

High Subcritical Water for the syn-Formation of Ferric Minerals and Molecules of Life

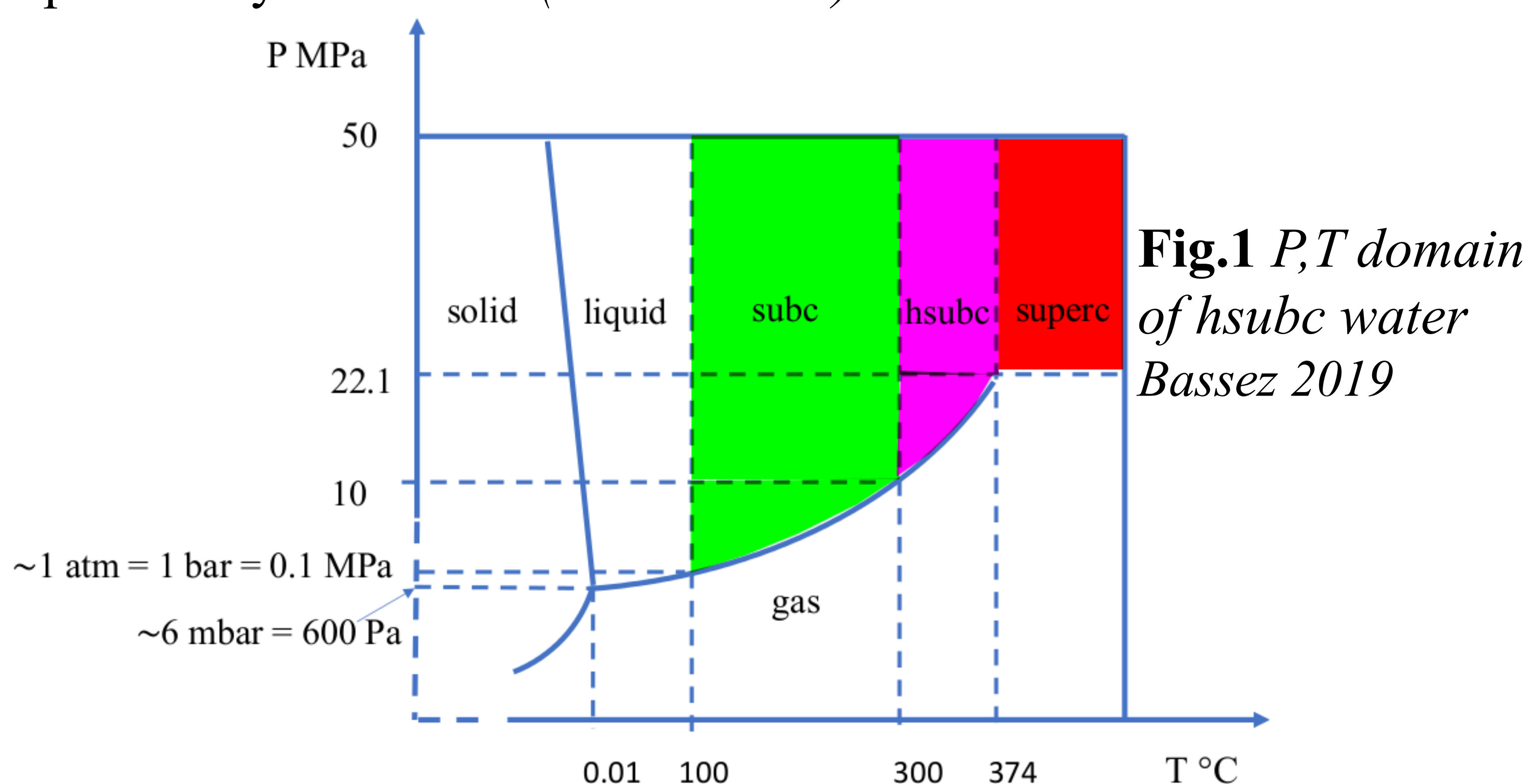
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Architecture of the Research

The research started in 1997 with the study of the structure of water under pressure and the dissolution of apolar molecules in supercritical water. Since 2013, results show that **anoxic, alkaline pH ~9.5-14, high subcritical, hsubc, water, ~300-350 °C, ~10-25 MPa, ~700-600 kg/m³**, constructs the continuity from rock to life in the process conceptualized with the term **geobiotropy**. When this peculiar water interacts with rocks containing Fe-silicates without sulfides, crystalline and amorphous silica, and ferric minerals can form. The minerals that are observed in Banded Iron Formations of the Archean to early Paleoproterozoic Earth can be explained by this action (Bassez 2018). On the Saturn's moon Enceladus, the interaction with Fe,Mg-silicates rocks can be at the origin of the Cassini observations.

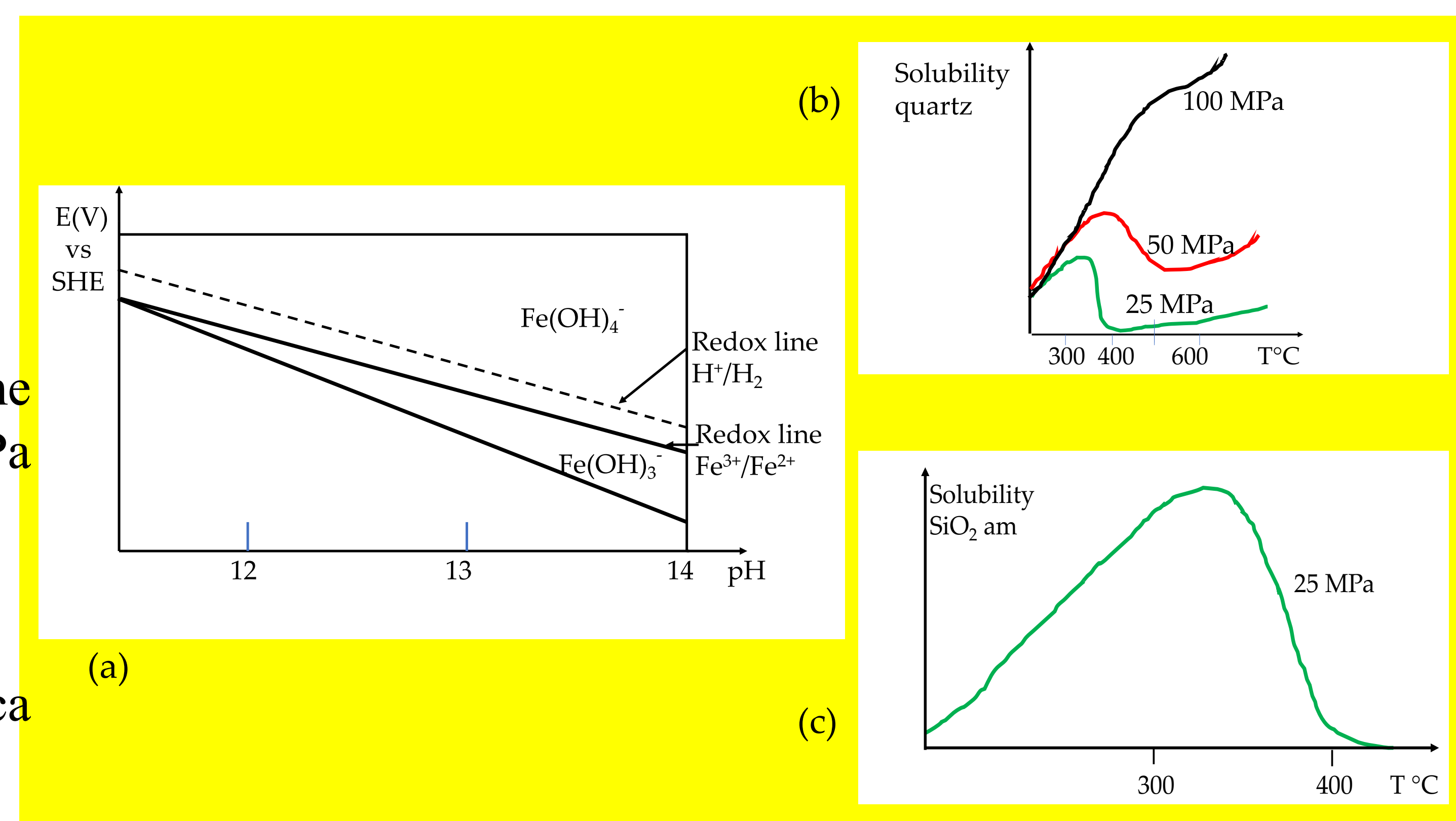


Results

Fig.2 a) E-pH diagram for the Fe-H₂O system at 350°C, 25 MPa
Cook, Olive 2012

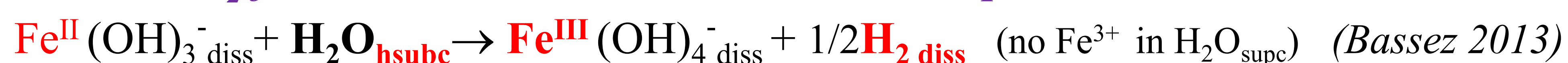
b) Solubility of quartz in water
Smith, Fang 2011

c) Solubility of amorphous silica
Karasek et al. 2013



Processes in hsubc water for the formation of H₂, SiO₂, Fe³⁺, CO, basic pH

1. Fe³⁺ and H₂ form in anoxic hsubc water at alkaline pH ~9.5-14



2. The solubility of silica is higher in hsubc water



3. Dissolution of fayalite in hsubc water



4. Hydrolysis of siderite in hsubc water



5. Formation of the reactive CO in hsubc water



Rem: $\text{NaHCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{CO}_2 + \text{H}_2\text{O}$ at 270 °C in chem labs

$\text{CO} + \text{H}_2 \rightarrow$ **organic molecules of life** in irradiated gas mixtures of H₂/H₂O, CO, N₂/NH₃ at low T, or in Sabatier-Fisher-Haber reactions (FTT) with H₂/H₂O, CO/CO₂, N₂/NH₃.

Heat on Enceladus

Radioactive decay to set water in the liquid state

Exothermic carbonations of Fe,Mg-silicates & **hydrolysis** of Mg-silicates Bassez OLEB2017

$\Delta_r H^\circ = -524.35 \text{ kJ/kg}$ of $(\text{Fe}_{0.5}\text{Mg}_{0.5})_2\text{SiO}_4$ olivine, including the endothermic hydrolysis of fayalite. $\text{Mg}_2\text{SiO}_4 + 2\text{CO}_2 \rightarrow 2\text{MgCO}_3 + \text{SiO}_2$; $\text{Fe}_2\text{SiO}_4 + 2\text{CO}_2 \rightarrow 2\text{FeCO}_3 + \text{SiO}_2$

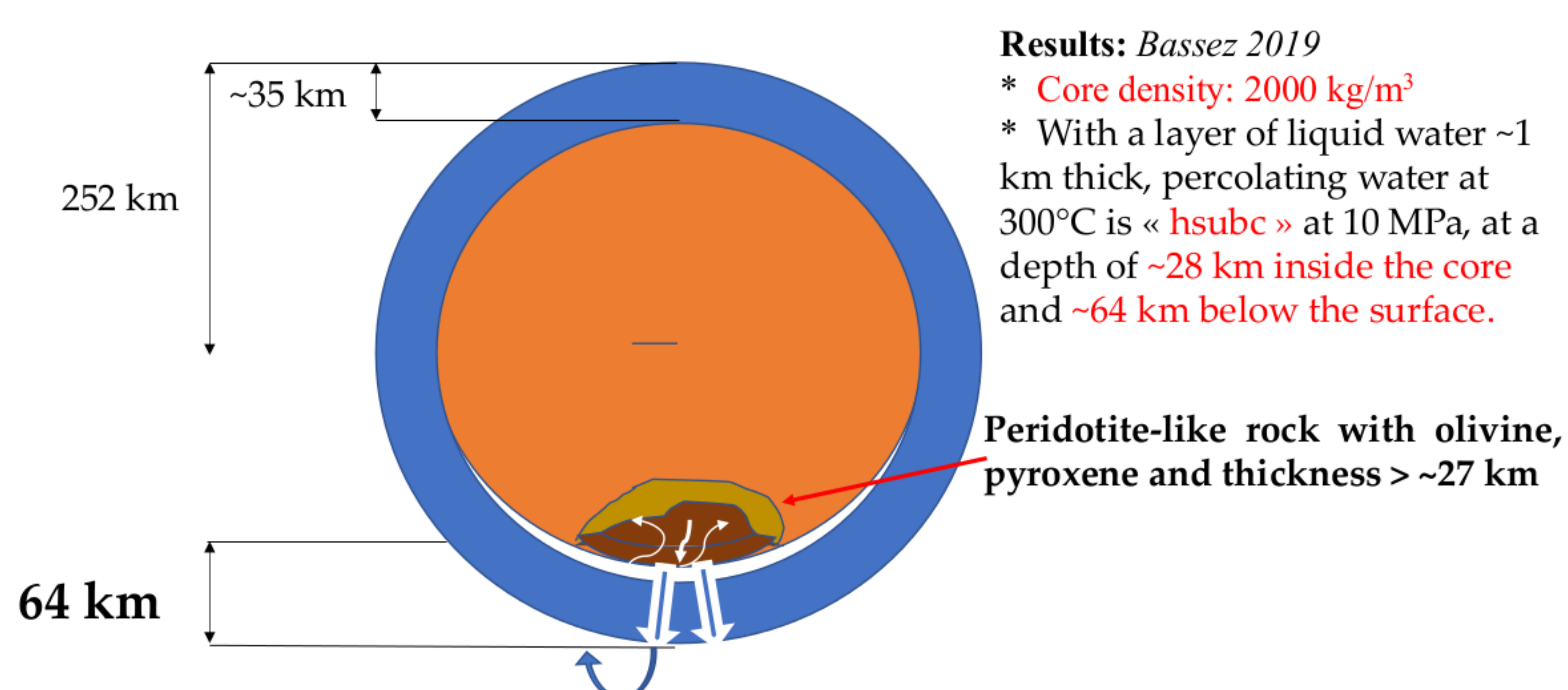
$\Delta_r H^\circ = -378.61 \text{ kJ/kg}$ of $(\text{Fe}_{0.5}\text{Mg}_{0.5})\text{SiO}_3$ pyroxene, includ. endoth. hydrol. of ferrosilite

Exothermic Sabatier Fischer Haber reactions + **Exothermic react. of CaC₂** calcium

carbide on Mg + **Exothermic hydrolysis of CaC₂ to form C₂H₂** Bassez Geosciences2019

Enceladus data: Mean density 1608.3 kg/m³ Porco 2006; Acceleration of gravity 0.113 m/s² Travis 2015; Thickness of the ice crust 30-40 km Iess 2014; Ice crust density 900 kg/m³ chosen for the calculation; hsubc water density at 10MPa and 300°C: 700 kg/m³ Bassez 2019, educed from Fig.2 in Cook & Olive 2012; pH 11-12 Glein 2015, CO₂, CH₄, C₂H₂, NH₃, H₂CO, CH₃CHO, HCN, C₃H₆, C₄H₂, C₄H₄, C₄H₈, C₆H₆, probably ⁴⁰Ar, mass 28 (N₂ or CO), H₂, NaCl, NaHCO₃, Na₂CO₃, K⁺.

A hypothesized water cycle in Enceladus



Results: Bassez 2019

* **Core density: 2000 kg/m³**

* With a layer of liquid water ~1 km thick, percolating water at 300°C is « hsubc » at 10 MPa, at a depth of ~28 km inside the core and ~64 km below the surface.

Peridotite-like rock with olivine, pyroxene and thickness > ~27 km

H₂, SiO₂ are produced and ejected with alkaline H₂O (pH ~9.5-14) through the conduits. They return to the surface and also fill the E-ring. The bottom of the ice crust melts, percolates and replaces the ejected water.

Conclusion The observed heat, H₂, pH, silica, Na salts & organic molecules can be explained by the interaction of alkaline high subcritical water with Fe,Mg-silicates located at a depth of ~64 km and higher below Enceladus surface. The hydrothermal conditions that are near the supercritical state have the values **pH ~9.5-14, ~10-25 MPa, ~300-350 °C, densities ~700-600 kg/m³**. Future models on Enceladus need to specify the term «hydrothermal» with the values of water in the high subcritical domain.

References: M.-P. Bassez Geophys. Res. Abstr. 15 EGU2013-22 (2013); OLEB 45:5-13 (2015); LPSC2016 Abtrs.1853, OLEB 47:453-480 (2017); 48:289-320 (2018) open; Geosciences 9(6)249 (2019) open.

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