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

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Executive Summary / Abstract:

An update for year 3 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 (2021 and 2022 Winter Schools - online) and subsequent ones organised and about to be held (2023 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 GMAP VA will aim at being robust enough regardless of how the external situation will play out.

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Table 1: Acronyms and abbreviations

Acronym	Description
ASP	Ames Stereo Pipeline
DFG	Deutsche Forschungsgemeinschaft

DoA	Description Of Action
ISIS	Integrated Software for Imagers and Spectrometers
IRSPRA	Istituto Superiore per la Protezione e la Ricerca Ambientale
JRA	Joint Research Activity
NA	Networking Activity
MOST	Ministry Of Science and Technology
USGS	United States Geological Survey
VA	Virtual Access

● Introduction

The GMAP VA activities are (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. D9.2, Rossi et al., 2022; Rossi et al., 2023, D9.10) have started, and several deliverables have been produced¹.

The Covid situation, as documented in the previous report (Y2) caused some shift in deliverable timing.

The second GMAP VA Call coincided with the 2nd GMAP Winter School, and resulted in several community mapping projects, subject of a specific deliverable in the reporting period (D8.5),

¹ <https://wiki.europlanet-gmap.eu/bin/view/Main/Deliverables/>

detailed in later sections and listed on the GMAP wiki². Some of the community mapping projects are going to be pitched as lightning talks at the 3rd GMAP Winter School³.

1. Continued impact of the COVID-19 situation on VA

GMAP VA Activities continued to cope with the prolonged pandemic situation, continuing to make use of online platforms, events and interaction, as well as JRA (see D9.10, Rossi et al., 2023). The 2nd Winter School, due to its online nature, reached out to a far greater number of individuals and groups than it could have ever done with a similarly scheduled in-person event, similarly to what was described for Year 2 and the 1st Winter School (Rossi et al., 2022). Therefore, despite the many disadvantages posed by the SARS-cov2 pandemic, VA activities expanded their reach.

The impact on deliverable dates and relevant shift is consistent with previous estimates (D8.2, Rossi et al., 2022; D9.10. Rossi et al., 2023).

Activities performed (per task) in the reporting period

The performed activities are described for each task. Plans and timeline 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 third year targeted the implementation of basic services that will be needed for supporting VA and JRA activities in terms of digital infrastructure.

The website⁴, described in D8.2 (Massironi, et al., 2021) has been active; updates and fixes to the web site have been following recommendations from the VA Review Board (D1.8, Rough et al, 2022).

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. The git server of GMAP is also providing authentication of the Jupyter⁵, developed within the JRA (see D9.8, Rossi et al., 2023)

² <https://wiki.europlanet-gmap.eu/bin/view/Main/community%20mapping%20projects/>

³ <https://www.planetarymapping.eu>

⁴ <https://europlanet-gmap.eu/>

⁵ <https://jupyter.europlanet-gmap.eu>

Internal tasks (see also D8.4, Rossi et al., 2022) are being handled via Git issues, as customary. Deliverable writing as well larger efforts such as the organisation of the 2023 Winter School have been performed with the help of Git issues.

Since the previous report (D8.4, Rossi et al., 2022) the GMAP wiki⁶ has been extended and links to various sets of documentation, both linked directly to deliverables⁷, and deriving, or branching from them⁸. A specific page lists the growing set of community mapping projects⁹.

Task 8.2 - Community mapping projects

Task 8.2 has been the focus of year 3, starting from the Winter School and VA calls¹⁰ and supported by monthly GMAP community calls¹¹, as well as informal non-periodic community interactions (mailing list, Discord server, etc.)

Support to the community of mappers has been provided by GMAP members in the form of data processing and map-creation support (see D9.8. Rossi et a., 2023).

The 2nd Winter School did allow to grow connections and foster community mapping projects. D8.5 (Rossi, et al., 2020) summarised community mapping projects focus, status and outlook. The report also includes some key figures of the 2nd Winter School, see also Figure 1.

The currently identified projects are listed in Table 2, as an excerpt of D8.5. with incremental updates.

Table 2: Started community mapping project as of Year 3: Each project links to the relevant GMAP wiki page.

Mapping project title	Project lead	GMAP contacts	Details

⁶ <https://wiki.europlanet-gmap.eu/>

⁷ <https://wiki.europlanet-gmap.eu/bin/view/Main/Deliverables/>

⁸ <https://wiki.europlanet-gmap.eu/bin/view/Main/Documentation/>

⁹ <https://wiki.europlanet-gmap.eu/bin/view/Main/community%20mapping%20projects/>

¹⁰ <https://www.europlanet-gmap.eu/gmap-va-call-2/>

¹¹ <https://wiki.europlanet-gmap.eu/bin/view/Main/GMAP%20community%20telecons/>

China's Chang'e-5 landing site: Geology, stratigraphy, and provenance of materials (2021) EPSL 561, 116855.	Yuqi Qian	WWU: van der Bogert, Hiesinger	A geological map of the Chang'e-5 lunar landing site for use in interpretation of the returned samples
Geology of the Hypanis outlet region	Agnese Caramanico	UdA: M. Pondrelli	Geologic and stratigraphic studies of the Hyspanis fan-delta system
Geology of the Tyras Vallis area	Davide Defilippis	UdA: M. Pondrelli	Map of the depositional environments of the Tyras Vallis paleolacustrine system using recent datasets.
Chronostratigraphic reconstruction of Eastern Tharsis volcanism	Pierre-Antoine Tesson	CBK PAN: P-A Tesson, D. Mège, J.Gurgurewicz	Lava flow mapping at regional scale.
A 1:600K Geological Map of the Sibelius Crater, Mercury	Marc Canale	INAF: Luca Penasa	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: Matteo Massironi	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) JGR - Solid Earth (2021)	Ilaria Tomasi	UNIPD: Matteo Massironi	comprising mapping and 3D laser scanning of an extended lava tube, which represent a good analogue for lava tubes on the Moon or Mars Ref.

			Tomasi, I., Massironi, M., Meyzen, C.M., Pozzobon, R., Sauro, F., Penasa, L., Santagata, T., Tonello, M., Gomez, G.D.S., Martinez-Frias, J., 2022. Inception and evolution of La Corona lava tube system (Lanzarote, Canary Islands, Spain). J. Geophys. Res. Solid Earth. https://doi.org/10.1029/2022JB024056
Geologic mapping and landing site characterization in Copernicus Crater (the Moon)	Filippo Tusberti	UNIPD: Matteo Massironi	Mapping aims to evaluate this region as landing site for exploration and sampling
Cerberus Fossae, Mars	Trishit Ruj	INAF: Riccardo Pozzobon	Structural mapping of the huge fractures system
Holden crater	Monica Pondrelli		
Geologic and structural mapping of chaotic terrains	Mauro Spagnuolo (University of Buenos Aires)	JacobsUni: Angelo Pio Rossi	Mapping focused to reconstruct the history of selected chaos-hosted layered deposits

Mars Double Impact Crater Lithostructural Virtual and 3-D Model Evaluation	Wayne Barnett	UNIPD: Matteo Massironi INAF: Riccardo Pozzobon JacobsUni: Angelo Pio Rossi	Virtual reality mapping of the double impact crater on Mars, and 3D modelling of the lithostratigraphy
Lunar LCROSS Impact Ice Study	Wayne Barnett	UNIPD: Matteo Massironi	Virtual Reality mapping of the LCROSS location
Geo-stratigraphic map of the North Polar Layered Deposits close to Olympia Rupes (Mars)	Nicole Costa	UNIPD: Matteo Massironi	Stratigraphy of a restricted area close to Olympia Rupes on the Northern Polar Cap
The geologic map of Sinus Iridum	Teng Hu	CUGB: Zhizhong Kang (MOST)	
The geologic map of Zhurong landing site	Teng Hu	CUGB: Zhizhong Kang (MOST)	
High-res descent map Chang'e 5 landing site map	Teng Hu	CUGB: Zhizhong Kang (MOST)	
Geological map of the Rima Bode region, Moon	Sascha Mikolajewski	WWU: Hiesinger, van der Bogert, Poehler	Geological mapping of the Rima Bode region of the Moon in preparation for a lunar mission
Geologic and compositional characterization of the Tsiolkovskiy crater, Moon	Gloria Tognon	UNIPD: Gloria Tognon, Matteo Massironi	Geologic, color-based and spectral mappings aimed at characterizing the lunar far side Tsiolkovskiy crater and laying the groundwork for a landing site evaluation

Geologic mapping of the H-9 Eminescu quadrangle, Mercury	Gloria Tognon and Mayssa El Yazidi	UNIPD: Mayssa El Yazidi, Gloria Tognon, Matteo Massironi INAF-IAPS: Valentina Galluzzi, Lorenza Giacomini	Geologic map of the equatorial H-9 Eminescu quadrangle on Mercury
Geologic mapping and interpretation of a Fractured-Floor Crater in Ladon Basin - Mars	Diandra Cardinali	UNIPD: Matteo Massironi	
Morphostratigraphic mapping of Valentine Domes on the Moon	Javier Suarez	JacobsUni: Javier Suarez	Mapping of the intrusive Valentine Domes on the moon.
Mapping of Martian geofoms as an input to construct an analogue environment in Colombia	Javier Suarez	JacobsUni: Javier Suarez	A necessary prior step to the construction of a rock garden in an analogue station in Colombia.
Morpho-stratigraphic mapping of Mikumi crater, northern Meridiani Planum, Mars	Beatrice Baschetti	UNIPD and INAF-IAPS: Beatrice Baschetti INAF-IAPS: Alessandro Frigeri	Morpho-stratigraphic mapping of layered phyllosilicate and sulfate rich sedimentary units within Mikumi crater. The map is needed to support stratigraphic investigation and interpretation.

GMAP VA Call and Winter School

As in year 2, the call has been established to remain open for the whole duration of the RI

The cumulative documentation produced by the first two Winter Schools is publicly available and its videos used beyond the few hundred

participants of the live events, for 2021¹² and 2022¹³. See also D8.5 (Rossi et al., 2022).

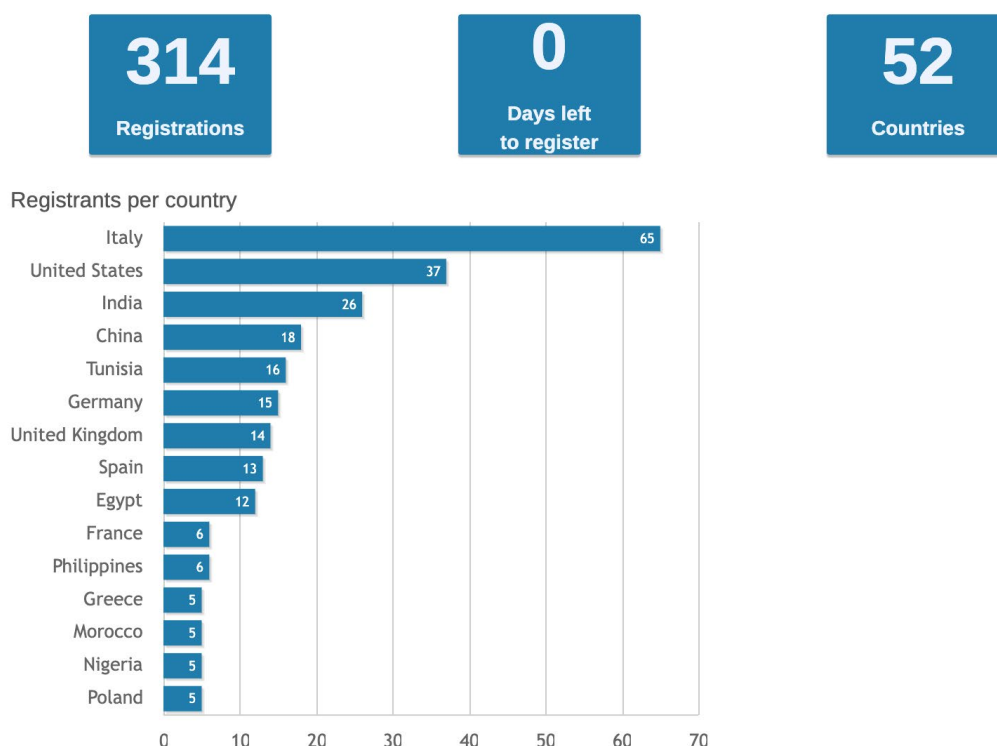


Figure 1: Breakdown of registered participants to 2022 GMAP Winter School.

The upcoming 3rd edition of the school is planned for the end of January / early February 2023 and will be entirely online and asynchronous.

The cumulative experience of online interaction for running the schools proved scalable (D8.4. Rossi et al., 2022). In particular for the 2023 edition of the Winter School, the asynchronous interaction has been build-it, for participants coming from very far time zones.

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 models 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

¹² <https://www.europlanet-gmap.eu/planmap-gmap-ws-2021-videos/>

¹³ <https://www.europlanet-gmap.eu/planmap-gmap-ws-2022-videos/>

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>
- Official documentation for the Mappy plugin is available at: <https://mappy.readthedocs.io>
- 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 process of updating.

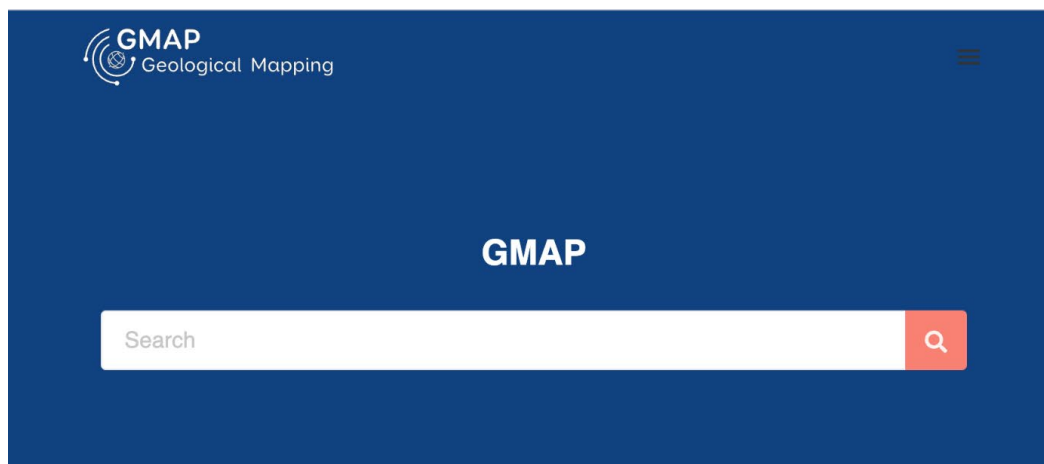
Deep learning methods are investigated parallel to machine learning methods and pipelines have been published (Nodjoumi et al., 2023).

Task 8.4 - Geological Mapping Integration

Data Portal

In year 3 the development of the GMAP data portal advanced further and data are discoverable through the interface¹⁴.

¹⁴ <https://data.europlanet-gmap.eu>



Data Integration Portal

<h3>Search Data</h3> <p>Use free-text search and tags to filter records:</p> <p>search page</p>	<h3>Data Analysis</h3> <p>Deeper data inspection and processing tools:</p> <p>user environment</p>	<h3>Documentation</h3> <p>Material about our data and map-making:</p> <p>wiki</p>
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Figure 2: the GMAP Integration portal¹⁵, providing access to documentation and tools.

Task 8.5 - Sustainability

¹⁵ <https://data.europlanet-gmap.eu>

Task 8.5 activities have been carried out, following the objectives outlined in D8.1 (Massironi et al., 2021), and building upon those described in D8.4 (Rossi et al. 2022):

- 1) Preparing concepts for future new projects which can support planetary geological mapping activity during EPN2024 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 the 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)
- 6) Following up with private companies interested on in situ resource utilization (SRK, see below) or 3D mapping (VRGS)

In addition, synergies with other EU projects for providing e.g. base mapping services exist, including NEANIAS H2020¹⁶ and started EXPLORE H2020¹⁷.

The cooperation with USGS has been strengthened thanks to planned common actions such as workshops, conferences and as dedicated meetings.

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 units description, units 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.

¹⁶ <https://www.neanias.eu>

¹⁷ <https://www.explore-platform.eu>

An initial step towards the integration of geological maps within the Matisse database¹⁸ 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; Rognini et al, 2022).

The already established agreement with the Geological Field Trip and Map journal¹⁹ represents the start of a strong relationship with the Italian Geological Survey and the Italian Geological society, which also is in turn associated with the Spanish Geological society for planetary geological science topics.

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 creation of geologic models for 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.

In addition, contacts with the VRGS software company dedicated to 3D geological interpretation of digital outcrops models and digital terrain models has been established for applications on planetary contexts.

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

Outreach and dissemination

- GMAP has taken care of the whole organisation of the organised second virtual Planetary Mapping Winter School that was held in February, 2022²⁰, with 170 registered participants from 34 countries.
- The 3rd Winter School is starting at the very end of January 2023²¹ with a prospective larger reach. Incremental updates will be

¹⁸ <https://tools.ssdsc.asi.it/matisse.jsp>

¹⁹ <https://www.geologicalfieldtripsandmaps.com>

²⁰ <https://indico.obsmpm.fr/event/1272/>

²¹ <https://indico.obsmpm.fr/event/1713/>

posted on the school on relevant Europlanet media, and will be reported in the next reporting period.

- GMAP continues fostering its established presence on several online platforms for outreach.
 - A Discord channel has been opened and maintained as a heritage to the first Planetary Mapping Winter School and to implement direct and asynchronous communication for the 2023 winter school.
- Outreach channels on social 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

Relevant deliverables in the reporting period:

Table 3: Deliverables for the reporting period

No.	Deliverable name	Delivery date	Access link
D8.5	Community Mapping Report 1	31 March 2022	PDF
D8.6	Training materials: 3d and geomodelling	31 May 2022	PDF
D8.7	Training materials: lithostratigraphy and landing sites	30 June 2022	PDF
D8.8	Geologic mapping integration report and published data	30 April 2022	PDF
D8.9	Training Materials for Resources	31 October 2022	PDF

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 through the projects.

Future Winter Schools will be organised along with smaller workshops, such the upcoming ERIM workshop in June 2023.

A plan for each task is included in Table 4.

Table 4: Envisaged activities of GMAP VA for Year 4

Task no.	Name	Plan for Y3 of RI
8.1	Coordination	Coordination among GMAP partners both within VA and JRA, as well with other VA WP (VESPA, ML).
8.2	Community projects mapping	Follow up and foster community mapping projects. Organize the final RI Winter School 2024 Organise smaller-scale topical workshops.
8.3	2D/3D Geological mapping	Preparing further geologic mapping training materials, building on JRA Materials (see D9.10, Rossi et al., 2022). as well as developed upon the cumulative knowledge base of the three Winter Schools so far
8.4	Geological Integration Mapping	Populate further and improve the data portal, allow more access to JRA-developed tools via the portal.

8.5	Sustainability	<p>Cooperate with external partners such as USGS</p> <p>Iteration with MOST and embedding of initial chinese mapping projects.</p> <p>Continue the dialogue and interaction with European Geological services and societies, ESA and National Space Agencies.</p> <p>Better define common projects with SRK, VRGSand other companies potentially interested in ISRU and software applications for 2D/3D planetary geological mapping.</p>
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