

Exploring the in situ high temperature emissivity of 2014–2015 Bardarbunga magma

Jonas Biren^{1*}, Aneta Slodczyk^{1,2}, Lionel Cosson², Leire del Campo², Cécile Genevois², Emmanuel Veron², Sandra Ory², Hao Li¹, Joan Andújar¹

¹CNRS-Université d'Orléans, ISTO, BRGM, UMR 7327, F-45071, Orléans, France.

²CNRS-Université d'Orléans, CEMHTI, UPR 3079, F-45071, Orléans, France.

<https://doi.org/10.5194/egusphere-egu21-714>

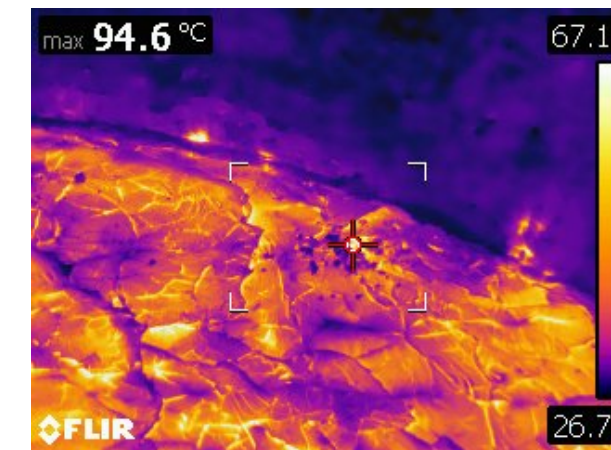
EGU2021 - GMPV10.1 - Volcano hazard modelling - 30 April 2021



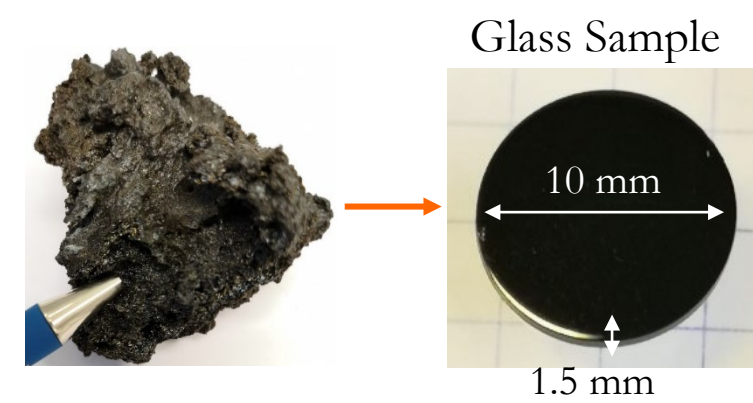
Context

- Temperature – major parameter to **understand volcanic activity** – is regularly retrieved by remote sensing (RS). →
- The accuracy of RS techniques depends on crucial parameters such as **spectral emissivity (ϵ)**.
- ϵ is mostly retrieved at **room temperature**, indirectly, using **Reflectance** data ($\epsilon = 1-R$).
- ϵ is considered **constant** for a given rock family (Harris 2013):
 - $\epsilon = 1$ or 0.95 for basalts.
- Only **few studies** have measured ϵ *in situ* in laboratory at **relevant magmatic T**: (Lee et al. 2013; Li 2018; Rogic et al. 2019a, b; Ramsey et al. 2019; Thompson and Ramsey 2020; Lombardo et al. 2020; and Li 2018)
 - **Limited temperature range**; $T \leq$ glass transition.
 - **Limited spectral range**; Mostly in TIR (5-16 μm) although RS are based on SWIR, MIR, TIR.
 - **Limited** natural or synthetic **compositions**.
 - Main conclusion of studies: Emissivity of melt $<$ Emissivity of crystallized lava in TIR.
- **Poorly-known ϵ** does **not allow** to obtain **reliable rheological properties of the magma**
 - Impact on the estimation of radiant flux measured by RS, calculated temperature, and ultimately on the accuracy of the lava flow modeling.

To solve this issue: **high temperature and broad spectral range ϵ data** are necessary!

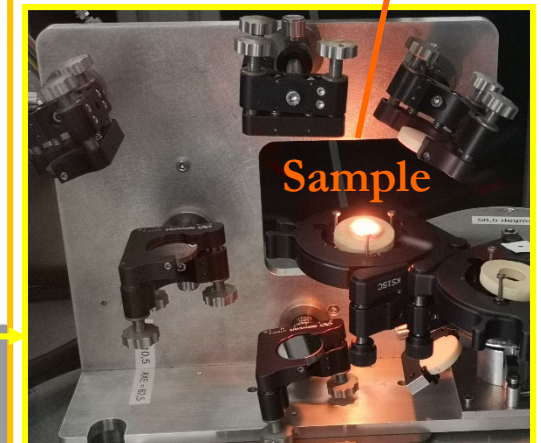
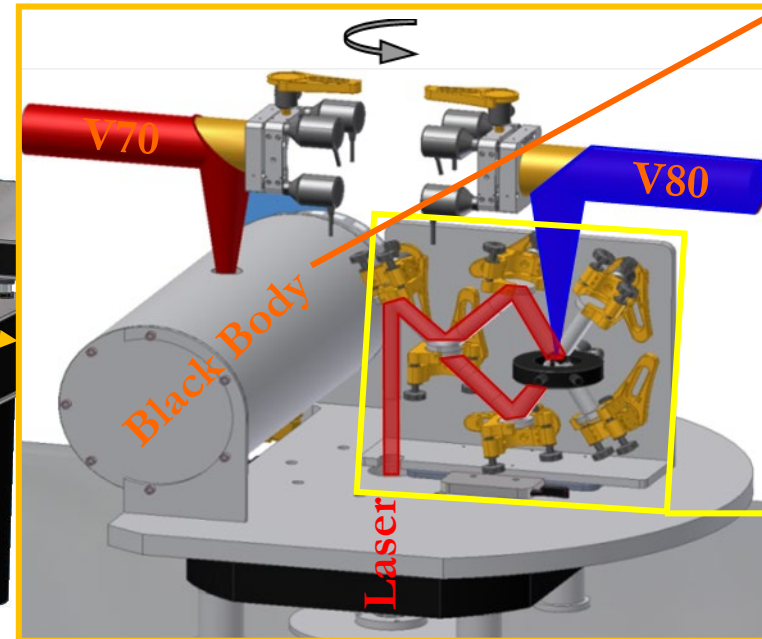
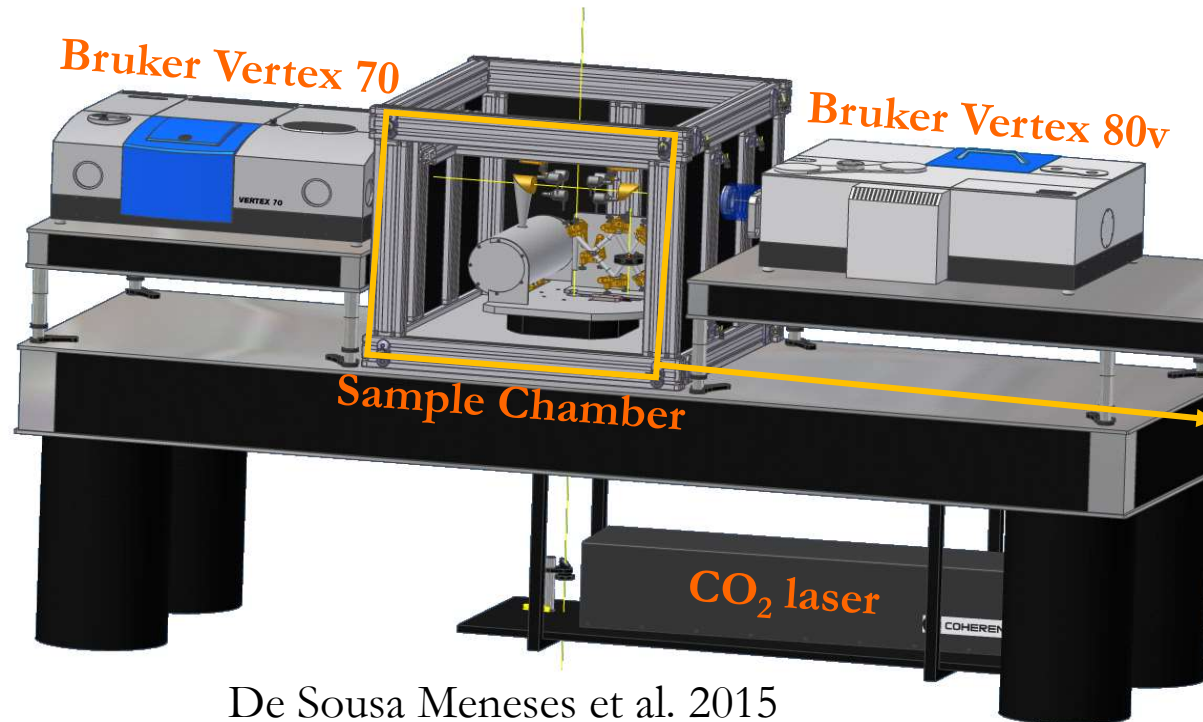


Method – Spectral Emissivity apparatus



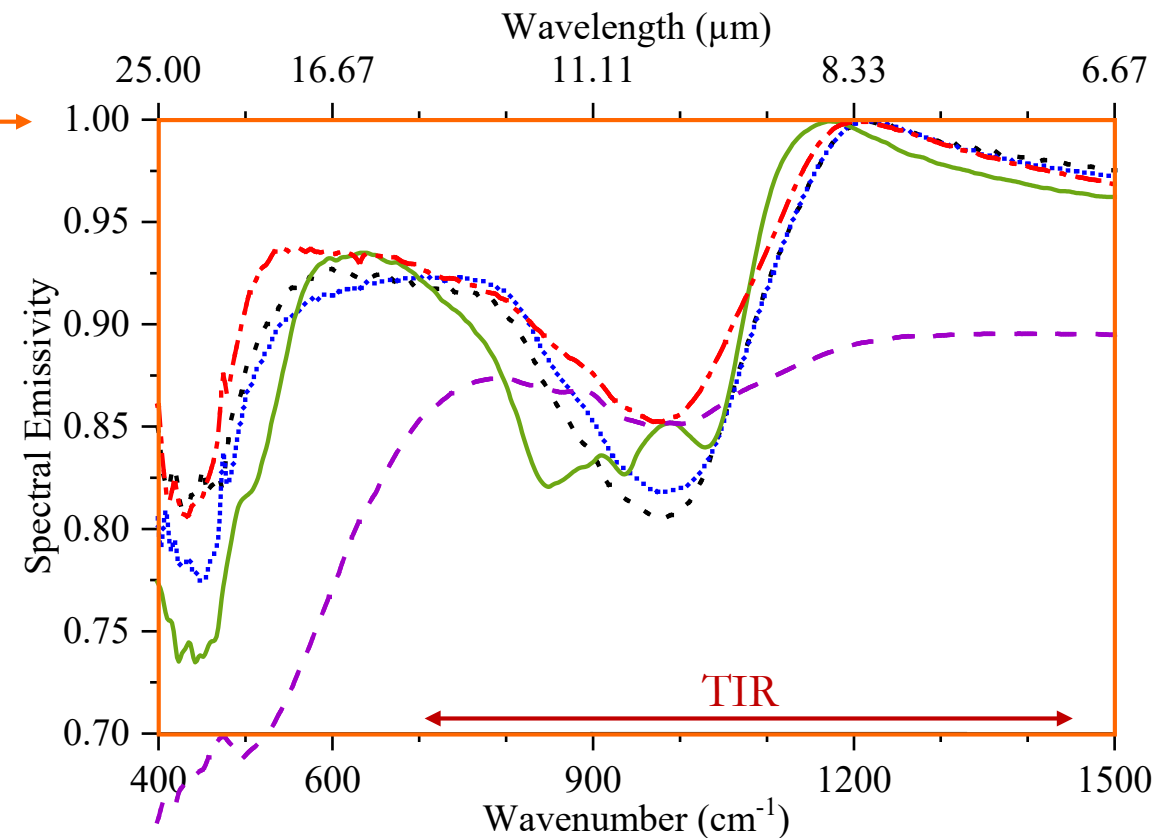
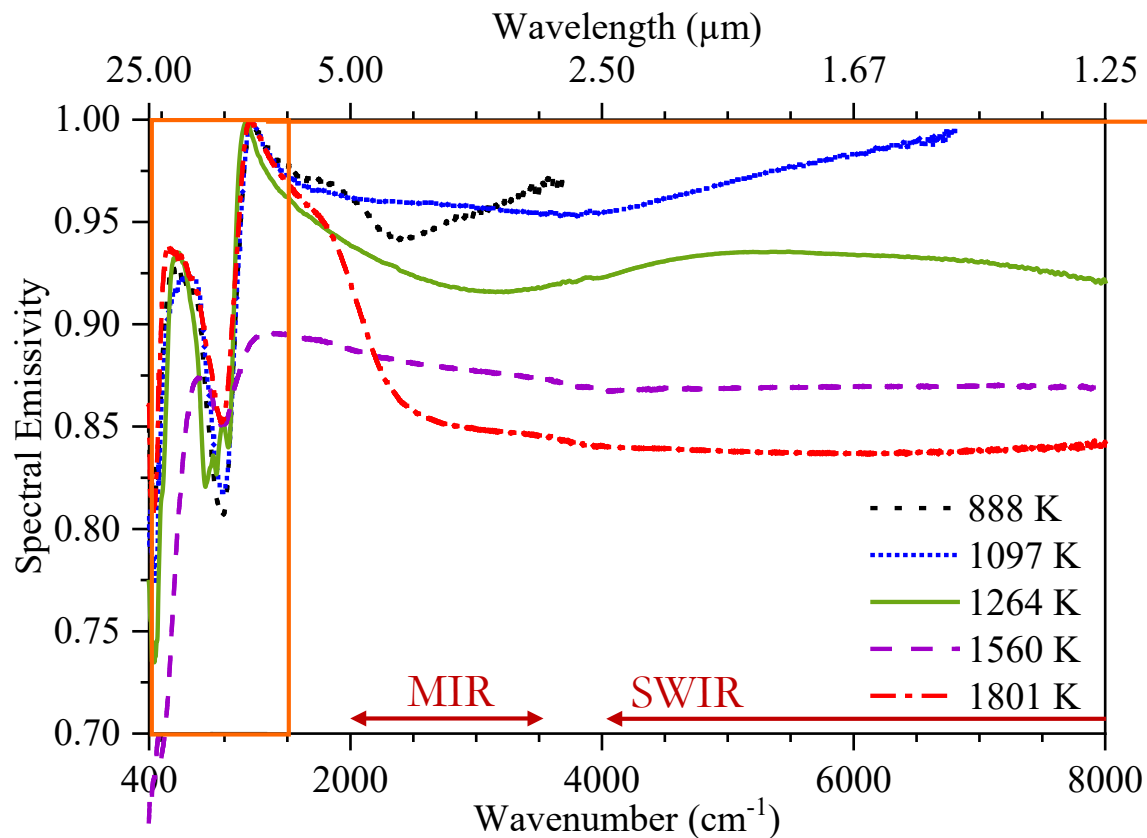
- HT *in situ* Apparatus developed at **CEMHTI** (Orléans):
 - **Two FTIR** spectrometers + **CO₂ laser** + sample **chamber**
 - Sample chamber: turntable with **sample** holder + **Black Body** furnace
 - **Wide spectral range**; 350-12 000 cm⁻¹, SWIR-MIR-TIR
 - **High temperature range**; from room T to 1800 K
- Basaltic glass samples from Bardarbunga volcano (Iceland).

$$\varepsilon_{\lambda}(\sigma, T, \theta) = \frac{L_{\lambda}(\sigma, T, \theta)}{L_{\lambda}^0(\sigma, T, \theta)} = \frac{\text{Sample}}{\text{BB}}$$



Results | T-ε relationship of Bardarbunga

Spectral emissivity behavior of Bardarbunga basalt depends on λ and T .



Temperature	Spectra Observation	Physical Process/Interpretation
<1020 K	Wide Reststrahlen bands in TIR, $\epsilon \geq 0.95$ in MIR	Typical radiative response of glass
1020-1100 K	ϵ constant in TIR and increases in MIR, SWIR	Opacification due to the formation of iron-rich clusters
1150-1350 K	New absorption bands in TIR, MIR, SWIR	Crystallization of iron-rich phases in the melting glass
1350-1550 K	Overall ϵ decrease	Surface segregation: iron-rich phases + melt. Radiative response of iron-rich phases
>1550 K	Wide Reststrahlen bands in TIR, $\epsilon = 0.85$ in MIR	Radiative response of homogeneous melt

Conclusion

Spectral emissivity behavior of Bardarbunga basalt is **complex**.

- ϵ depends on wavelength and temperature.
- **Crystallization** of Fe-rich phases strongly impacts ϵ .
- ϵ_{melt} (~ 0.85) **similar to** ϵ_{glass} (~ 0.80) in TIR, in contrast with literature.
- ϵ_{melt} (~ 0.84) **lower than** ϵ_{glass} (~ 0.95) in MIR, SWIR.

→ ϵ can **not** be considered **constant** and must be measured **at magmatic temperatures** and **wide spectral range**, for **each composition**.

- Room temperature reflectance data are inappropriate for active lava flow.
- An extended ϵ database is needed.

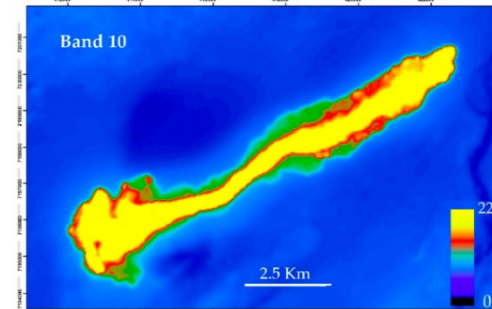
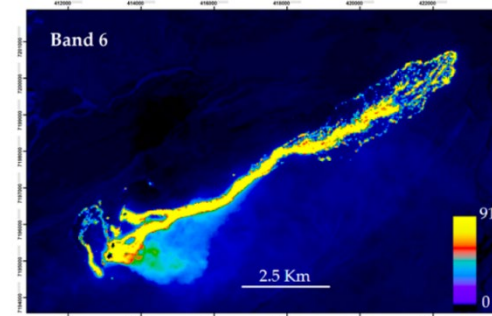
Implications

→ **Field data** must be **refined** with in situ laboratory ϵ data.

- Better constrain on surface radiance from RS and retrieved temperature.
- Strong impact on the dual band technique

→ **Accurate lava flow modeling** with appropriate rheological evolution;

- information that are crucial to improve hazard assessment in volcanic systems.



Modelisation of lava flow;
Aufaristama et al. 2018

Thank you for reading me...

Acknowledgements:

This PhD thesis is funded by French Region "Centre" and supported by Labex Voltaire, Planex and by CNRS/INSU TelluS program with RADIABAR project. A. Hoskuldsson is kindly thanked for providing the starting materials for this study. M. Aufaristama is thanked for scientific discussions. JA thanks IGN from Canary Islands for giving support in field campaigns.

References:

- **Aufaristama, M., et al. 2018**, *Remote Sensing*, 10, 151.
- **De Sousa Meneses, D., et al. 2015**, *Infrared Physics & Technology*, 69, 96-101.
- **Harris, A.J.L.** *Cambridge University Press*. Cambridge, UK, **2013**. Volume 9780521859, ISBN 9781139029346.
- **Lee, R.J., et al. 2013**, *Journal of Geophysical Research of Solid Earth* 118, 1968–1983.
- **Li, H., 2018**, *PhD thesis*, Université d'Orléans.
- **Lombardo, V., et al. 2020**, *Remote sensing*. 12, 2046.
- **Ramsey, M., et al. 2019**, *Annals of Geophysics*. 61.
- **Rogic, N., et al. 2019**, *Remote Sensing*. 11, 662.
- **Rogic, N., et al. 2019**, *Remote Sensing*. 11, 3032.
- **Thompson, J.O., et al. 2020**, *Remote Sensing*. 12, 193.



Want to contact me ? jonas.biren@cnrs-orleans.fr https://www.researchgate.net/profile/Jonas_Biren

GMPV 15 min talk – 19th May 2021, 15:00 (CEST)