Numerical modelling of subduction initiation on Europa

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Résumé

Icy moon Europa, the fourth largest Jovian satellite, is a prominent target of space exploration, soon to be visited by JUICE (ESA) and Europa Clipper (NASA) spacecrafts. Scarcity of impact craters and overall smoothness suggest that the surface is not older than 90 Myr, being one of the youngest in the Solar system. Ubiquitous features, such as bands, double ridges or cycloids, otherwise unique amongst icy bodies, are proof of recent and possibly active tectonic processes, as well as of a complex interaction between the ice shell and the subsurface ocean.
Dominated by extensional bands, Europa's surface shows a very limited signs of compression. Yet, several studies presented an evidence for missing surface area that can be explained by subduction (1,2). Motivated by plate tectonics on Earth, a number of studies have been questioning the feasibility of an analogical process on icy moons (3,4). However, up to this date, no numerical models have been used to verify this concept.

Here we address this issue by modelling compression of Europa's ice shell using finite element model with free surface, taking advantage of the parameters that have led to a successful reproduction of extensional bands (5). We prescribe constant convergent velocity and employ visco-elasto-plastic rheology to capture both ductile and brittle deformation of the ice. We show that a subduction can be initiated, with its efficiency and continuity dependent on the shell thickness and the heat transfer regime. Our model also predicts a specific topographic signature that accompanies the convergent regions, which may in future help to identify where the subduction might have occurred. Providing material transport from the surface to the subsurface ocean, a subduction, albeit episodic, could have profound implications for Europa's habitability.

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References

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