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| | |

1. **Nature:** R = Report, P = Prototype, D = Demonstrator, O = Other

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PU

Public Restricted to other programme participants (including the Commission Service)

PP

Restricted to other programme participants (including the Commission Service)

RE

Restricted to a group specified by the consortium (including the Commission Services)

CO

Confidential, only for members of the consortium (excluding the Commission Services)

Executive Summary / Abstract:

An update for Year 2 of the GMAP VA activities (WP8) is provided. Community mapping projects developed, as well as documentation and tools through deliverable production to support the community. Training activities have been performed (1st Winter School - Online) and subsequent ones organised and about to be held (2nd Winter School - Online). Engagement with the community was performed using online interaction, monthly calls, and remote support. Overall, the VA activities were not too negatively affected by the pandemic. Future activities of the GMAP VA will aim at being robust enough, regardless how the external situation will play out.

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1. List of acronyms and abbreviations

Table 1: Acronyms and abbreviations

| Acronym | Description |
|----------------|--|
| ASP | Ames Stereo Pipeline |
| CERN | Conseil Européen pour la Recherche Nucléaire |
| DFG | Deutsche Forschungsgemeinschaft |
| DoA | Description Of Action |
| DTM | Digital Terrain Model |
| EPEC | Europlanet Early Career |
| ESPL | Earth and Planetary Science Letters |
| ESA | European Space Agency |
| EU | European Union |
| FAIR | Findability, Accessibility, Interoperability, and Reuse |
| ISIS | Integrated Software for Imagers and Spectrometers |
| IRSPRA | Istituto Superiore per la Protezione e la Ricerca Ambientale |
| ISRU | In-Situ Resource Utilisation |
| JRA | Joint Research Activity |
| NA | Networking Activity |
| MOST | Ministry Of Science and Technology |

| | |
|---------|---|
| PLANMAP | Planetary Mapping Project |
| PSIDA | Planetary Science Informatics and Data Analytics (conference) |
| RI | Research Infrastructure |
| RMB | Chinese Yuan |
| USGS | United States Geological Survey |
| VA | Virtual Access |
| VESPA | Virtual Planetary and Solar European Access |
| GMAP | Geologic MApping of Planetary bodies |

2. Introduction

The GMAP VA activities (see DoA, D8.1) include the following tasks:

- Task 8.1 - Coordination
- Task 8.2 - Community Mapping Projects
- Task 8.3 - 2D/3D Geological mapping
- Task 8.4 - Geological Mapping Integration
- Task 8.5 - Sustainability

The various tasks, individually and collectively based on inputs and developments of the JRA (e.g. Nass et al., 2020; D9.1, Rossi et al., D9.2), have started, and the first deliverables have been produced.

The Covid situation has prompted some delay for the upcoming deliverables and milestones, as detailed in the relevant section.

The first GMAP VA Call coincided with the 1st GMAP Winter School, and resulted in several community mapping projects, and the subject of a specific upcoming deliverable (D8.5) detailed in later sections and listed on the GMAP wiki.¹

3. Impact of the COVID-19 situation on VA

GMAP VA Activities coped with the prolonged pandemic situation and took advantage of the challenging boundary conditions, maximising the use of online platforms, events and interaction, as well as JRA (see D9.6, Rossi et al., 2022). Paradoxically, the

¹ <https://wiki.europlanet-gmap.eu/bin/view/Main/community%20mapping%20projects/>

1st Winter School benefited from the situation and GMAP managed to reach a far greater number of individuals and groups than it could have ever done with a similarly scheduled in-person event.

Therefore, despite the many disadvantages posed by the SARS-cov2 pandemic, VA activities could expand their reach, possibly.

The impact on deliverable dates has been estimated and is reflected in the updated schedule with just slight delays, compatible with the overall project timeline (see last Grant Amendment).

4. Activities performed (per task) in the reporting period

The performed activities are described for each task. Plans and timelines for upcoming activities of the various tasks are provided in the final section.

Task 8.1 - Coordination

Activities of coordination Task 8.1 during the second year targeted the implementation of basic services that will be needed for supporting VA and JRA activities in terms of digital infrastructure.

The website², described in D8.2 (Massironi, et al., 2021), has been populated and posts periodic updates and relevant information for the GMAP and the planetary geologic communities. Typically, news items of relevance for the GMAP community are selectively shared and posted via NA on the main Europlanet RI website³ and relevant social media.

To support the code development and long term tracing of the activities, an internal GitLab instance is maintained at git.europlanet-gmap.eu, as well as at <https://github.com/europlanet-gmap>, providing the repository system that will be used internally for development purposes and versioning control.

Management of tasks, including deliverable design, preparation and finalisation has been performed throughout the second year of GMAP VA using the issue-tracking system of the GitLab instance of GMAP. This has also been used to support JRA activities and, in general, to foster and simplify collaborative tasks across partners.

Since the previous report (D8.1, Massironi et al., 2021) the GMAP wiki⁴ has been populated further and extended, in particular its public portion. In addition to providing entry points to access deliverables, the wiki is progressively going to host

² <https://europlanet-gmap.eu/>

³ <https://www.europlanet-society.org/europlanet-2024-ri/>

⁴ <https://wiki.europlanet-gmap.eu/>

basic information on community mapping projects, later to be embedded and integrated in the GMAP data portal (spring / summer 2022).

Task 8.2 - Community Mapping Projects

Task 8.2 has been the subject of the most action in the previous year, kick-started at the 2021 Winter School and supported by monthly GMAP community calls⁵ as well as informal non-periodic community interactions (mailing list, Discord server, etc).

Initial support to the community of mappers has been provided by GMAP members in the form of data processing and map-creation support. Contacts with mappers has been mostly inherited by previous projects, although some new collaborations have been already established (i.e. University of Tokyo) and further ones have been initiated after the first edition of the Planetary Mapping Winter School. The upcoming edition of the school, which is currently undergoing preparation, will foster the creation of new collaborations.

The user-base will consistently be increased during next month's activities that will directly target individuals and entities through dedicated actions. In addition to distribution through the Europlanet newsletter and social media, mailing lists and directly reaching out to different countries/areas is planned through VA partners and the RI, including EPEC. A dedicated upcoming deliverable (D8.5) will detail community mapping projects' focus, status and outlook. The currently identified projects are listed in Table 2:

⁵ <https://wiki.europlanet-gmap.eu/bin/view/Main/GMAP%20community%20telecons/>

Table 2: Started community mapping project as of Year 2.

| Mapping project title | Project lead | GMAP contacts / reference partners | Notes |
|---|-----------------------|---|--|
| China's Chang'e-5 landing site: Geology, stratigraphy, and provenance of materials (2021) EPSL 561, 116855. https://www.sciencedirect.com/science/article/pii/S0012821X20306464 https://zenodo.org/record/5015053#.YO7WvUyxWUk | Qian | WWU: van der Bogert, Hiesinger | |
| Morphological mapping of the lunar south pole | Such | WWU: Poehler, van der Bogert, Hiesinger | |
| Geology of the Hypanis outlet region | Agnese Caramanico | UDA: M. Pondrelli | |
| Geology of the Tyras Vallis area | Davide Defilippis | UDA: M. Pondrelli | |
| Chronostratigraphic reconstruction of Eastern Tharsis volcanism | Pierre-Antoine Tesson | CBK PAN: P-A Tesson, D. Mège, J.Gurgurewicz | |
| A 1:600K Geological Map of the Sibelius Crater, Mercury | Marc Canale | INAF/UNIPD | A geological map of spectral and geomorphological features of the Sibelius Crater on Mercury using MESSENGER MDIS imagery. |
| Structural map of Noctis Labyrinthus region on Mars, | Mayssa El Yazidi | UNIPD | Will provide a quantitative framework for a better characterisation of the extensional history of the Region |

| | | | |
|--|--|------------------|---|
| Characterisation of La Corona lava field planetary analogue at Lanzarote Island (Spain), | Ilaria De Tomasi | UNIPD | Comprising mapping and 3D laser scanning of an extended lava tube, which represent a good analogue for lava tubes on the Moon or Mars |
| Landing site and traverses geologic map - Northwestern quadrant of Copernicus crater, Moon | Filippo Tusberti | UNIPD | Mapping aims to evaluate this region as landing site for exploration and sampling |
| Landing site and traverses geologic map - Tsiolkovskiy crater, Moon | Gloria Tognon | | |
| Cerberus Fossae, Mars | Trishit Ruj | UNIPD | Structural mapping of the huge fractures system |
| Holden crater | Monica Pondrelli | UNICH (internal) | Legacy mapping projects to be integrated |
| Geologic and structural mapping of chaotic terrains | Mauro Spagnuolo (University of Buenos Aires) | JacobsUni | Mapping focused to reconstruct the history of selected chaos-hosted layered deposits |

GMAP VA Call and Winter School

The call has been established to remain open for the whole duration of the RI. This choice is due to the peculiarity of the mapping process, which might require many months for completion, and can find better support in a longer term activity in which each new action to support users is staggered in time to produce a constant load for the infrastructure.

As a first-year activity, this call has been formally opened during the planetary mapping winter school⁶, targeting young scientists at Master's, PhD, and early post-doc level.

⁶ <https://www.europlanet-gmap.eu/call/>

The school also provided filmed material for future sponsorships of GMAP activities. The next school is planned for mid-February 2022, and will be entirely online. In the future focused, in-person workshops might be considered, depending on the pandemic's evolution. The first winter school corresponded to the opening of the public call for mappers. The call has been kept open during the year and will be further announced during the next edition of the Winter School. The GMAP VA is supporting proposals similar to VESPA VA, i.e. using the school/workshop yearly appointment to kick-start the mapping projects to be carried out in the upcoming year(s). The follow-up, as per the DoA, will be done using mostly online interaction (e.g. direct or via the Open Planetary forum) and, when relevant, possible and desirable dedicated on-site visits.

The experience so far, driven by the COVID-19 situation and the forced choice of online interaction methods, despite difficulties, has demonstrated the potential added value of such online school/workshop interactions, particularly related to its scalability, e.g. recording and sharing school/workshop materials, as well as not limiting to synchronous interaction. This is particularly valid for a winter school with people joining from very different time zones, and with potentially different travel resources.

Task 8.3 - 2D/3D Geological Mapping

Activities of Task 8.3 targeted the adaptation and creation of teaching material and the contribution to mapping tools that will be needed for practical mapping activities and 3D model creation.

Task 8.3 also contributed to several other community-driven projects that are instrumental to JRA activities:

- The Mappy QGIS plugin for easy-to-use and consistent mapping has been refined, adding more topology control functions and bug fixes. It has been released in its stable version in the official QGIS plugin repository. A technical publication about Mappy is in the works.
- Further updates on Mappy development are available at <https://github.com/europlanet-gmap/mappy>.
- Planetary mapping symbols (<https://github.com/afrigeri/geologic-symbols-qgis>), which constitutes the first collection of open source symbologies for planetary geologic mapping, are in the course of updating.

Deep learning methods are investigated parallel to machine learning methods and pipelines are under development and testing.

An image classification Python notebook, based on PyTorch, is available for demonstration purposes and includes a small dataset and a pretrained model.

The code relative to proper classification will be published after the consolidation of pipelines (Giacomo Nodjoumi, 2021, January 6, PyTorch-ImageClassifier (Version v1), Zenodo. <http://doi.org/10.5281/zenodo.4421270>).

A landforms object-detection Python notebook, based on PyTorch, has been developed and has been used for mapping possible cave candidates on Mars' Tharsis Region; this is still undergoing validation.

Task 8.4 - Geological Mapping Integration

Data Portal

The development of the GMAP data portal, based on existing developments from PLANMAP⁷, has been initiated with its first release (see D8.2, Rossi et al., 2021) and is being further developed⁸⁹ in order to allow data publishing, access, and versioning for the community. To grant better integration with external long-term storage services (for example the well-known CERN-provided Zenodo¹⁰) the backend of the portal has been partially redesigned based on the same software infrastructure used by Zenodo itself, Invenio-RDM. These changes will provide better integration for long-term product hosting with DOI-based citations. Data produced and served by GMAP and the data portal are all meant to be FAIR (See D8.1, Rossi et al., 2021, as well as Raugh et al., 2020; see also Brandt et al. 2020).

Task 8.5 - Sustainability

Task 8.5 activities have been carried out, following the objectives outlined in D8.1 (Massironi et al., 2021):

- 1) Preparing concepts for future new projects which can support planetary geological mapping activity during EPN 2024 RI and beyond
- 2) Setting up a common coordination with Chinese projects on similar subjects
- 3) Setting up interactions with USGS for future cooperation
- 4) Consolidating cooperation with the European and national space agencies, e.g. ASI, see below.
- 5) Setting up relationships with European national geological surveys and societies, starting with the cooperation with ISPRA (Italian Geological Survey)

⁷ <https://planmap.eu/>

⁸ https://github.com/europlanet-gmap/inveniordm_project

⁹ https://github.com/europlanet-gmap/data_site

¹⁰ <https://zenodo.org>

- 6) Following up with private companies interested on in-situ resource utilisation (SRK, see below).

In addition, synergies with other EU projects for providing e.g. base mapping services exist, including NEANIAS H2020¹¹ and the recently started EXPLORE H2020¹².

National funding, such as from the German DFG, is also being attempted, during Year 2 and Year 3 of the RI VA.

The matching MOST project of the Chinese partners of GMAP has been confirmed and funded for more than 3M RMB. This result is a significant step forward on points 1 and 2 of the list.

The cooperation with USGS has been strengthened thanks to planned common actions such as workshops, conferences as well as dedicated meetings. GMAP has been present at the 2021 PSIDA/Planetary Data Workshop¹³.

In particular, an initial discussion on the following topics of common interest and mutual benefit has been already initiated:

- Promotion of an international discussion on techniques and methods, e.g. on map unit descriptions, unit correlation and mapping of cratered terrains.
- Co-authorship of resulting manuscripts on methods and techniques.
- Formation of an international geological mapping working group, with different panels for each planetary body.
- Potential for USGS publication of non-U.S. maps.
- Future shared planetary mapping meetings in Europe to foster European community efforts.

An initial step towards the integration of geological maps within the Matisse database¹⁴ of the Italian Space Agency has also begun as a sustainability action for future stable dissemination of GMAP products (see also Camplone et al., 2021).

There is an already-established agreement with the Geological Field Trip and Map journal¹⁵. This represents the start of a strong relationship with the Italian Geological Survey and the Italian Geological Society, which is in turn associated with the Spanish Geological Society, for planetary geological science topics.

¹¹ <https://www.neanias.eu>

¹² <https://www.explore-platform.eu>

¹³ <https://aprossi.github.io/planetdata2021/>

¹⁴ <https://tools.ssd.cnr.it/matisse.jsp>

¹⁵ <https://www.geologicalfieldtripsandmaps.com>

Preliminary contacts have been carried out with the mining exploration company SRK Consulting (<https://www.srk.com>) for in-situ resource detection and evaluation. However, a long-term collaboration project is not yet agreed.

The contact with SRK Consulting for planetary mining resources is ongoing. Planetary data and DTMs have been tested in a newly developed software for 3D mapping and the creation of geologic models of the subsurface based on VR experience. A first implementation of this software will be made available shortly, with future implementations and upgraded functions fostered by the GMAP consortium.

The mapping projects and related products of the MOST project will be published via GMAP VA channels.

5. Outreach and dissemination

1. GMAP is responsible of the organisation of the second virtual Planetary Mapping Winter School that is due to be held in February 2022¹⁶, with 170 registered participants from 34 countries
2. The school is completely focused on covering all the basics for planetary mapping, including technical and scientific insights as well as map finalization for publication
3. GMAP continues fostering its established presence on several online platforms for outreach
4. A Discord channel has been opened and maintained as a legacy of the first Planetary Mapping Winter School, and to implement direct and asynchronous communication for the 2022 winter school
5. Outreach channels on social media platforms (e.g. Instagram, Twitter, Facebook) have been opened for the Winter School and will be maintained as a heritage, to foster future didactic activities and workshops.

6. Timeline and Outlook

The GMAP Winter School embeds several activities of the VA, including the collection of community mapping projects, the training of the community at various levels and the initiation of documentation on 2D and 3D mapping that will evolve throughout the project.

The ongoing high interest of the community in the winter school is prompting the planning of follow-up activities in the form of online or hybrid summer schools and workshops at levels being currently evaluated, which will allow for engagement with the community and follow-up with participants, and starting mapping projects.

¹⁶ <https://indico.obspm.fr/event/1272/>

A plan for each task is included in Table 3.

Table 3: Envisaged activities of GMAP VA for Year 3

| Task no. | Name | Plan for Y3 of RI |
|----------|--------------------------------|---|
| 8.1 | Coordination | Coordination among GMAP partners both within VA and JRA. Coordinate activities with Chinese equivalent MOST project. |
| 8.2 | Community mapping projects | Follow up and foster community mapping projects. Organize future Winter Schools Organise smaller-scale topical workshops. |
| 8.3 | 2D/3D Geological mapping | Preparing further geologic mapping training materials, building on JRA Materials (see D9.6, Rossi et al., 2022) |
| 8.4 | Geological Mapping Integration | Deploy updates to the data portal with data publishing options |
| 8.5 | Sustainability | Cooperate with external partners such as USGS Iteration with MOST and embedding of initial Chinese mapping projects. Develop relationships with European Geological services and societies, ESA, and National Space Agencies. Better define common projects with SRK and other companies potentially interested in ISRU. |

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