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Stability of clathrate hydrates in Martian crust

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Clathrate hydrates are crystalline compounds constituted by cages formed by hydrogen-bonded water molecules inside of which guest gas molecules are trapped. These materials are typically stable at high pressure and low temperature and are present on Earth mainly in marine sediments and in permafrost. Moreover, clathrate hydrates are expected to exist on celestial bodies like the icy moons Titan, Europa or Enceladus. Current conditions in the Martian crust are favourable to the presence of clathrate hydrates.
In this study, we focused on the stability of methane and carbon dioxide clathrates in the Martian crust. We coupled the stability conditions of clathrates with a 1D thermal model in order to obtain the variations of the clathrate stability zone in the crust of Mars with time and for different crust compositions. Indeed, the type of soil directly controls the geothermal conditions and therefore the depth of clathrates formation. Unconsolidated soil acts as a thermal insulator and prevents the clathrates formation in the crust except on a small part of a few tens of meters thick. In contrast, sandstone or ice-cemented soil allows the clathrates formation with a stability zone of several kilometers. This is explained by the fact that they evacuate heat more efficiently and thus maintain lower temperatures. We also studied the stability zone of clathrates formed from a mixture of methane and hydrogen sulphide as well as from a mixture of methane and nitrogen. Contrary to the addition of N_2, the addition of H_2S to CH_4 clathrates extends the stability zone and thus brings it closer to the surface. Therefore, mixed clathrates CH_4-H_2S will be more easily destabilized by changes in surface temperature than CH_4 clathrates.