Li isotope and numerical modelling to constrain evolution of magmatic volatile phase

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November 16, 2023

Personal Statement For HKU Doctor Application

Content

Pegmatite in Mufushan complex, Southern China

Self-introduction

Personal homepage:http://home.ustc.edu.cn/~yxying/

Ye, Xiangying
1998-10-4

Skills:
Python, R

Hobbies:
Science Popularization
Blues Harp
Chinese Chess

➢ Education

University of Science and Technology of China (USTC)
MA in Geology (竞赛加分推免) 2021-Now
Mentor: Professor Xiao, Yilin. GPA: 3.84/4.3

Central South University (CSU)
BA in Geological Engineering 2017-2021
Mentor: Professor Li, Bin. GPA: 82.5/100

➢ Publications and Software Copyright

1. **Ye, X.Y.**, Li, B.*, Chen, X.D., Lu, A.H., Lei, J., Zhao, L., Tan, D.B., Xiao, Y.L.*, 2023, Lithium isotopic systematics and numerical simulation for highly-fractionated granite-pegmatite system: Implications for the pegmatite-type rare-metal mineralization. *Ore Geology Reviews*, doi: https://doi.org/10.1016/ j.oregeorev.2023.105722 (IF =3.3, Q1)
2. **Ye, X.Y.**, Li, B.*, Zhu, Z.Y., Tan, D.B., Xiao, Y.L., 2023, A critical review of lithium isotope analytical methods, with implications for rare-element mineralization in granite-pegmatite systems. *Journal of Earth Science*, (IF =3.3, Q2) (Major revision)
3. **叶祥鹰**,刘岢城,肖益林, 2024, 岩石之书：寻找地球消失的记忆. 杭州：浙江科学技术出版社 (编辑润稿中)
4. Copyright of computer software: Yu, M.*, **Ye, X.Y.**, Zhao, H.T., Song, X.Q., Shang, L.X., 2020, *Geochemical Thermodynamics Visualization Platform* (GEOTVP) V1.0, 2020SR0481441. http://120.77.253.99:3838/work/shiny-server/

In preparation: **Ye, X.Y.**, Wang, Y.Y., Yang, T.Y., Tan, D.B., Xiao, Y.L*., Lithium isotope evidence for rapid climate cooling during the Late Devonian event.

Research interest: Crystal mush reservoir

- **Studies of modern-day magmatic systems have revealed the complexity of melt generation and transport through the crust (**e.g. *Bachmann and Bergantz 2004; Hildreth 2004; Marsh 2004; Cooper and Kent 2014; Bachmann and Huber 2016; Huber and Parmigiani 2018; Cashman et al., 2017; Jackson et al. 2018***)**

  - Isolated, melt-rich magma chamber ✗
  - Vertically extensive crystal mush zone ✓

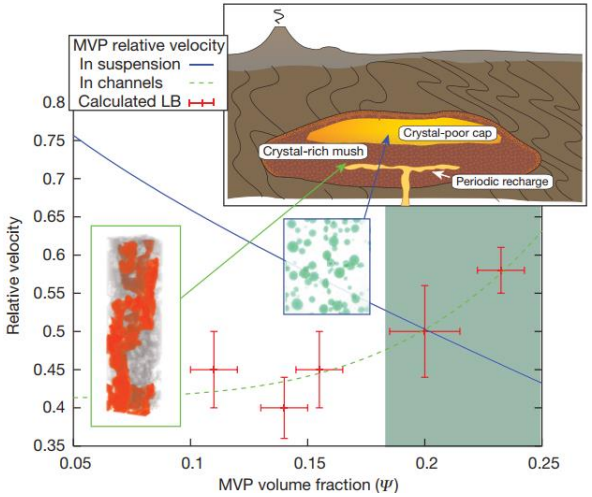
➢ **Relative viscosity (η) of high crystal content melt is the key point.**

➢ **How to understand the role of Magmatic Volatile Phase(MVP)?**

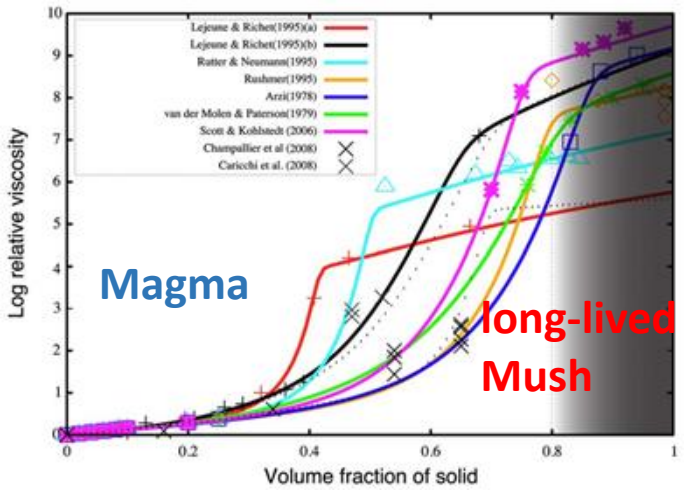
$$\eta(\phi) = \left\{1 - \alpha \,\mathrm{erf}\left(\frac{\sqrt{\pi}}{2}\phi\left[1 + \frac{\beta}{(1-\phi)^{\gamma}}\right]\right)\right\}^{-B/\alpha}$$

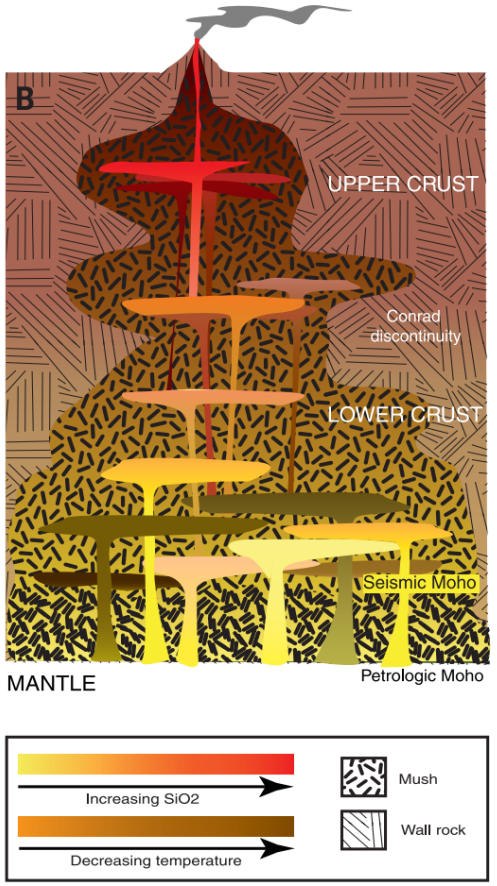
Costa et al., 2009, G-Cube

ϕ is the volume fraction of suspended particles and B (=2.5) is the Einstein coefficient (Einstein, 1905)



Parmigiani et al., (2016) Nature



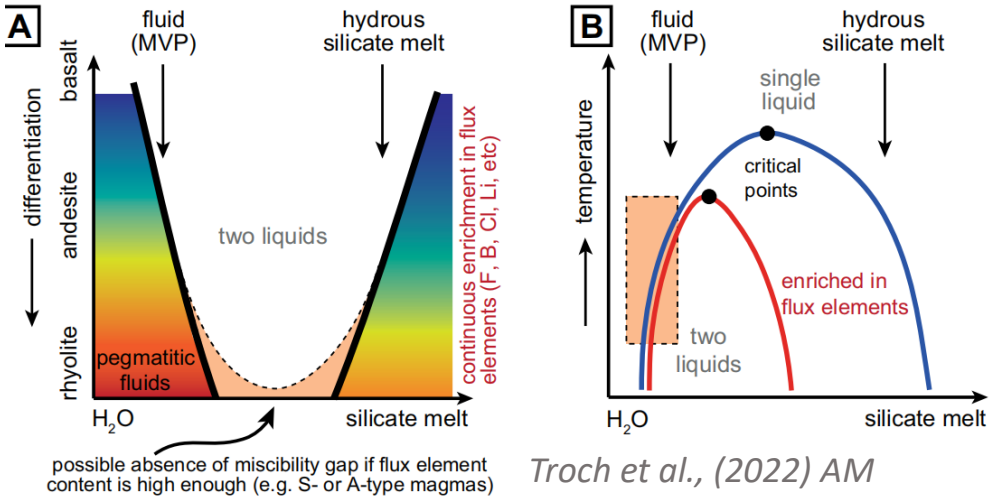


Cashman et al., (2017) Science

Research interest: Magmatic volatile phase

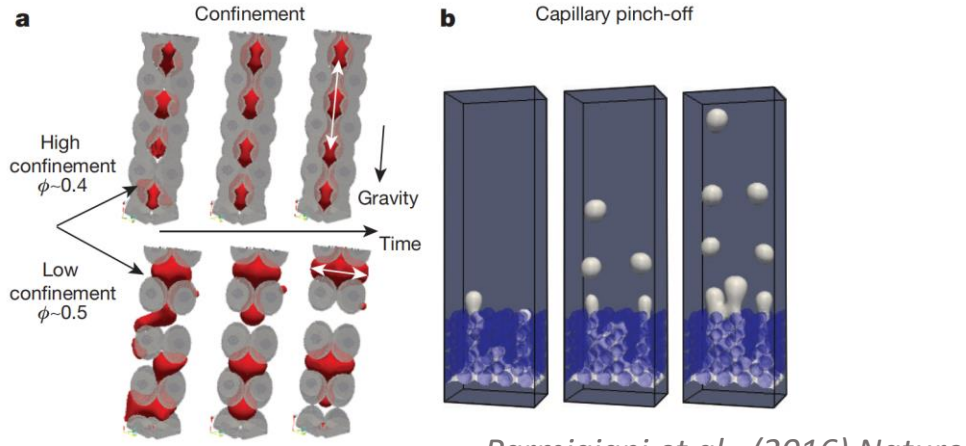
- **Numerous numerical models have confirmed that volatiles have large influences on the chemical and physical properties of magmas (*e.g., Parmigiani et al. 2016, 2017; Li et al.,2020; Edmonds and Woods, 2018*).**

- **Magmatic volatile phase (MVP):** a very general term for fluids and hydrous silicate liquids in magmatic systems.



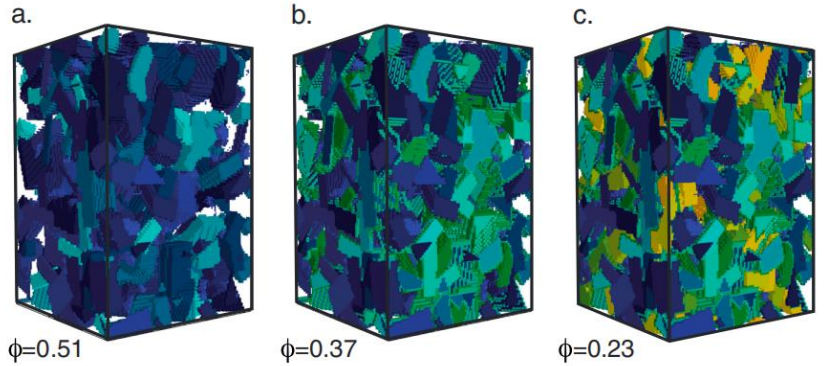
Troch et al., (2022) AM

The cooling and evolution of magma affect the immiscibility of MVP and aqueous silicate melts.



Parmigiani et al., (2016) Nature

Magmatic volatile phase (MVP) can migrate effectively in mush and accumulate in crystal poor cap.



Huber and Parmigiani, (2018) JGR

Melt extraction and matrix compaction features

➢ **How to trace the key process of magmatic volatile phase (MVP) in natural samples?**

Research interest: Late magmatic and hydrothermal processes

■ **Highly evolved granite-pegmatite system in Mufushan complex in South China.**

➢ **Petrography**

Biotite granite;

Muscovite granite;

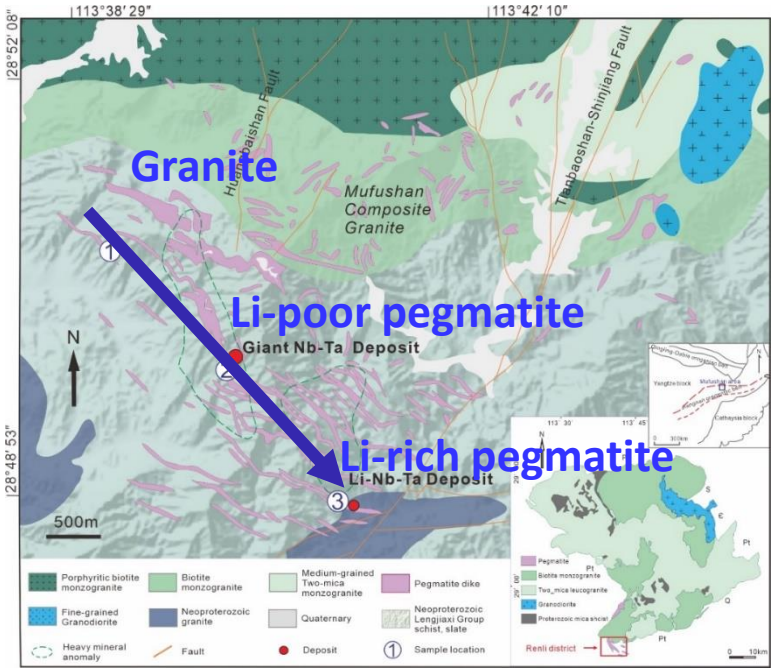
Tourmaline pegmatite;

Spodumene pegmatite.

➢ **Deposit geology**

Giant Nb-Ta deposit;

Li- Nb-Ta deposit;

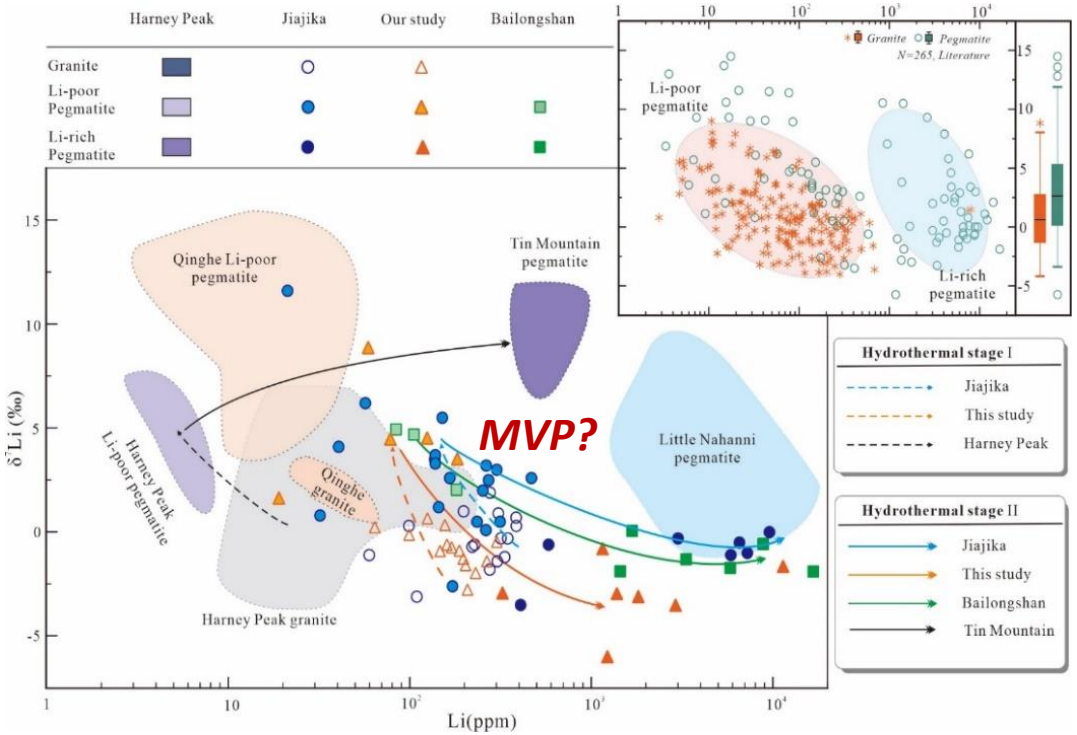


■ **Pegmatite: The hallmark of the magmatic-hydrothermal transition.**

- **Economic importance**
  e.g. Over 38% of global lithium mineral resources come from pegmatites (*Grosjean et al., 2012; Bowell et al., 2020*).
- **Dramatic textures**
  Giant Crystals, Graphic Texture, Mineral Banding, Flow Structures.
- **Colorful gemstones**
  Beryl, Tourmaline, Aquamarine, Amazonite, etc.

Research experience: Li isotope fractionation

- **Lithium is a fluid-mobile element, and significant Li isotope fractionation can be observed in various hydrothermal fluid related processes (*Teng et al., 2006; Tomascak et al.,2016; Ellis et al.,2022*)**
- **The fractionation of Li isotopes is primarily controlled by the coordination number of Li, which varies in different hydrothermal processes *(Li et al.,2018; Wunder et al.,2007*).**



Li isotope data in granites and pegmatites across the world.
From Ye et al., (2023) OGR

- "Horn" like evolution curve.
- Li concentration is negatively correlated with δ^7Li in granite-pegmatite system.
- Extraordinary lithium enrichment (exceeding saturation, >11000ppm) in Li-rich pegmatites.
- Li-rich pegmatites have lower δ^7Li values compared to Li-poor pegmatites.

- **Are these caused by the participation of MVP?**
- **How do lithium isotopes behave in response to compositional changes in MVP during the pegmatite formation process?**

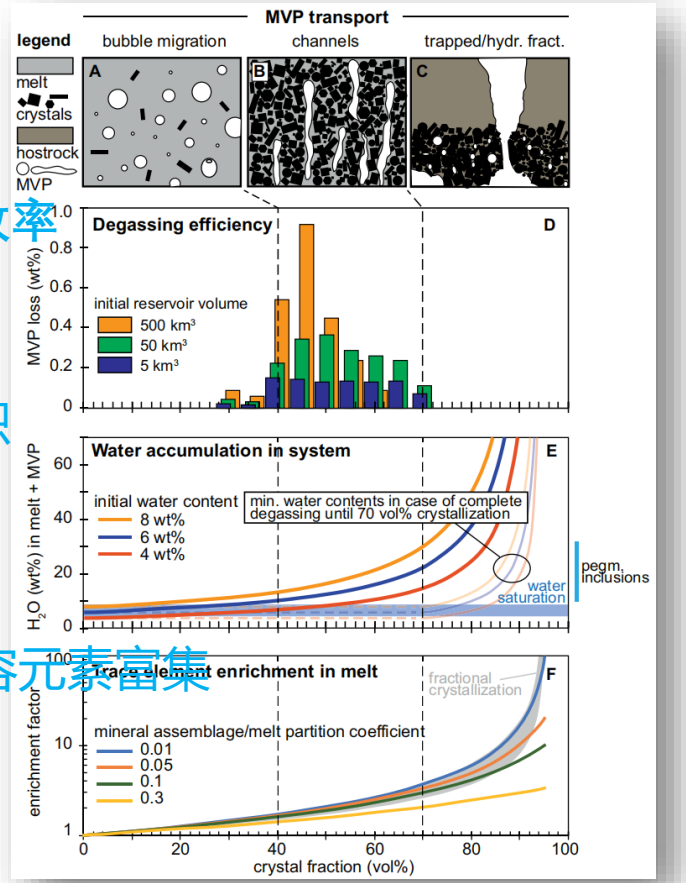
Research experience: Li-poor and Li-rich pegmatite

- **Li-poor pegmatite formed during MVP exsolution and MVP accumulation period.**
- **Li-rich pegmatite was may be related to long-distance MVP migration.**

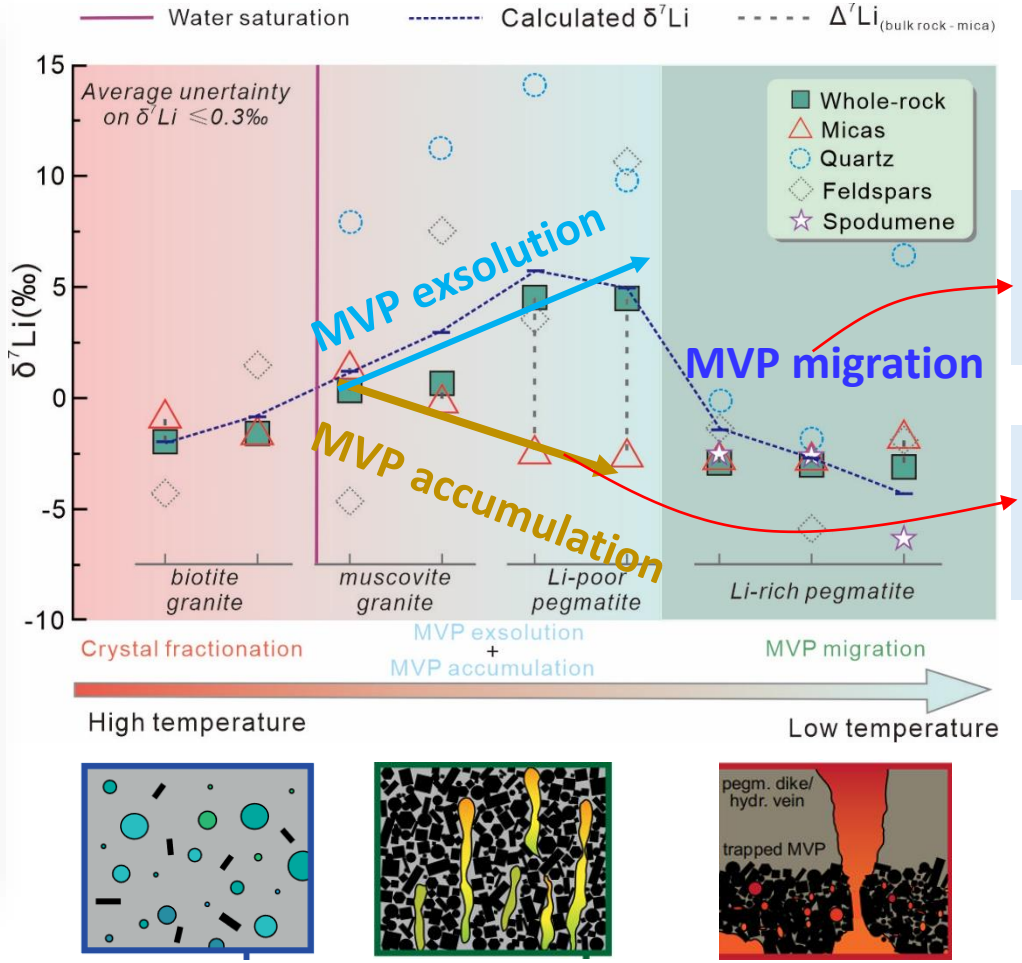
脱气效率

水累积

不相容元素富集



Troch et al., (2022) AM



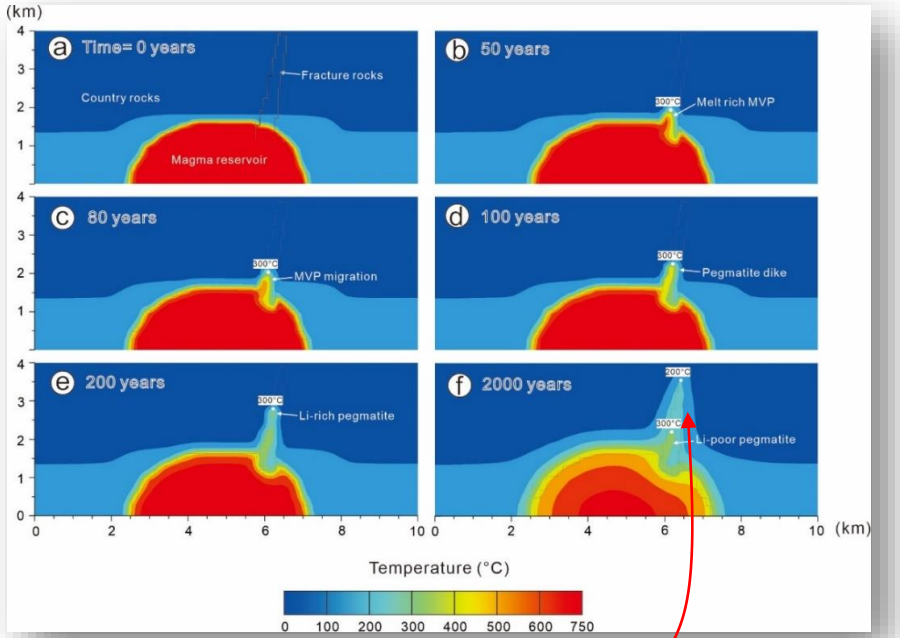
MVP exsolved from silicic magmas trend toward **high Li contents and low δ^7Li**.

Magmatic volatile phase trapped between **layers of mica crystals** (*Ellis et al., 2022*).

Research experience: Numerical simulation

■ Temperature field modelling

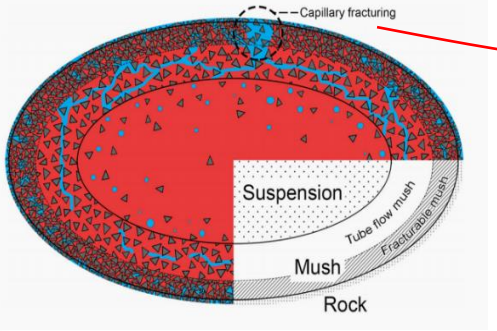
- 3km away from the magma reservoir.
- Different cooling times



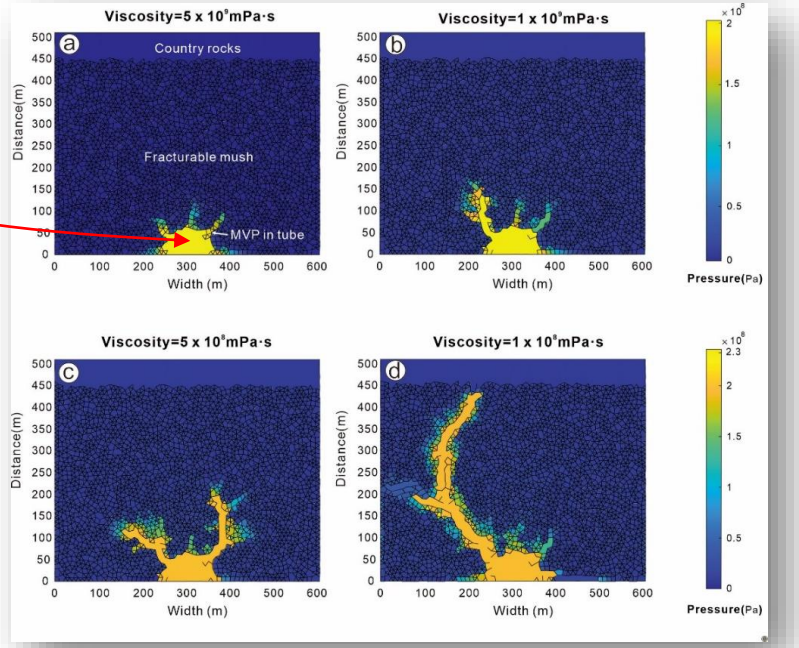
The crystallization temperature of pegmatite is generally **300 -400 ℃**, and fluxing components could lower the temperature (HYDROTHERM3.2 simulation (Kipp et al., 2008).

■ MVP migration modeling

- Low viscosity MVP :migrate further and larger fractures.
- Related to the mineralization of Li, Nb, and Ta etc.



Lamy-Chappuis et al., 2020

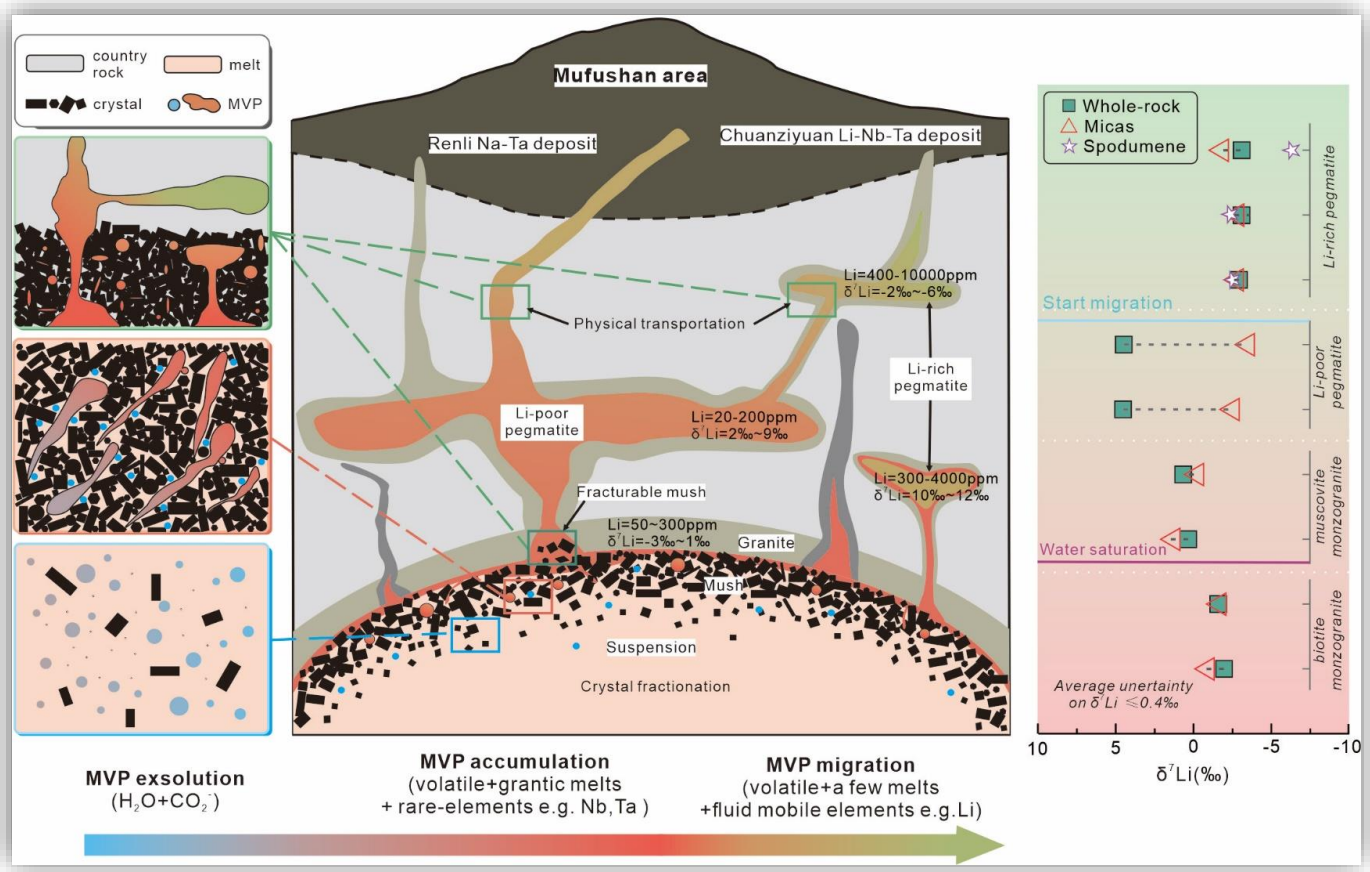


Relative viscosity of MVP, space dilatation, capillary fracturing, discrete element simulation (MatDEM; Liu et al., 2013)

Ye et al., 2023 OGR

Research experience

■ **Schematic diagram of pegmatite formation and related Li-Nb-Ta mineralization derived from Li isotope and MVP composition changes.**



Ye et al., (2023) OGR

➢ Conclusion

- MVP exsolution: a prerequisite for pegmatite formation.
- MVP accumulation: trapped in the crystal network, enriched volatile, rare-element, lower the solidus.
- large-scale MVP migration: Li-poor and Li-rich, 3km.

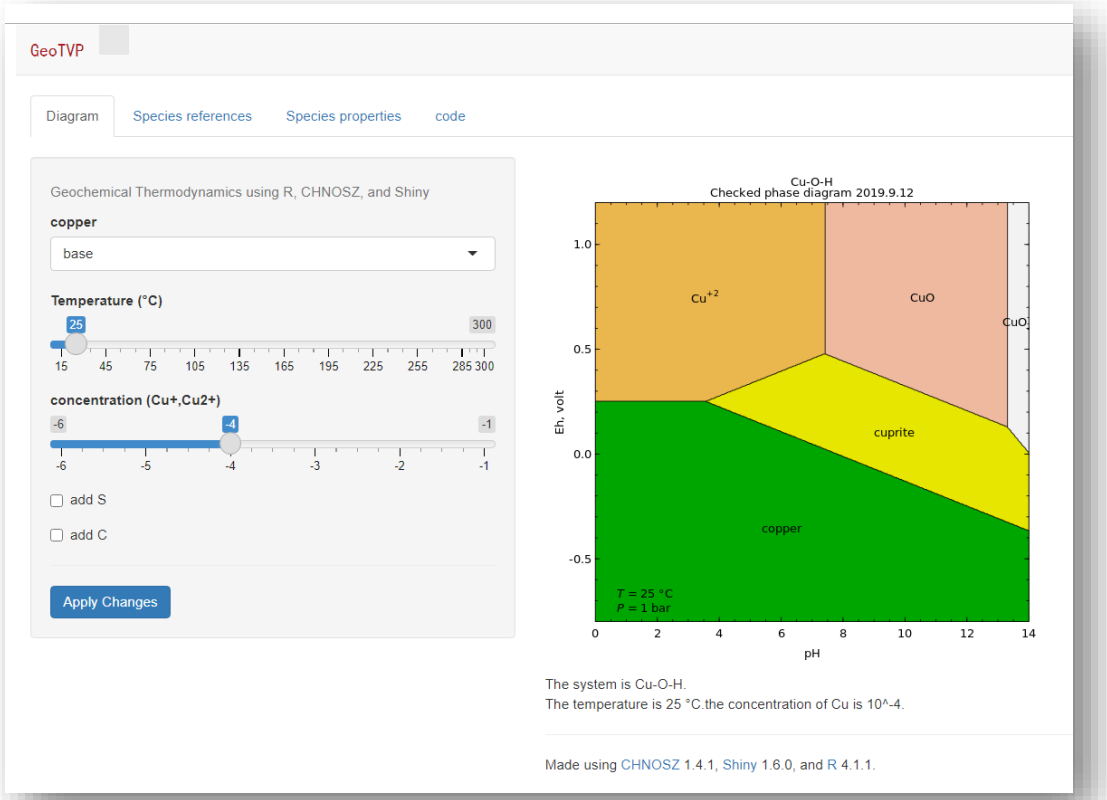
➢ Unresolved issues:

- Which volatile component (H_2O, F, etc.) has a decisive impact on the formation of pegmatite?
- Different types of granite pegmatite?
- Undercooling or long crystallization time?

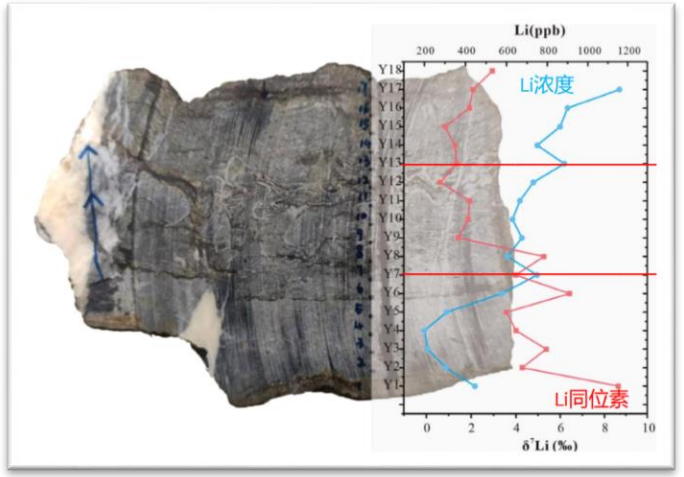
Other experiences

1. Geochemical Thermodynamic Visualization Platform

- You can try some demos on our website: http://120.77.253.99:3838/work/shiny-server/



2. Magmatic Volatiles in Large Igneous Provinces and Their Environmental and Ecological Effects



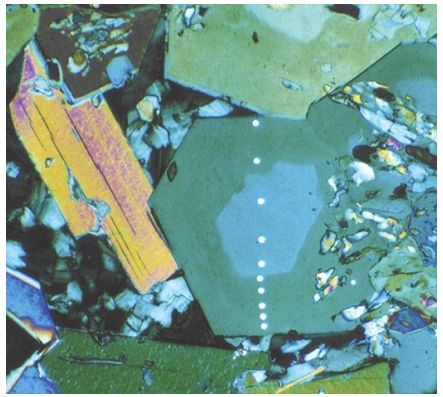
3. Popular science writing at *Dr. Stone Cartel, USTC*

- The Disappearing Memory of the Earth. (地球消失的记忆) https://mp.weixin.qq.com/s/1kRjdW-39ZQNIp8gJTGdsA
- Anthropocene: Have humans really changed the Earth?(人类世：人类真的改变地球了吗？) https://mp.weixin.qq.com/s/1MOcFGYPz0_MdCUDslqynw
- The Love Story between the Earth and the Moon.(与月老师的爱情故事：人类最后一次登月50周年) https://mp.weixin.qq.com/s/TjruIyMwu4FuKVS6hwXqNQ
- The Book of Rocks. (岩石如何记录地球历史)

Future plan

- **Compared to whole rock analysis, in situ analysis (SIMS) has more advantages in analyzing pegmatite samples :** e.g. Avoidance of sample preparation, non-destructive, and high spatial resolution (<50 µm), etc
- **Combining numerical and geochemical modelling with real-world data.**

➢ **Tourmaline** is sensitive to changes in melt and fluid compositions during its growth and resistant to alteration by later fluids.

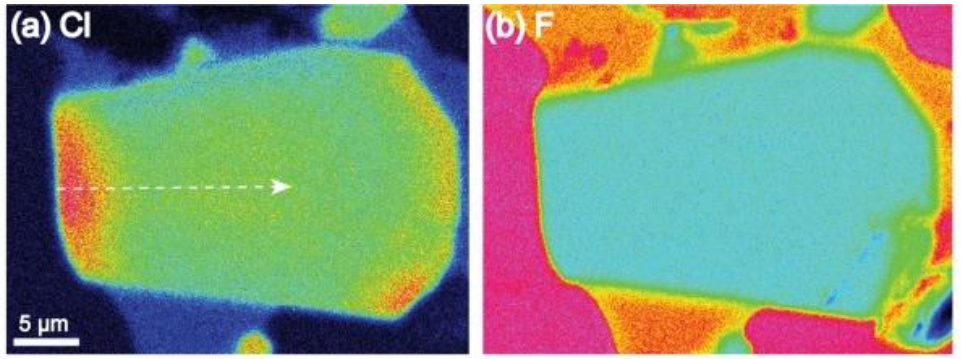


Zoned hexagonal tourmaline

Marschall and Jiang, 2011, Element

➢ Tourmaline Li isotopic composition changes at evolution of pegmatite dikes, from **emplacement**, through **magmatic–hydrothermal transition**, to **solidification and cooling** (*Maloney et al. 2008*).

➢ **Apatite** incorporates several volatile elements such as F, Cl, H, C and S into its structure, and thus has been proposed as an alternative tool for tracking the melt volatile contents(*Li et al.,2020, GCA*).



Li et al.,2020, EPSL

➢ Estimating water concentrations in silicate melts.
➢ Determine the timescales of magma ascent.
➢ Estimating the magma storage depths , and the magmatic volatile budgets and ascent rates.

Thanks for your time!

感谢聆听，请提宝贵意见

中国科学技术大学
University of Science and Technology of China