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Geological, geochemical, and engineering criteria for choosing a landing site on Europa

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Abstract

We have a presented a short list of landing site candidates for a Europa lander mission based on the combined data sets that are available from Voyager and Galileo, and taking into account geological and gechemical interests in addition to engineering concerns. This list should help in selecting prime targets for high resolution cameras on future orbital missions to the Jovian system.

Introduction:

The Jovian satellite Europa represents one of the most intriguing planetary bodies within our solar system. Scientific planetary missions to Europa would seek to ascertain the composition of its frozen surface, confirm the hypothesis of an underlying liquid ocean, and crucially, search for past or even present traces of life. Ideally, a lander would be employed to carry out geochemical and biological investigations on the satellite surface. In this case, careful choice of suitable landing sites would be critical to both the fulfilment of its scientific objectives and engineering constraints. This work aims at selecting suitable locations meeting these criteria.

Available datasets:

The site candidates are chosen through the analysis of high (less than 100m/pixel) and medium resolution (100-300 m/pixel) images of the Galileo solid state imager (SSI), and spectral data from the near-infrared mapping spectrometer (NIMS). The aim of this approach is to combine the knowledge of the terrain geology and morphology [1] with spectral data of areas of chemical significance [cf. 2, 3]. Due to lack of high resolution images from high latitudes, all the site candidates are proposed in the mid latitudes, i.e. ±50 degrees from the equator.

Geological considerations:

A thorough and detailed description of the various geologic units and history of Europa's geologic evolution has been carried out by several authors [cf. 1, 4, 5]. The relevant part to this work is that a candidate landing site should be chosen with the aim of analyzing material that has been ejected recently in geologic terms, i.e., mottled terrain and Chaos regions (see the references above for details). Consequently, we have chosen sites that are mostly located in Chaos regions, pull-apart bands, and regions that show evidence of recent material ejected from the surface, ex., Fig. 1(c, d, h, i, and k). In addition, large impact craters with central peaks are targets of high scientific values regardless of their age. Large craters would contain material excavated by the impact process that otherwise would not be directly accessible to analysis. For that reason, we included two crater targets to the candidate sites: Pwyll crater (fig. 1a) and an unnamed crater north of Manannán crater that lies in old rough terrain (fig. 1b). Both craters are almost 25 km in diameter and display central peak features.

Geochemical considerations:

Spectra of Europa were acquired by the NIMS instrument during the Galileo mission. The most interesting spectra collected were those for regions showing what came to be named "Non-icy" material which are characterized by distorted and asymmetric adsorption features near 1.5 and 2 μm [6]. Many candidates were chosen to explain these features, but the two most prominent candidates have been hydrated salts [2], hydrated sulfuric acid [3], or a combination of both [7]. It is clear that one of the main objectives of any upcoming lander mission would be not only the in-situ analysis of ice, but also that of these "non-icy" materials. Consequently, we have taken into account spatial distribution of this material in choosing our candidate landing sites in order to maximize the

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scientific gains of the mission (Fig. 2). Consequently, most of the candidate sites fall in regions that show high concentrations of non-icy material as shown in fig. 2

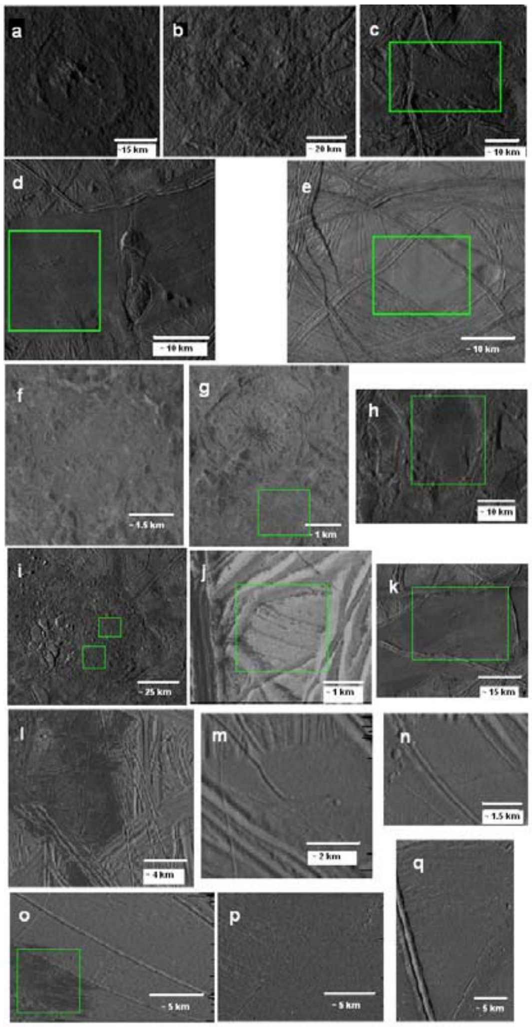

Fig. 1. Candidate landing sites; (a) Pwyll crater; (b) Unnamed crater north of Manannán crater lying in old rough terrain ; (c) Small dark area south of Belus linea, highly indicative of recent material that has been injected into the surface disrupting the previous terrain; (d) Dark pull-apart band south of (c) of material that has cut through and separated the older ridges on either side of the band; (e) A remarkably "smooth" inter-banded region between several small ridges lying in region full of small unnamed lineae between Cadmus Linea in the north and Belus linea in the south; (f) A rather smooth region within the Dyfed Regio east of Manannán crater; (g) A smooth region just south of Manannán crater which appears in the upper part of the image; (h) A smooth plain in a chaotic terrain south of Belus Linea; (i) A chaotic-like terrain southeast of Manannán crater, similar in appearance and mode of formation to (c) but on a larger scale. No higher resolution images exist for this region to asses it fully in terms of its suitability for a lander; (j) One of the highly resolved sites on the eastern edge of Yelland Linea in Argadnel Regio; (k) A pull-apart dark band similar to (d) west of Castalia Macula in the Argadnel Regio; (l) A highly resolved area in the Thrace Macula. Note the contrast between the Macula and the surrounding terrains in terms of color and texture; (m) and (n) Both taken from the same high resolution image for terrain around Thrace Macula. Should prove as excellent targets for "older" terrains; (o) Another site in the terrain around Thrace Macula which seems to show a transition between the darker and lighter colored terrains (appears more clearly in the parent image); (p) and (q) High-latitude targets around an unnamed Macula-like terrain around Libya Linea. The area shows features similar to the pull-apart bands of (d) and (k).

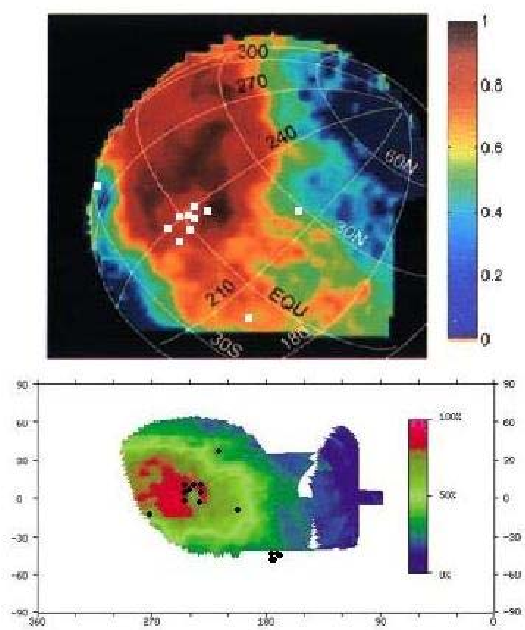

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Fig. 2. Global distribution of “non ice-mixtures” as measured by NIMS onboard Galileo. White squares (upper panel)and black dots (lower panel) represent approximates locations of the candidate landing sites; **(a)** Spatial distribution of what McCord et al., assumed to be hydrated salts; **(b)** Similar distribution fractions reported by Carlson et al., assuming the non-ice mixtures to be those of hydrated sulfuric acid mixtures.

Engineering considerations:

The severe radiation environment at Europa should present significant challenges for the scientific payload. Nonetheless, despite Europa’s lack of a permanent magnetic field, it still attenuates a large portion of the electron and proton fluxes by absorbing them along the moon’s trailing hemisphere (centered on 270W) [9]. This is bad news considering that most of the proposed landing sites fall within the center of the trailing hemisphere. It is clear by now that the choice of a landing site is biased by two important factors: scientific interest (i.e., geochemical data), and more significantly, the larger high resolution image database for the trailing hemisphere. Indeed, the only high resolution images we have for Europa’s leading hemisphere, are the ones taken during Galileo’s E11 orbit (11^{th} orbit around Jupiter, with Europa being the main imaging target) of a small (50 by 80 km) area[10]. However, it is assumed that the final choice for a landing spot would be based on high-resolution data acquired beforehand by the orbiting “mothership” carrying the lander. It is assumed that the lander will separate from the orbiter when it arrives, maintains a closed orbit (circular or otherwise), and collects data that can help in constraining a candidate site. In terms of engineering safety concerns, the chosen landing sites have been picked in areas with a combined scientific interest and apparent “smoothness” of the terrain which would be essential for a safe landing.

Conclusions & Future work:

This work shows that even with our currently available data, it is still possible to propose prime target areas for a lander, which can be further revised when more data is available. Future work should address the radiation environment more thoroughly to assess objectively the pros and cons of choosing a landing site in the leading or trailing hemispheres of Europa.

Fig.#	Image ID*	Lat*	Lon*
2a	11E0012	5.7	240.5
2b	E6E0031	-25.3	274.6
2c	11E0014	-0.1	240.2
2d	11E0016	-5.9	240.1
2e	15E0007	29.8	220.1
2f	14E0006	3.3	238.8
2g	14E0007	3.3	239.4
2h	11E0011	5.8	234.3
2i	11E0013	0.0	234.0
2j	12E0067	-16.7	196.0
2k	11E0015	-5.8	233.9
2l	17E0056	-47.0	173.5
2m	17E0057	-47.7	172.1
2n	17E0057	-47.7	172.1
2o	17E0058	-48.4	170.6
2p	17E0059	-52.7	177.6
2q	17E0060	-51.7	177.2

Table 1. Source images in the PDS library for the images displayed in Fig. 3. Latitude and longitude values are the central coordinates of the parent image, so the actual coordinates of the small sub-images may differ slightly. Longitude values are counted from the local West. Latitude values are counted from the local equator with negative values indicating locations in the southern hemisphere. ***** Image ID, Intercept point latitude, and intercept point longitude are the official header descriptions in the PDS library for Galileo images

References

[1] Papplardo R. T., et al., (1999), JGR, 104, 24,015-24055.

[2] McCord, T.B., et al., (1999), JGR, 104, 11827-11,851.

[3] Carlson R. W., et al, (2005), Icarus, 177, 461-471.

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European Planetary Science Congress,
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[4] Carr, M.H., et al., (1998) Nature, 391, 363-365.
[5] Procketer L. M., et al., (1999), JGR, 104, 16,531-16540.

[6] Dalton J. B., et al., (2005), Icarus, 177, 472-490.

[7] Orlando T.M. et al., (2005), Icarus, 177, 528-533.

[8] Ball A. J, Garry R. C., Lorenz R. D., and Kerzhanovich V. V., (2007), Planetary Landers and Entry Probes, ISBN 978.5218200028, Cambridge University Press.

[9] Paranicas C., et al. (2007), Geophyical. Research Letters., Vol 34, L15103.

[10] Figueredo, P. H., and R. Greeley (2000), JGR., 105(E9), 22,629–22,646.