CRYOMAGMA ASCENT ON EUROPA. Elodie Lesage[1], Hélène Massol[1], Frédéric Schmidt[1], [1] GEOPS, Univ. Paris-Sud, CNRS, Université Paris-Saclay, Rue du Belvédère, Bât. 504-509, 91405 Orsay, France (elodie.lesage@@u-psud.fr)

Introduction: Europa's surface exhibits morphological features associated with a low craters density that demonstrate a recent internal activity. In particular, the morphology of the smooth plains covering parts of the surface (see Fig. 1), and their relationship to the surrounding terrains suggest that they result from viscous liquid extrusions [1]. Furthermore, recent literature explains the emplacement of liquid-related features, such as double ridges [2], lenticulae [3] and chaos [4] by the presence of liquid reservoirs beneath the surface.

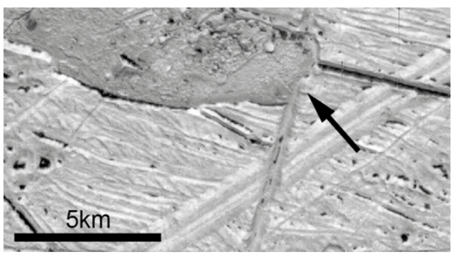

Fig. 1 : smooth lobate feature (Image ID: 15E0071)

The aim of this study is to define the conditions and timing of ascent of liquid water, and whether or not liquid water extrusion from sub-surface reservoirs can produce the lobate features. In order to do this, we first model the ascent of water through a dike or a pipe-like conduit for Europa's surface conditions and different chamber depths and volumes. We also estimate the freezing time of the sub-surface reservoir necessary to trigger an eruption. We consider pure water but also briny cryomagmas. Considering available data for density and eutectic temperature of salt impurities recently proposed for Europa [5], we discuss their effect on the cryomagma freezing time and ascent.

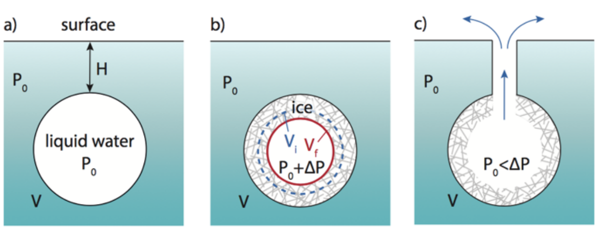

Fig. 2 : Model used in this study. a) A hot liquid water lens is at isostatic pressure P_0 and depth H. b) The cryomagma freezes and the liquid is compressed from a volume V_i to a volume V_f, generating an overpressure ΔP . c) The eruption begins when the pressure reaches a critical value and ends when the chamber is back at isostatic pressure.

Model: Based on the work by Fagents [6], we consider the following mechanism summarized in Fig. 2: a liquid water pocket is present in the subsurface and the cryomagma contained in the chamber freezes and pressurizes over the time. The pressure increase generated by the cryomagma freezing is related to the liquid volume decrease through the water compressibility χ. When the stress applied on the chamber walls reaches a critical value, the walls break and a fracture may propagate to the surface. The remaining fluid flows out at the surface through a dike or a pipe-like conduit. A numerical model calculates the evolution of flow velocity and chamber pressure with time. One of the main output of the simulation is the total volume of water extruded at the end of the eruption.

In order to approximate the necessary time for the cryomagma to freeze to trigger an eruption, we solve for the Stefan problem at the cryomagma chamber walls.

Results: For plausible volumes and depths varying between $0{,}1\text{km}^3<V<10\text{km}^3$ and $100\text{m}<H<10\text{km}$, the total extruded cryolava volume ranges from 10^5 to 10^8 m^3, and the time scale of the eruptions varies from few minutes to few tens of hours. The freezing timescale of the cryomagma pocket varies with the cryomagma composition: it varies between 10^2 to 10^3 years for a pure water cryomagma and from 10^2 to 10^4 years for a briny cryomagma. These results are in agreement with the life-time of putative liquid water lenses [7], which varies from 10^3 to 10^5 years.

We plan to compare these results with the Galileo observations by carrying out a stereoscopic study of some lobate features aiming at defining plausible locations of cryovolcanic active areas on Europa. These results could be useful for the two missions JUICE (ESA) and Europa Clipper (NASA).

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