UNIVERSITÉ Clermont Auvergne

Chimie Mathématiques Sciences de l'Univers Physique

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Title of the thesis: Mantle melting at high pressures (5-30 GPa) and high temperatures. Implications for the dynamics of early Earth and Mars.

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Summary:

Planetary material are chemically complex. They generally melt partially over a wide range of temperatures between their solidus and liquidus. In early stages of the planetary formation, extensive melting occurred down to great mantle depths, with formation of magma oceans. Partial melting can still occur today in the silicated mantle, but at limited degree of partial melting and in specific regions. It potentially induces some types of volcanism. Knowledge of melting properties is critical to predict the nature and the fate of melts produced in planetary mantles. Unfortunately, despite major experimental and theoretical efforts, major unknown remain.

Addressing properly the evolution with pressure of the mantle solidus requires careful experiments. Ideally, one should determine the onset of melting in presence of the right amount of volatiles, such as CO_2 and H_2O. Generally, the dry solidus is used as a reference to which is added the role of volatiles. The dry solidus profile currently accepted for the upper mantle is derived from a very limited amount of previous studies. Unfortunately, none of them report precise information about the degree of partial melting as a function of pressure and temperature. However, this information is major to model the mantle dynamics.

The melt composition is also poorly constrained. This matter is of major importance to understand the deep volcanic sources. The melt composition also controls the liquid buoyancy, which ultimately controls the ability of deep melts to reach the Earth's surface. For example, it has been propose that it exist a density trap for the melt just above the seismic discontinuity at a mantle depth of 410 km. However, this issue needs to be verified.

The proposed research work will be performed using multi-anvil apparatus at LMV. Investigations of the sample properties *in situ* using synchrotron radiation are also available.

Major references from our group on this matter [1-3]:

[1] J. Monteux, D. Andrault, H. Samuel, On the cooling of a deep terrestrial magma ocean, Earth Planet. Sci. Lett., 448 (2016) 140-149.
[2] J. Chantel, G. Manthilake, D. Andrault, D. Novella, T. Yu, Y.B. Wang, Experimental evidence supports mantle partial melting in the asthenosphere, Science Advances, 2 (2016).
[3] D. Andrault, et al., Melting curve of the deep mantle applied to properties of early magma ocean and actual core-mantle boundary, Earth Planet. Sci. Lett., 304 (2011) 251-259.

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