CV for **OLIVIER BOLLENGIER** (November 2019)

Born on February 21, 1985 – French citizen – US H-1B VISA

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INTERESTS

Experimental / analytical laboratory work

High-pressure physical chemistry (phase transitions and properties)

Internal structure, dynamics, and habitability of icy planetary bodies

Thermodynamics of water (aqueous solutions, ices, gas hydrates)

EDUCATION

2010-2013	Ph.D. in Earth and Planetary Sciences, University of Nantes, France
2007-2010	M.Sc. in Earth and Planetary Sciences, University of Nantes, France
2004-2007	B.Sc. in Earth and Planetary Sciences, University of Nantes, France

EXPERIENCE

September 2019 – Present
Visiting Research Specialist, University of Illinois at Chicago
Department of Earth and Environmental Sciences, Univ. of Illinois at Chicago, US
(referees: D. Meyer-Dombard, F. Kenig)

I joined the UIC to provide expertise on high-pressure, large volume hydraulic systems. As part of the NASA Astrobiology Institute investigation "Habitability of Hydrocarbon Worlds: Titan and Beyond", my task is to explore the survivability of selected microorganisms under pressure (≤ 1.4 GPa) under varied temperatures and chemistries. DNA, RNA and lipid analyses will be conducted to understand the expression and selection of traits making effective barophiles.

LABORATORY WORK
- development of a high-pressure hydraulic system
- culture of selected microorganisms

June 2014 – May 2019
Postdoctoral Researcher, University of Washington
Department of Earth and Space Sciences, Univ. of Washington, US
(referees: J. M. Brown, E. Abramson)

My main task has consisted in improving the design, taking care of the assembly, and operating a custom hydraulic system to bring large liquid samples (mL) to high pressures (≤ 0.7 GPa). The system allows the acquisition of acoustic data using an ultrasonic transducer. In turn, the acoustic data are used to derive the thermodynamic properties of the fluids. I have also contributed to other projects using diamond anvil cells to observe smaller samples (nL) at higher pressures (≤ 7 GPa) using Raman spectroscopy and X-ray diffraction techniques, mainly for H_2O-CO_2 samples.

LABORATORY WORK
- development of a high-pressure hydraulic system
- LabVIEW interfacing with temperature, pressure, and acoustic sensors
- spectroscopy (Raman, X-ray) for non-destructive analysis of microscopic samples
- calibration and monitoring of pressure and temperature sensors

PROGRAMMING
- signal processing of raw data (LabVIEW, MATLAB)
- data analysis of 4D databases (MATLAB)
- thermodynamic modeling of fluid properties and liquid-ice transitions (MATLAB)

MANAGEMENT
- standard operating procedures (sample handling, system operation)
- health & safety (chemical and physical hazards)
- supervision of undergraduates

October 2013 – April 2014
Research Assistant, CNRS
Laboratoire de Planétologie et Géodynamique de Nantes, Univ. of Nantes, FR
(referees: O. Grasset, G. Tobie)

For this appointment, I used the Raman quantitative approach developed during my Ph.D. to explore the H_2O-$MgSO_4$ ice-brines equilibria under pressure ($\leq$ 1.2 GPa) in an anvil cell.

October 2010 – September 2013
Ph.D. Student, Université de Nantes
Laboratoire de Planétologie et Géodynamique de Nantes, Univ. of Nantes, FR
(supervisors: O. Grasset, G. Tobie, Y. Morizet)

My Ph.D. was devoted to the analysis of the H_2O-CO_2 system under pressure ($\leq$ 2.3 GPa) by means of spectroscopic techniques (mostly Raman) and anvil cells. I used these results to model the stability of CO_2 and CH_4 hydrates in the GPa range. I also developed a Raman spectroscopy approach to quantify the concentration of sulfate brines in anvil cells. THESIS - *Composition of the oceans of Jupiter and Saturn's icy moons: experimental and thermodynamic approaches.*

LABORATORY WORK
- optimization of a sapphire anvil cell system, and use of a diamond anvil cell
- spectroscopy (Raman, X-ray) for non-destructive analysis of microscopic samples
- analytical techniques (SEM, ICP-OES) as part of quality control procedures

PROGRAMMING
- processing of spectroscopic data (Origin)
- thermodynamic modeling of gas hydrates and liquid-ice phase transitions (Fortran)
- scientific text writing (LaTeX)

February 2010 – June 2010
M.Sc. Internship Student, LPG-Nantes
Laboratoire de Planétologie et Géodynamique de Nantes, Univ. of Nantes, FR
(supervisor: O. Grasset)

For my Master's Degree internship, I produced sieved ice sands as analogs to the icy surfaces of the outer solar system. I acquired infrared spectra of these samples under a vacuum, at various temperatures, using a vacuum cryostat coupled to a FT-IR spectrometer. The resulting experimental

database was used to invert the surface properties of the moon Enceladus from the Cassini spacecraft VIMS data. THESIS - *Effect of temperature and grain size on the infrared signature of icy materials: implications for planetary sciences.*

SKILLS

Experimental physical chemistry: high-pressure anvil cells; hydraulic pressure systems for large volumes; cryostats for cold to moderate temperature regulation of vacuum and high-pressure systems; autoclaves for liquid-gas and solid-gas sample synthesis; PT sensors calibration.

Analytical techniques: Raman and infrared spectroscopy; acoustic measurements; ICP-AES; synchrotron X-Ray diffraction (ESRF beamlines ID09A and ID27, ALS beamline 12.2.2).

Theory: equilibrium chemical thermodynamics.

Teaching assistant: B.Sc. level Earth Sciences and Thermodynamics, 130 hours (Univ. of Nantes, FR); ESS 454 Hydrogeology, 30 hours (Univ. of Washington, WA, US).

Programming languages & software: MATLAB, LabView, Fortran.

PUBLICATIONS

[1] O. Bollengier, J. M. Brown and G. Shaw. *Thermodynamics of pure liquid water: sound speed measurements to 700 MPa down to the freezing point, and an equation of state to 2300 MPa from 240 to 500 K.* The Journal of Chemical Physics, 151 (2019) 054501 (DOI 10.1063/1.5097179)

[2] E. H. Abramson, O. Bollengier, J. M. Brown, B. Journaux, W. Kaminsky and A. Pakhomova. *Carbonic acid monohydrate.* American Mineralogist, 103 (2018) 1468-1472 (DOI 10.2138/am-2018-6554).

[3] E. H. Abramson, O. Bollengier and J. M. Brown. *The water-carbon dioxide miscibility surface to 450 °C and 7 GPa*. American Journal of Science, 317 (2017) 967-989 (DOI 10.2475/09.2017.01).

[4] E. H. Abramson, O. Bollengier and J. M. Brown. *Water-carbon dioxide solid phase equilibria at pressures above 4 GPa*. Scientific Reports, 7 (2017) 821 (DOI 10.1038/s41598-017-00915-0).

[5] S. Vance, T. Loerting, J. Stern, M. Kropf, B. Journaux, C. Jamieson, M. L. Cable and O. Bollengier. *Solids and Fluids at Low Temperatures,* in *Low Temperature Materials and Mechanisms.* CRC Press, 2016 (ISBN 9781498700382).

[6] L. Bezacier, E. Le Menn, O. Grasset, O. Bollengier, A. Oancea, M. Mezouar and G. Tobie. *Experimental investigation of methane hydrates dissociation up to 5 GPa: Implications for Titan's interior.* Physics of the Earth and Planetary Interiors, 229 (2014) 144-152 (DOI 10.1016/j.pepi.2014.02.001).

[7] O. Bollengier, M. Choukroun, O. Grasset, E. Le Menn, G. Bellino, Y. Morizet, L. Bezacier, A. Oancea, C. Taffin and G. Tobie. *Phase equilibria in the H_2O-CO_2 system between 250-330 K and 0-1.7 GPa: stability of the CO_2 hydrates and H_2O-ice VI at CO_2 saturation.* Geochimica et Cosmochimica Acta, 119 (2013) 322-339 (DOI 10.1016/j.gca.2013.06.006).

[8] A. Oancea, O. Grasset, E. Le Menn, O. Bollengier, L. Bezacier, S. Le Mouélic and G. Tobie. *Laboratory infrared reflection spectrum of carbon dioxide clathrate hydrates for astrophysical remote sensing applications.* Icarus, 221 (2012) 900-910 (DOI 10.1016/j.icarus.2012.09.020).

[9] C. Taffin, O. Grasset, E. Le Menn, O. Bollengier, M. Giraud and S. Le Mouélic. *Temperature and grain size dependence of near-IR spectra signature of crystalline water ice: From lab experiments to Enceladus' south pole.* Planetary and Space Science, 61 (2012) 124-134 (DOI 10.1016/j.pss.2011.08.015).

SELECTED COMMUNICATIONS

[1] O. Bollengier. *Life deep down? High-pressure experiments to explore the hydrospheres of large icy worlds.* University of Illinois at Chicago, Earth and Environmental Sciences Seminars, Chicago (2019), talk.

[2] O. Bollengier, E. Abramson, J. M. Brown and B. Journaux. *Experimental exploration of the speciation, solubility and solid phases of carbon in the CO_2-H_2O and CO_2-H_2O-NaCl systems to 7 GPa and 700 K. pressure with application to icy worlds.* American Geophysical Union Fall Meeting, Washington (2018), poster.

[3] O. Bollengier. *High-pressure experimental thermodynamics for icy worlds.* Jet Propulsion Laboratory, Pasadena (2018), talk.

[4] O. Bollengier, J. M. Brown and S. Vance. *Experimental thermodynamics of [Na-Mg-Cl-SO_4] aqueous solutions at GPa pressure with application to icy worlds.* American Geophysical Union Fall Meeting, New Orleans (2017), poster.

[5] O. Bollengier, J. M. Brown and S. Vance. *The evolution of oceans in large icy satellites.* Astrobiology Science Conference, Mesa (2017), talk.

[6] O. Bollengier and B. Journaux. *Thinking alien abysses – how high-pressure experimental thermodynamics help us understand the structure and habitability of deep planetary hydrospheres.* University of Washington Astrobiology Spring Seminars, Seattle (2017), talk.

[7] O. Bollengier, J. M. Brown, S. Vance and G. Giesa-Wilson. *Thermodynamic potentials of NaCl(aq) between 0-0.7 GPa and 250-340 K. Properties of aqueous solutions for icy worlds. quations of state for ocean worlds.* American Geophysical Union Fall Meeting, San Francisco (2016), poster.

[8] O. Bollengier and J. M. Brown. *Equations of state for ocean worlds.* NASA Astrobiology Institute Team Meeting, Burbank (2016), talk.

[9] O. Bollengier, J. M Brown, S. Vance and G. H. Shaw. *Speed of sound in aqueous solutions at sub-GPa pressures – a new experiment to unveil the properties of extra-terrestrial oceans.* American Geophysical Union Fall Meeting, San Francisco (2015), poster.

[10] O. Bollengier. *Experiments on Water-Rich Systems Under Pressure and the Internal Structure of Large Icy Moons.* Asia Oceania Geosciences Society Meeting, Singapore (2015), talk.

[11] O. Bollengier, J. M Brown, S. Vance, O. Grasset, E. Le Menn and G. Tobie. *The H_2O-$MgSO_4$ system up to 1 GPa: implications for deep oceans in Ganymede and Titan.* American Geophysical Union Fall Meeting, San Francisco (2014), poster.

[12] O. Bollengier, O. Grasset, E. Le Menn and G. Tobie. *The H_2O-$MgSO_4$ system and the perspective of deep oceans for large icy moons.* Workshop on The Habitability of Icy Worlds, Pasadena CA (2014), poster.

[13] O. Bollengier, M. Choukroun, O. Grasset, G. Tobie, E. Le Menn, G. Bellino, L. Bezacier, Y. Morizet, A. Oancea and C. Taffin. *Experimental investigation of the H_2O-CO_2 system between 250-330 K and 0-1.7 GPa and modeling of the sI clathrate hydrate of CO_2 and CH_4 at high pressures.* American Geophysical Union Fall Meeting, San Francisco (2013), talk.

[14] O. Bollengier, O. Grasset, E. Le Menn and G. Tobie. *$MgSO_4$ et la perspective d'océans profonds pour Ganymède et Titan ($MgSO_4$ and the perspective of deep oceans for Ganymede and Titan).* Exobiologie Jeunes Chercheurs Conference, Paris (2013), talk.

[15] O. Bollengier. *Apports des expériences de laboratoire à l'étude des satellites de glace (Contribution of laboratory experiments to the study of icy moons*). LPGN, University of Nantes, Nantes (2012), talk.

[16] O. Bollengier, O. Grasset and G. Tobie. *Carbon dioxide and methane: are carbon molecules available for life in icy moons?* Astrobiology Graduate Conference, Los Angeles (2012), talk.

[17] L. Bezacier, O. Bollengier, O. Grasset, E. Le Menn, A. Oancea and G. Tobie. *Stability of clathrate hydrates under planetary conditions: experimental approaches*. Jet Propulsion Laboratory, Pasadena (2012), talk.

[18] O. Bollengier, M. Choukroun, O. Grasset, G. Tobie, E. Le Menn, G. Bellino, L. Bezacier, Y. Morizet, A. Oancea and C. Taffin. *The H_2O-CO_2 system up to 1.7 GPa: implications for large icy moons.* Lunar and Planetary Science Conference, The Woodlands (2012), poster.

[19] O. Bollengier, M. Choukroun, E. Le Menn, G. Bellino, L. Bezacier, O. Grasset, Y. Morizet, A. Oancea, C. Taffin and G. Tobie. *Clathrate hydrates of carbon dioxide above 0.2 GPa: new experimental results and theoretical developments.* European Planetary Science Congress – Division for Planetary Sciences Joint Meeting, Nantes (2011), poster.

REFEREES

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