deposits?

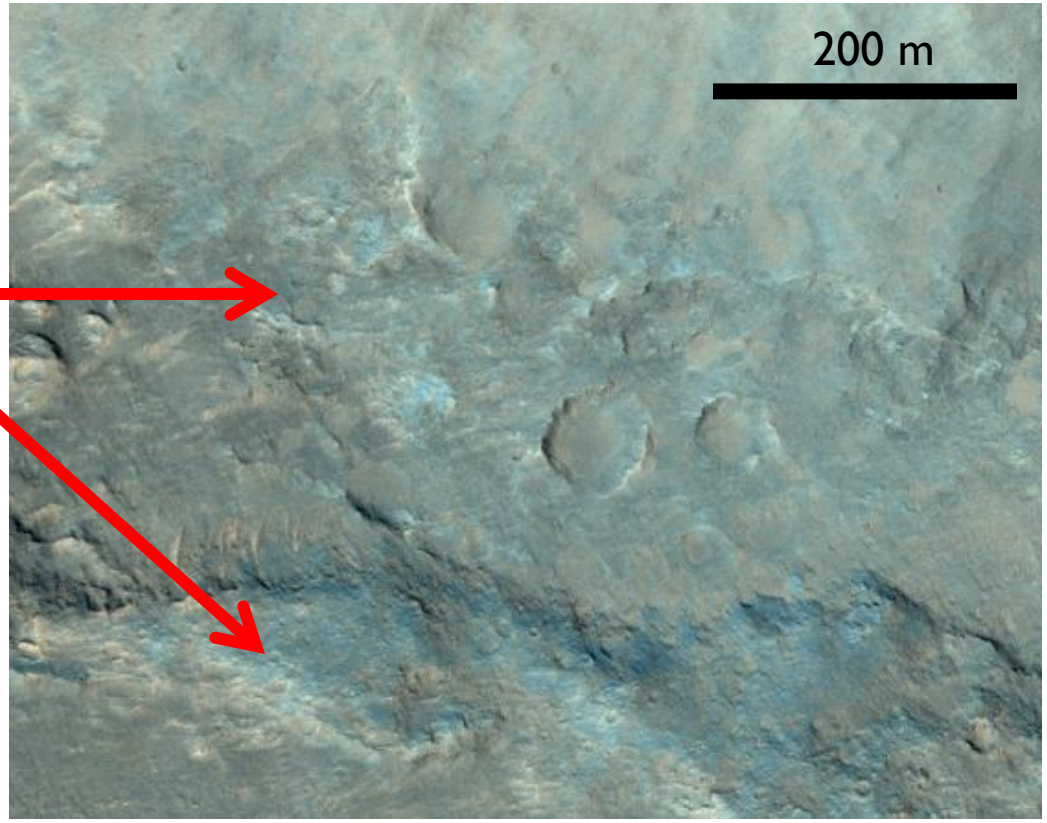


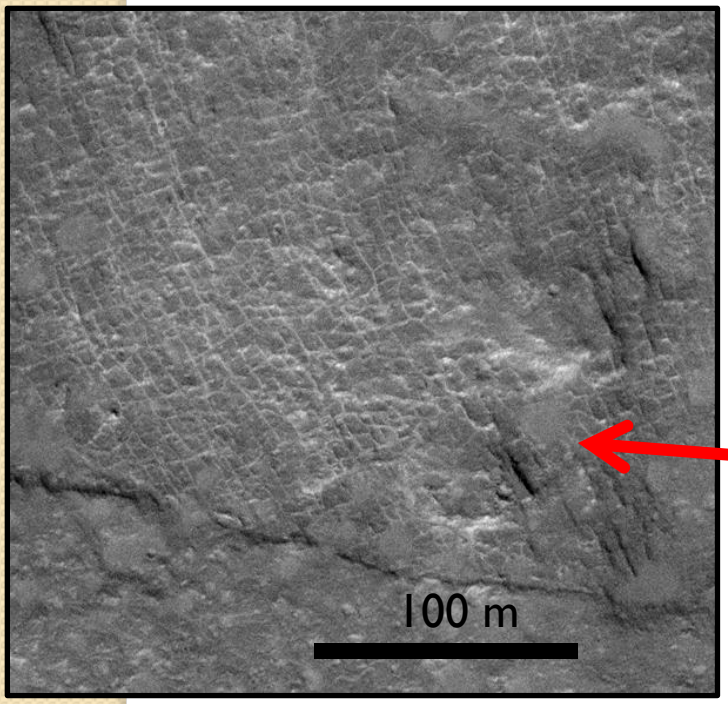
After Naumov, 2005

- Gale ellipse – Northern crater rim: megabreccia (but MSL unlikely to head this way). Central ellipse: lower fan materials with cemented fractures (lake sediments?), transported crater wall material (aqueous and hydrothermally altered basement?)
- Gale mound – Post-impact lake sediments and aeolian or fluvial deposits.
- No exposures of thick and hot impact ejecta or melt sheets

Gale - New HiRISE of N. edge of ellipse

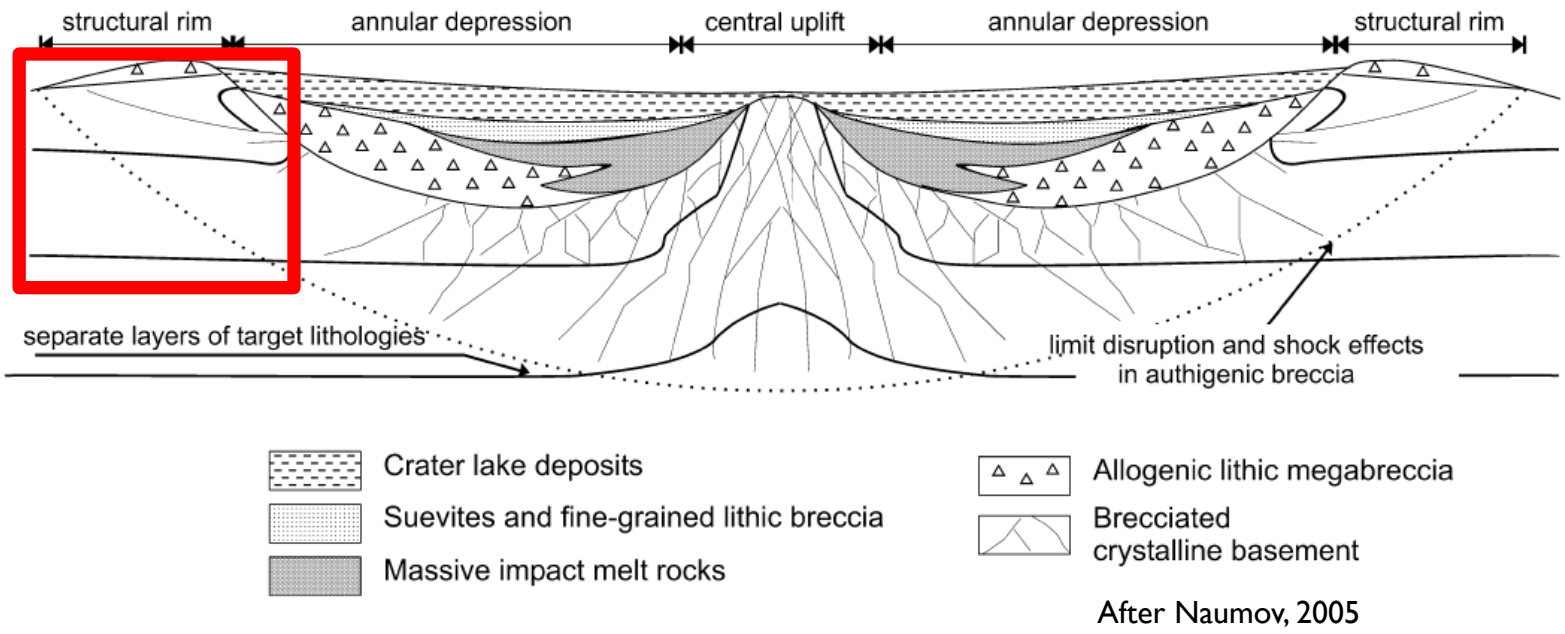
- Megabreccia at base of crater rim? (Parautochthonous basement)
- Inverted channel





- Cemented fractures (e.g., Anderson and Bell 2010) Lake sediments with patterned fill? (north central portion of ellipse)

Mawrth – edge of Oyama Crater



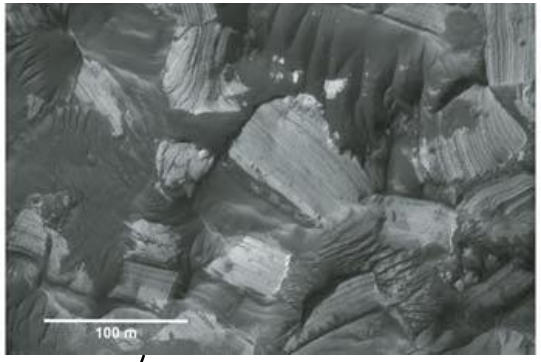
After Naumov, 2005

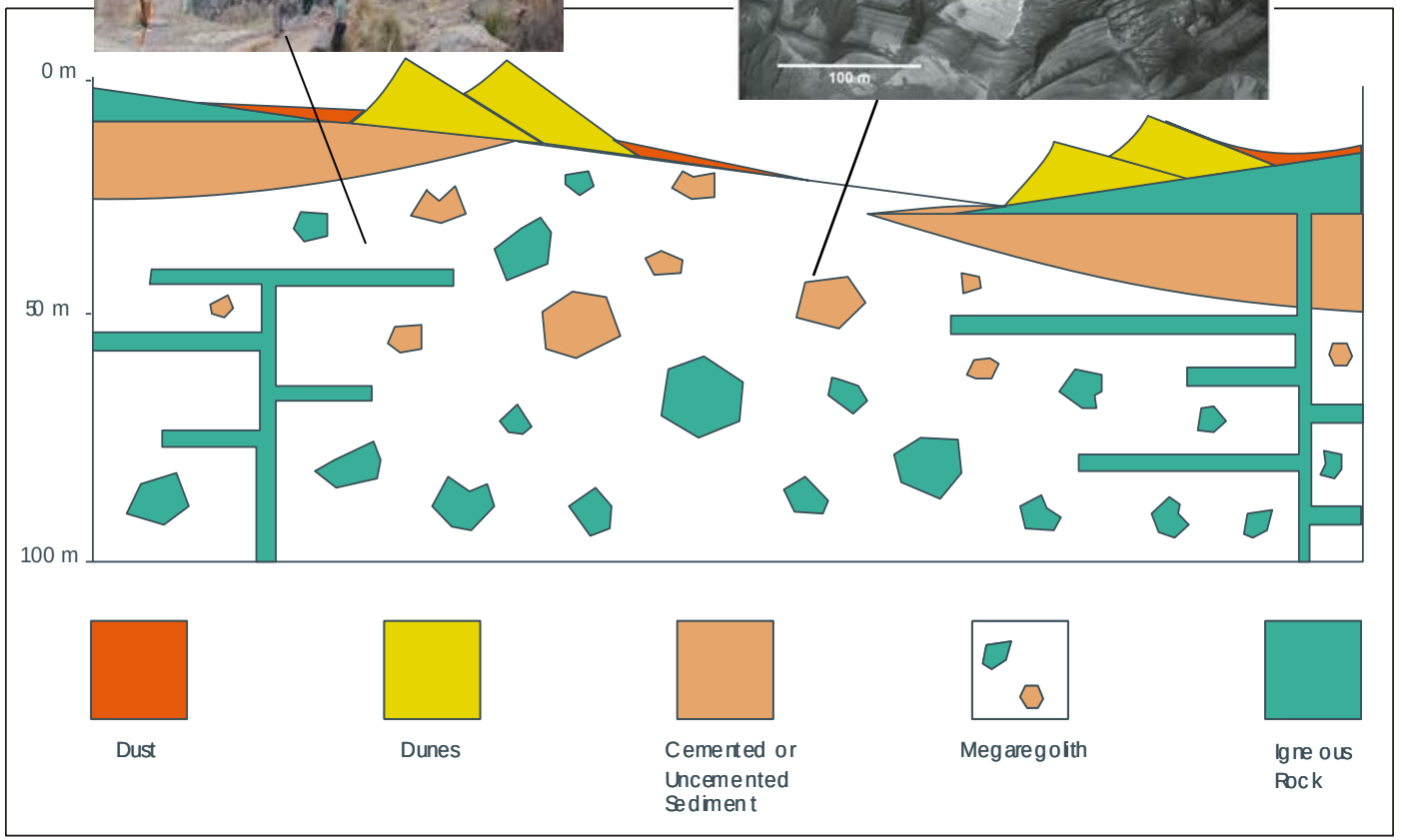
- Mawrth ellipse – Altered basement near Oyama crater,
  - Fractured basement – possible megabreccias
  - Capping unit may be hot ejecta (impact melt-bearing) from Oyama Crater and may be responsible for hydrothermal fluid alteration forming extent clays?

Ancient crust

Fault-related pseudotachylyte

Megaregolith/megabreccia

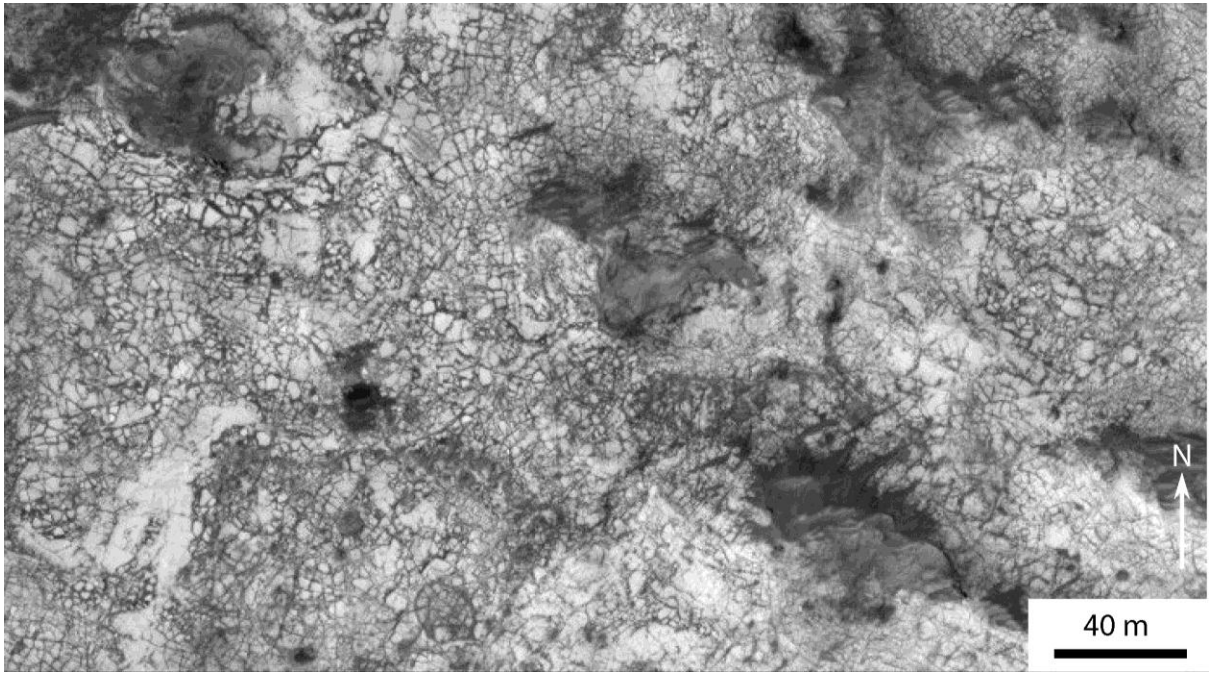




J. Spray

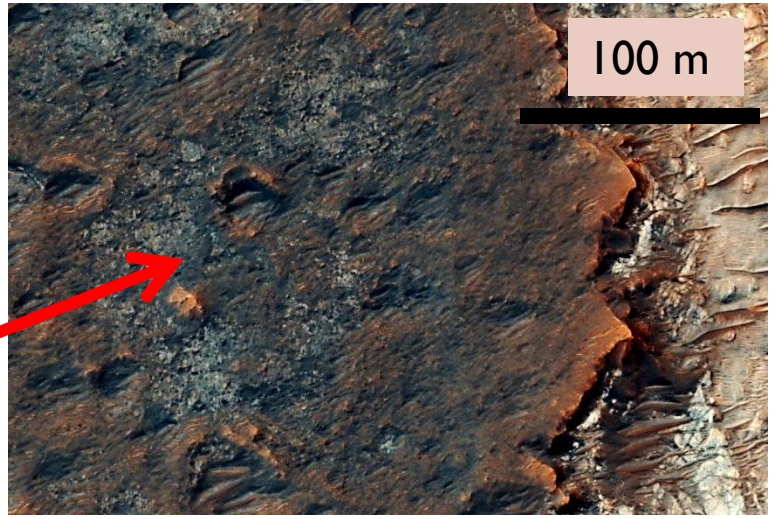
Basement brecciation beneath a transient cavity – See Dawn Sumner's Mawrth talk

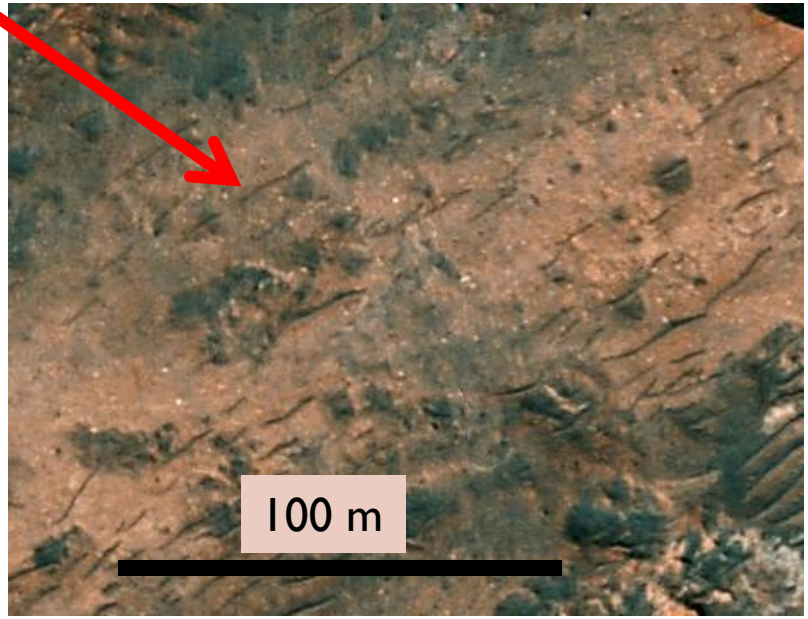
- Mawrth –Possibly in landing site ellipse due to nearby Oyama Crater



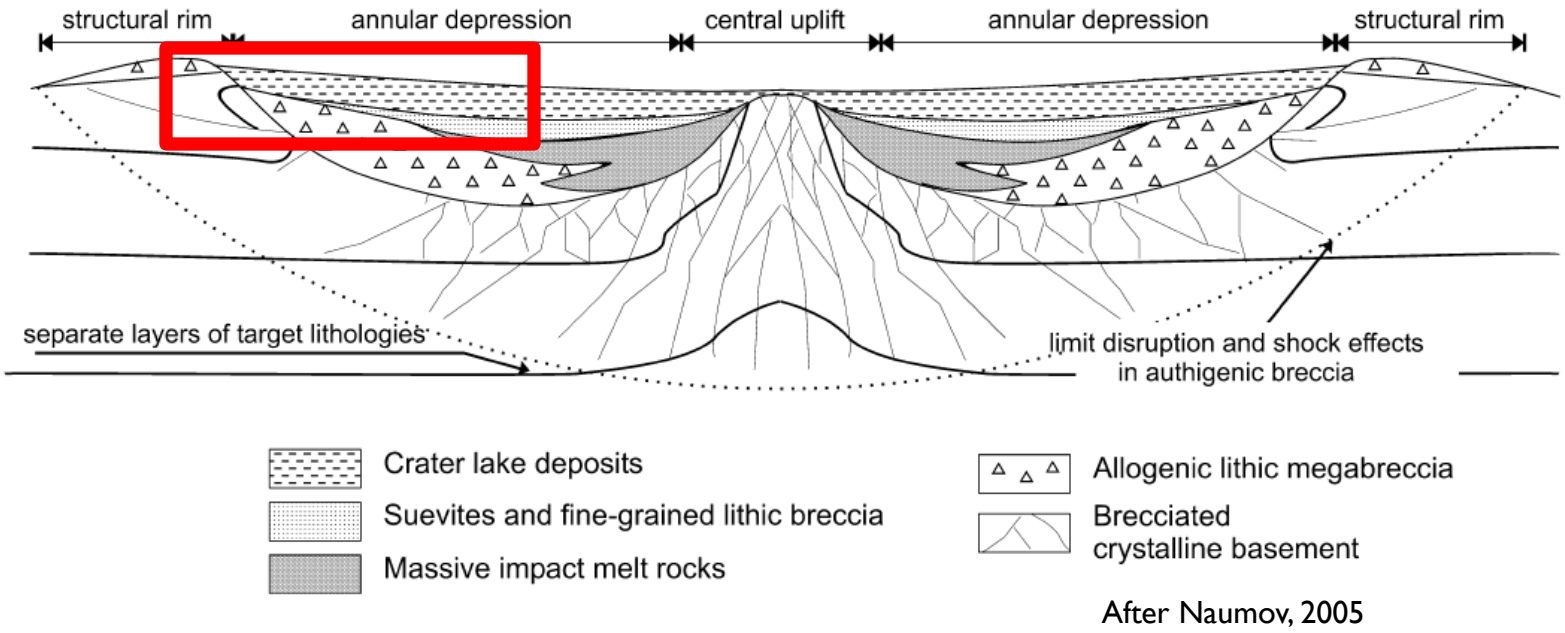
Mawrth - Dark capping unit as impact melt – New HiRISE image West of ellipse

- Evidence for breccia nature of capping unit (allochthonous ejecta probably melt-bearing):
  - from West of the center of Mawrth ellipse
  - along rim of Oyama, north of Mawrth ellipse (new image)
  - Sudbury Onaping melt breccia





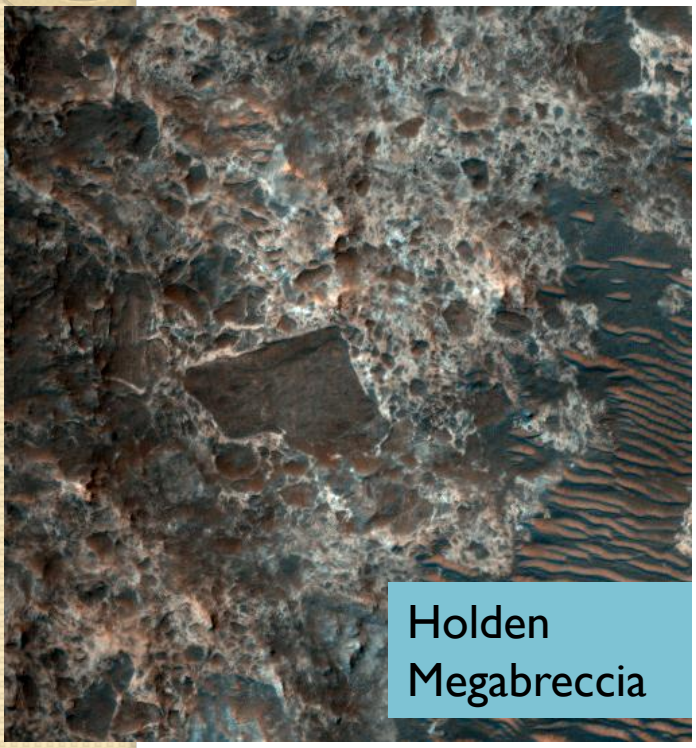
Holden Crater – Megabreccias, lake sediments



After Naumov, 2005

- Holden ellipse – Crater wall material and megabreccia, (aqueous and hydrothermally altered basement) also lake sediments
- Holden go-to – Better examples of lake sediments, megabreccia, impact melt sheet? and aeolian or fluvial deposits
- No exposures of thick and hot impact ejecta or impact melt sheets

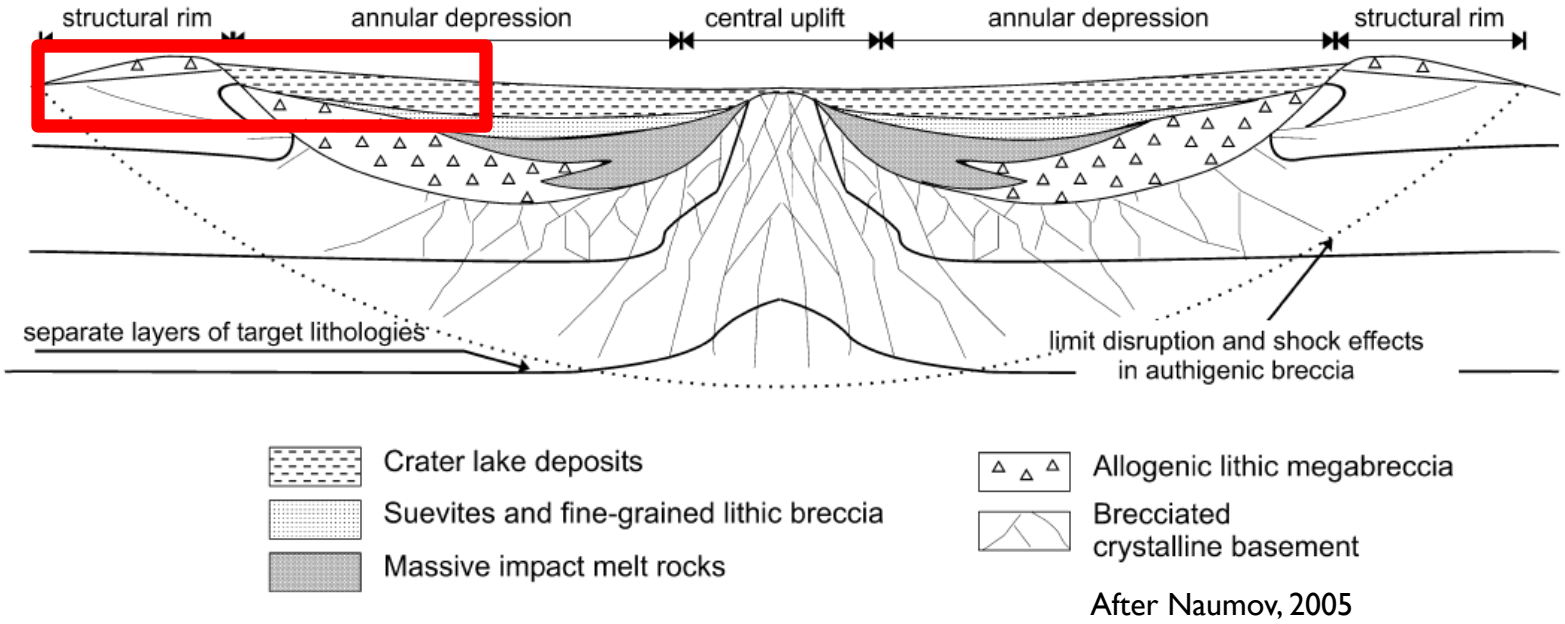
Impact ejecta blocks and megabreccias - meters to hundreds of meters in size, with varying shock levels



Holden Megabreccia

Popigai impact megablock zone, Russia

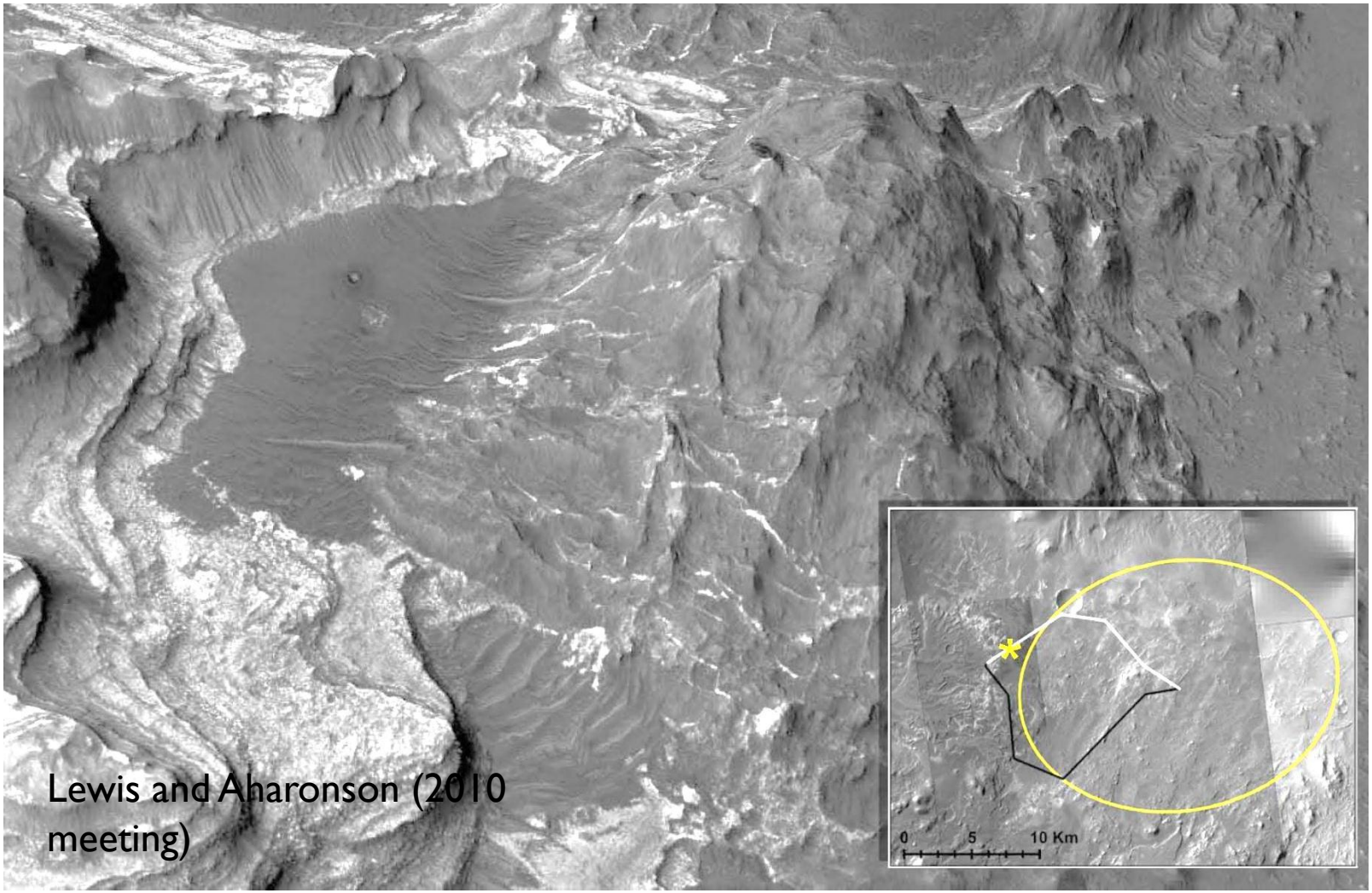
Eberswalde Crater – Megabreccia, Holden eiecta



After Naumov, 2005

- Eberswalde ellipse – Transported crater wall material and megabreccia (aqueous and hydrothermally altered basement?), lake sediments, extensive outcrops of thick ejecta from Holden crater (may include impact melt)
- Go-to sites – Crater rim material, lacustrine and fluvial deposits
- No exposure of the Eberswalde impact melt sheet

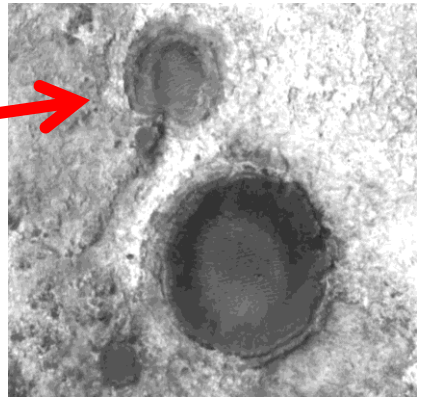
Eberswalde – megabreccia outcrop



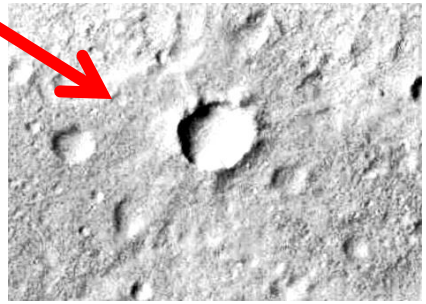
Lewis and Aharonson (2010 meeting)

Smaller craters in landing site

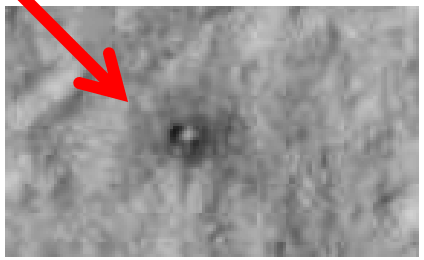
- Ancient eroded or exhumed craters – possible exposures of local units in craters
- Craters with extent ejecta blankets – representative samples of local units with stratigraphic context
- Young recent or "fresh" craters with ejecta blanket, surface blocks and meteorites
  - Materials or rocks due to recent groundwater (or ground-ice?) alteration, including salts or evaporites should be accessible as clasts in ejecta (e.g., Lonar ejecta clasts – both shocked and unshocked - of aqueously altered basalt: (Wright & Newsom, LPSC 2011)



Mawrth ellipse



Gale ellipse



Gale ellipse

Impact crater processes - conclusions

- Impact hydrothermal deposits – Allochthonous or parautochthonous impact megabreccias
  - Holden – Ellipse megabreccia outcrop, transported fan deposits, also in Go-to site
  - Eberswalde – Ellipse megabreccia outcrops
  - Gale Rim – Outcrop edge of ellipse (but wrong direction from mound), fan deposit
- Thick ejecta blanket– Autochthonous impact melt bearing breccias
  - Eberswalde – Ellipse outcrops of Holden ejecta
  - Mawrth – Ellipse capping unit - remnants of Oyama ejecta?
  - Holden – Possible distal ejecta layers in fan and sediments
  - Gale – Possible distal ejecta layers in fan and sediments
- Small crater deposits and processes – All sites
  - Excavation and preservation of target rocks – traceability to formations, meteorites, shallow aqueous processes, salts, chlorides, etc. with evidence for recent climate conditions