Radar Imagery of the Chryse-Xanthe Region, Mars

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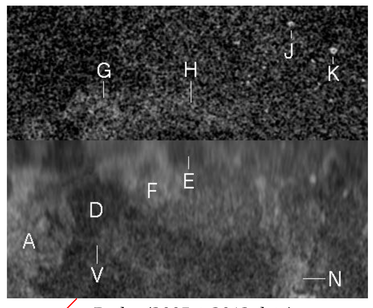
Introduction

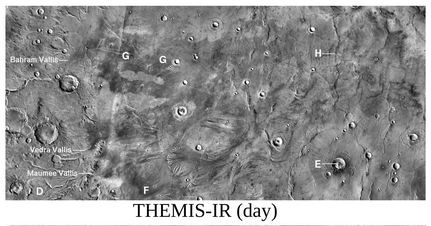
Earth-based radar imagery of Mars has been used to map regions of enhanced small-scale (sub-meter) surface roughness based on the brightness of the depolarized echo component. Although most bright depolarization features are associated with lava flows in the major volcanic provinces [1,2], some apparent non-volcanic bright features were also seen in early (pre-upgrade) Arecibo imagery of the Chryse–Xanthe region [3]. Here we present updated imaging results for Chryse–Xanthe and environs based on observations made with the upgraded Arecibo radar during the 2005 and 2012 Mars oppositions. We will concentrate on four specific subregions showing bright depolarization features that appear to be signatures of aqueous deposition/modification or other effects peculiar to the unique Chryse–Xanthe region.

Southwest Chryse and VL-1 Lander Site

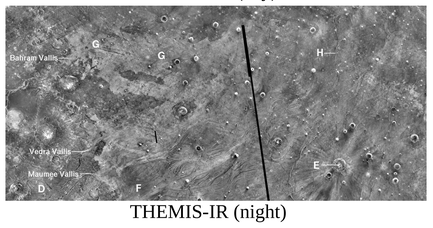
Northeast of Maja–Lunae Basin **(A)** is a radar-bright region covering a large area of southwest Chryse Planitia. This feature, which is separated from the Maja–Lunae feature by the radar-dark Xanthe Montes **(D)**, appears to be largely attributable to rocky outwash debris debouched from the various narrow Maja-system drainage channels cutting through the Montes. The brightest part of the southwest-Chryse feature constitutes a large arc that wraps around the north and west sides of the dark-halo crater Santa Fe **(E)**. The southern part of the arc **(F)** appears to be largely outwash debris from Maja, Vedra, and Maumee Valles, while the northern swath **(G)** may be dominated by rocky flood deposits from Bahram Valles. There is support for this scenario from THEMIS imagery, which shows dark daytime IR features and bright nighttime IR features in the Bahram and Maja-Vedra-Maumee outwash zones. The radar image shows the Viking-1 lander site **(H)** lying on the eastern end of the northern bright band **(G)**. This suggests the possibility that the VL-1 lander site contains surface debris from Bahram Valles. At the very least, the radar and THEMIS imagery strongly suggest that the Bahram Valles outwash deposits are more extensive than previously thought.



Radar (2005 + 2012 data)

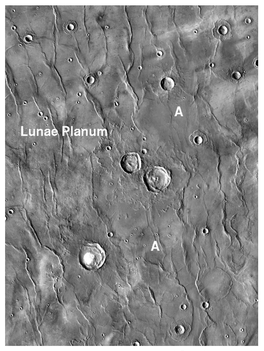


THEMIS-IR (day)



THEMIS-IR (night)

"Maja–Lunae Basin" (west-side detail)



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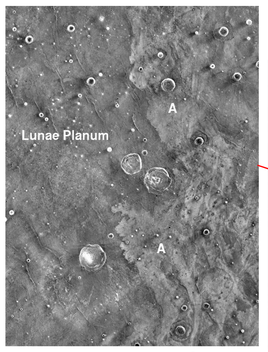

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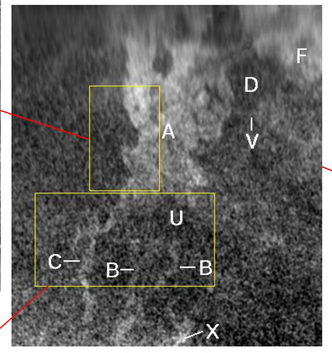
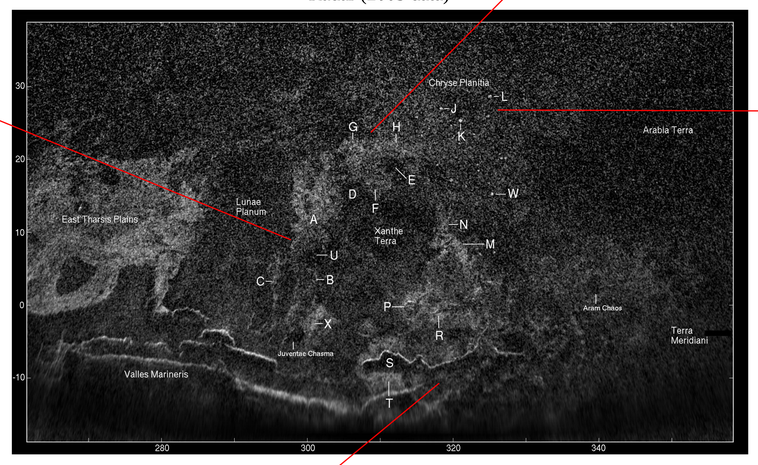
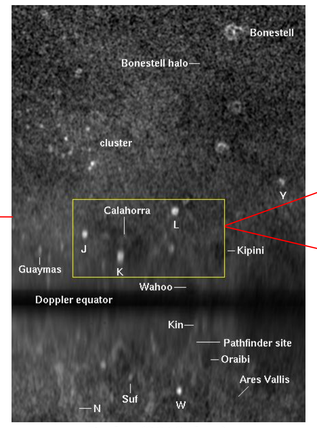


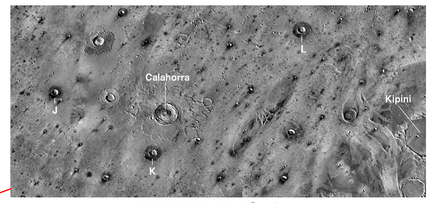
Radar (2012 data)

Radar (2005 data)





Radar (2012 data)



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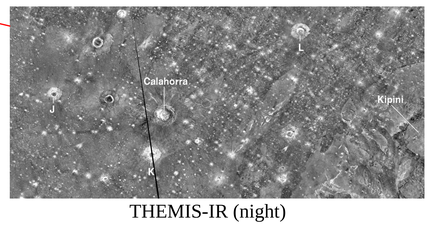
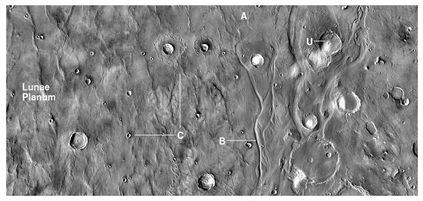


THEMIS-IR (night)

"West Branch" and Maja Valles



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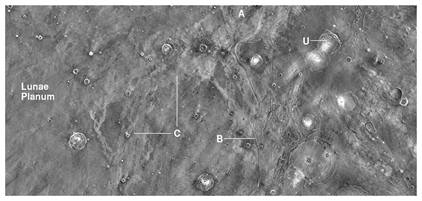
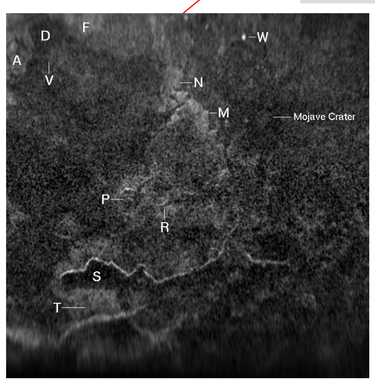


THEMIS-IR (night)

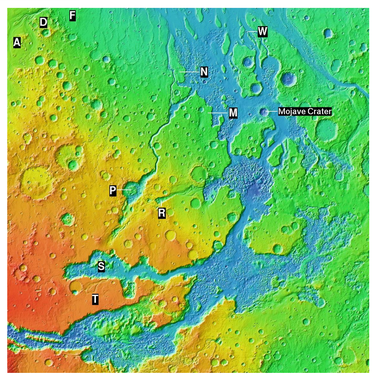
"Maja–Lunae" Complex

The most prominent of the Chryse–Xanthe radar features is a large bright patch **(A)** centered near 300°E, 15°N. This "Maja–Lunae Basin" feature includes previously mapped mapped Maja Valles floodplain as well as an extended portion of eastern Lunae Planum to the west. The feature apparently shows where rocky sediments have been deposited by floods and/or debris flows debouching from the south. The southern source flows include Maja Valles itself **(B)** as well as a previously unrecognized "West Branch" **(C)** that appears to have arisen from catenae west of Juventae Chasma. The Maja-Lunae Basin, Maja Valles, and West Branch all show up as bright in THEMIS nighttime IR images (see above), which would be consistent with surface coverage by high-thermal-inertia material such as rocky sediments. A radar-dark gap between the Maja Valles features and the Maja–Lunae Basin is attributable to surface mantling by radar-absorbing ejecta from a dark-halo crater **(U)**. A rather faint radar-bright feature **(V)** appears to show a breakout flow that exits the eastern edge of the Maja–Lunae Basin and spreads out across the Xanthe Montes **(D)**. Just to the north of this can be seen narrow radar features showing where the Maja Valles outlet channels cross Xanthe Montes before debouching into a radar-bright region **(F)** of southwest Chyse basin. Another radar-bright feature **(X)** in the Maja–Lunae region is corresponds to an unusual cratered mountain located just northeast of Juventae Chasma; the radar brightness of this feature probably represents backscatter off rocky debris on the eroded slopes and alluvial fans of this mountain. The floor of Juventae Chasma itself is very radar-dark, which indicates mantling by some low-density, non-rocky surface material. In general, the radar and infrared imagery suggest that the floods and flood deposits in the "Maja–Lunae" region were more areally extensive than is usually recognized.

Xanthe Terra



Radar (2005 + 2012 data)



MOLA topography

Xanthe Plateau Features

The Xanthe Terra region south of Chryse shows three main radar-bright regions, all of which are located on plateaus bordering chasma, chaos, or channel features. The first of these includes the north edge **(M)** of the plateau between Simud and Shalbatana Valles and the island plateau **(N)** just to its north. The second region includes the plateaus surrounding Orson Welles Crater and chaos **(P)** and the Aromatum Chaos/Ravi Valles complex **(R)**. The third region lies on the plateau surrounding Ganges Chasma **(S)** and includes Aurorae Planum **(T)** separating Ganges and Capri Chasmata. Some possible explanations for the Xanthe radar features include: debris deposition by overbank flooding; surface roughening by subsurface aqueous eruptions, possibly associated with incipient chaos formation; and dielectric enhancement through aqueous induration or alteration.

Central Chyse and Bright Craters

Central and northern Chryse Planitia shows moderate depolarized radar brightness attributable to rocky outwash from the various southern and western channels draining into the basin, although the deposits are probably sparser than those in the brighter Maja outwash region of southwest Chryse. Superimposed on the general background brightness of the region are numerous bright and dark features associated with impact craters. The dark features are identified with "dark-halo craters" such as **Calahorra**, which are similar to dark-halo craters seen in Mars' volcanic regions [2], or with other craters (**Kipini**, **Oraibi**, **Wahoo**) whose elevated rims divert surrounding radar-bright outwash. The unusual crater **Bonestell** is interesting for showing a radar-bright rim and central dome as well as a large surrounding radar-dark halo. The radar-bright crater features are mostly "bright-ejecta craters" of a type we have not found elsewhere on Mars outside of the Chryse–Xanthe channel region. The more prominent of these include a trio of named craters Lismore **(J)**, Grindavik **(K)**, and Sefadu **(L)**, a fourth crater **(W)** located in channel floor near the terminus of Tiu Valles, and a cluster of smaller bright craters northwest of the trio. The ejecta blankets of these craters appear very bright in THEMIS nighttime infrared images and dark in daytime IR images (see above), which implies very rocky ejecta surfaces consistent with the radar brightness. The fact that the bright-ejecta craters are located in outwash plains or outflow channel floors suggests that aqueous modification/alteration effects were conducive to the formation of rocky impact ejecta, although it is also possible that Chryse has peculiar crustal properties making for rockier ejecta.

Summary

Arecibo radar imagery of the Chryse–Xanthe region of Mars reveals an interesting variety of radar-bright depolarization features that can be identified with enhanced diffuse backscatter from the following types of surfaces:

(1) Rocky floodplain or outwash debris deposited by aqueous flows.
(2) Unusually (for Mars) rocky ejecta blankets of impact craters.
(3) Rough plateaus surfaces bordering chasma, chaos, and channel features.

Perhaps the two most important questions raised by these findings are:

(1) What mechanism is responsible for the surface roughening of the Xanthe plateau border regions?
(2) Why does Chryse host bright-ejecta craters not seen elsewhere on Mars?

References:

[1] Harmon, J. K. et al. (1999). Mars mapping with delay-Doppler radar. *J. Geophys. Res.*, *104*, 14065–14089.
[2] Harmon, J. K., et al. (2012). Arecibo radar imagery of Mars: The major volcanic provinces. *Icarus*, *220*, 990–1030.
[3] Harmon, J. K. (1997). A radar study of the Chryse region, Mars. *J. Geophys. Res.*, *102*, 4081–4095.