GANYMEDE'S SURFACE INVESTIGATION IN SUPPORT OF THE RADAR FOR ICY MOON EXPLORATION (RIME) INSTRUMENT. A. Cofano[1,2], G. Komatsu[1,2], A. Pizzi[2], A. Di Domenica[2], L. Bruzzone[3], G. Mitri[4], and R. Orosei[5], [1]International Research School of Planetary Sciences, Università d'Annunzio, Viale Pindaro 42, 65127 Pescara, Italy (cofano@irsps.unich.it), [2]Dipartimento di Ingegneria e Geologia, Università d'Annunzio, Via dei Vestini, 31, 66100 Chieti Scalo (CH), Italy, [3]Dept. of Information Engineering and Computer Science University of Trento, Via Sommarive 5, 38123, Trento, Italy, [4]Laboratoire de Planétologie et de Géodynamique, Université de Nantes, UMR 6112, 2 rue de la Houssiniére, 44322 Nantes, France, [5]Istituto di Radioastronomia, Istituto Nazionale di Astrofisica,Via Piero Gobetti 101, 40129, Bologna, Italy.

Introduction: Icy moons of Jupiter have regained attention recently with the approval of the JUpiter ICy moons Explorer (JUICE) mission by the European Space Agency and its partners for a scheduled launch in 2022 and arrival in the Jovian system in 2030. The instruments particularly important and relevant to geological investigation of the icy moons are Jovis, Amorum ac Natorum Undique Scrutator (JANUS) camera system [1], Ganymede Laser Altimeter (GALA)[2], and Radar for Icy Moon Exploration (RIME) [3]. RIME is a radar sounder optimized for the penetration of the Galilean icy moons, Ganymede, Europa and Callisto, up to a depth of 9 km. RIME is a key instrument for achieving groundbreaking science on the geology and the geophysics of icy moons. In order to support RIME activities, we have initiated research effort in understanding geology of Ganymede.

The RIME instrument is expected to yield subsurface information that would be compared with surface data acquired by JANUS and GALA, altogether they will shed light on the geological and geophysical processes operated on the icy moons. The scientific interpretation of the RIME data in the form of radargram will depend partially on our capacity to understand geological features observable on the surface. This is because such geological features are surface manifestations of subsurface structures. For this reason, we have begun to map and interpret surface geology of icy moons, beginning with Ganymede that will be the main target of the JUICE investigation. The interpreted surface geology will be used as a basis for constructing plausible subsurface structures, which will be assessed for detectability with the RIME instrument.

Questions on Ganymede's geology and internal structure: Ganymede is one of the four Galilean moons, and it is the largest satellite in the Solar System. The study of this icy satellite has been less extensive in comparison to two other Galilean moons Io and Europa and there are many unanswered questions, such as whether it is still geologically active today. Another outstanding issue is its orbital motion around Jupiter, whether it is synchronous or not due to the tidal forces [4]. Finally, there are various geophysical theories on its internal structure, such as the presence of an ocean below the surface, a core still "hot" and some hypotheses related to the thickness of an ice shell or ice shells that comprise Ganymede's subsurface [5, 6, 7].

We may answer to these questions by interpreting the information we have today of its surface and by studying tidal forces in the present and in the past. The study of Ganymede's surface consists also in the understanding of different types of ice and materials of which it is composed, and especially of the structures that characterize them. We may comprehend the surface compositions from NIMS (Near-Infrared Mapping Spectrometer) data, but also through the behavior of the ice resulting in the production of geological features on the surface [8, 9].

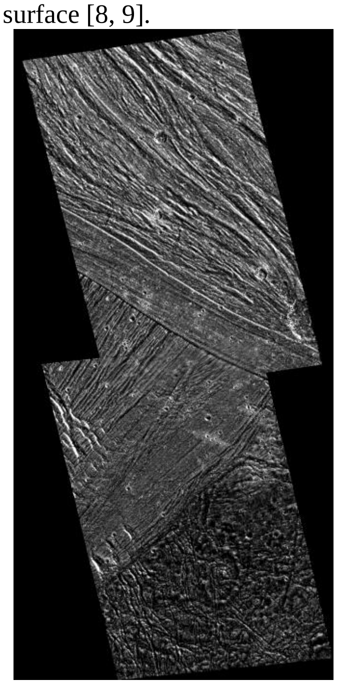

Fig. 1: An example of grooved terrain and the difference between light and dark terrain (near the bottom of the figure). A Galileo image of resolution 98 m/pixel.

A particular interest in our investigation is the grooved terrain (Fig. 1), because the division of dark and light terrains suggests a past in which there have been major tectonic events [10], and its subsurface structures should preserve vital information on the formation mechanism that should be important to understand the evolution of Ganymede. Instead, cryovolcanism is in general considered to have played a less important role in the Ganymede history [11], but searching evidence for cryovolcanism would also be our task because its identification would imply a complex thermal history of the icy moon [3, 7].

Methods: The used technique, to study the structures reflected from the geological past of Ganymede, is to compare the satellite's areas of interest. The images used, obtained from NASA PDS nodes, are those of the missions Galileo and Voyager 1, 2. They were processed mainly with ISIS3 but also with ISIS2 because some of the camera data were available only in ISIS2. To analyze large structures or regional/global trends, for example, large craters, we analyzed images that did not require a high resolution (see Fig. 2). Instead, there were areas in which the relatively high resolution Galileo images (up to 14 meters per pixel) help considerably to observe features and allow us to identify, for example, grooved terrain features or areas divided by tectonics, as shown in Fig. 3.

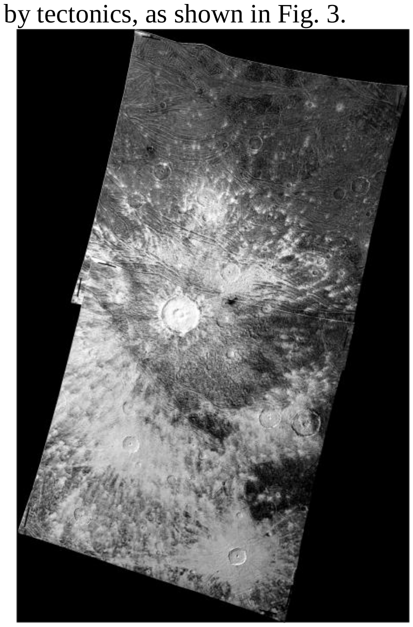

Fig. 2: An example of low-resolution Voyager images that are useful in studying some large-scale features such as craters with far-reaching ejecta deposits. Resolution is 764 m/pixel.

In addition, in order to understand the structures better, we also use Digital Terrain Models (DTMs) of some limited localities. We produce them mainly with Ames Stereo Pipeline from stereo pairs, but also with Stereo Matcher Toolkit to verify the results. We begin our investigation utilizing a geological map recently published [12] in order to identify the areas of interest, in particular taking into account the plausible RIME coverage during the flyby and mapping operations and also the availability of previous mission data (i.e., Galileo and Voyager). The hypotheses produced in our studies will be compared with various geophysical models for assessing their reasonability. Furthermore, we intend to test the detectability of the RIME instrument in the subsurface for various case scenarios based on the hypotheses.

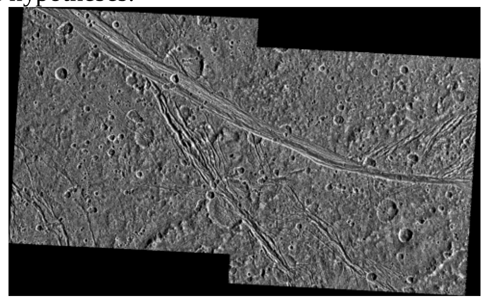

Fig. 3: An example of high-resolution Galileo images that are useful in studying some features such as craters divided by tectonism. The spatial resolution is 152 m/pixel.

Conclusions: The JUICE mission, although still many years away, provides a great opportunity and motive for reassessing the previously proposed interpretations and obtaining new insights on geology of three icy moons, Europa, Ganymede, and Callisto in light of an array of instruments that would be greatly improved over the ones used by the Voyager and Galileo missions. In particular, the RIME instrument is expected to provide a totally new type of data set that is radargram reflecting the subsurface structures up to 9 km in depth. The subsurface structures observed by RIME should greatly help improving our understanding of geological processes operated in the icy moons. In order to assist the RIME activity and prepare for eventual data acquisition, we have initiated a series of geological investigation with the main focus on Ganymede. The expected results indicating possible subsurface structures present under the observed surface features will be assessed for detectability of the RIME instrument.

References: [1] Palumbo P. et al. (2014) *LPS 45th*, Abstract #2094. [2] Lingenauber K. et al. (2013) *EPSC 2013*, Abstract #428. [3] Bruzzone L. et al. (2013) *IGARSS*, *IEEE*, 3907–3910. [4] Greenberg R. (1989) *NASA SP Series*, *NASA-SP-494*, 100–115. [5] Schubert G. (1981) *Icarus*, *47*, 46–59. [6] Mitri G. et al. (2005) *Icarus*, *177*, 447–460. [7] Mitri G. et al. (2008) *Icarus*, *193*, 387–396. [8] Hansen G.B. et al. (2004) *JGR*, *109*, E01012. [9] McCord T.B. et al. (1998) *JGR*, *103*, E4, 8603–8626. [10] McKinnon W.B. (1981) *Proc. LPS 12*, 1585-1597. [11] Pappalardo R.T. et al. (1998) *Icarus*, *135*, 276–302. [12] Collins G.C. et al. (2013). *Global geologic map of Ganymede*, USGS, SIM 3237.