

Olivine in picrites from Continental Flood Basalt provinces classified using machine learning

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Text S1

Additional Supporting Information (Files uploaded separately)

Supporting Information S1: Data file used in this study (Excel file)

Supporting Information S2: Matlab source code with Excel file

Supporting Information S3: Matlab source code with Excel file

Text S1. Description of Supplementary material

Both the Matlab source code and the input data required to fully reproduce the results presented in the paper are included in the Supporting Information. This Matlab source code is designed to allow the user to use ANN. User need have Matlab R2018a or other versions with Neural Network Toolbox. User need put both code and excel file into one Matlab folder, and then run the code and train the ANN to obtain the results.

The source code is provided as “olivine_ann.m with traindata.xlsx” and “olivine_ann_3groups.m with traindata3.xlsx” which is designed for three outputs.

The input data are provided in a excel file (“Table 1s”) and are taken from the GEOROC (<http://georoc.mpch-mainz.gwdg.de/georoc/>) databases. The references for these data are listed as follow:

Reference for the data we used in Table 1s:

- Arguin, J. P., Pagé, P., Barnes, S. J., Yu, S. Y., & Song, X. Y. (2016). The effect of chromite crystallization on the distribution of osmium, iridium, ruthenium and rhodium in picritic magmas: an example from the Emeishan Large Igneous Province, Southwestern China. *Journal of Petrology*, 57(5), 1019-1048.
- Beccaluva, L., Bianchini, G., Natali, C., & Siena, F. (2009). Continental flood basalts and mantle plumes: a case study of the Northern Ethiopian Plateau. *Journal of Petrology*, 50(7), 1377-1403.
- Cucciniello, C., Demonterova, E. I., Sheth, H., Pande, K., & Vijayan, A. (2015). 40 Ar/39 Ar geochronology and geochemistry of the Central Saurashtra mafic dyke swarm: insights into magmatic evolution, magma transport, and dyke-flow relationships in the northwestern Deccan Traps. *Bulletin of Volcanology*, 77(5), 1-19.
- Gibson, S. A., Thompson, R. N., & Dickin, A. P. (2000). Ferropicrites: geochemical evidence for Fe-rich streaks in upwelling mantle plumes. *Earth and Planetary Science Letters*, 174(3/4), 355-374.
- Hanski, E., Kamenetsky, V. S., Luo, Z. Y., Xu, Y. G., & Kuzmin, D. V. (2010). Primitive magmas in the Emeishan large igneous province, southwestern China and northern Vietnam. *Lithos*, 119(1-2), 75-90.
- Harris, C., Le Roux, P., Cochrane, R., Martin, L., Duncan, A. R., Marsh, J. S., ... & Class, C. (2015). The oxygen isotope composition of Karoo and Etendeka picrites: high δ 18 O mantle or crustal contamination?. *Contributions to Mineralogy and Petrology*, 170(1), 1-24.
- Heinonen, J. S., Jennings, E. S., & Riley, T. R. (2015). Crystallisation temperatures of the most Mg-rich magmas of the Karoo LIP on the basis of Al-in-olivine thermometry. *Chemical Geology*, 411, 26-35.
- Heinonen, J. S., & Kurz, M. D. (2015). Low-3He/4He sublithospheric mantle source for the most magnesian magmas of the Karoo large igneous province. *Earth and Planetary Science Letters*, 426, 305-315.
- Heinonen, J. S., & Luttinen, A. V. (2008). Jurassic dikes of Vestfjella, western Dronning Maud Land, Antarctica: Geochemical tracing of ferropicrite sources. *Lithos*, 105(3-4), 347-364.
- Heinonen, J. S., & Luttinen, A. V. (2010). Mineral chemical evidence for extremely magnesian subalkaline melts from the Antarctic extension of the Karoo large igneous province. *Mineralogy and Petrology*, 99(3-4), 201-217.
- Heinonen, J. S., Luttinen, A. V., Riley, T. R., & Michallik, R. M. (2013). Mixed pyroxenite–peridotite sources for mafic and ultramafic dikes from the Antarctic segment of the Karoo continental flood basalt province. *Lithos*, 177, 366-380.
- Heinonen, J. S., Luttinen, A. V., & Whitehouse, M. J. (2018). Enrichment of 18 O in the mantle sources of the Antarctic portion of the Karoo large igneous province. *Contributions to Mineralogy and Petrology*, 173(3), 1-21.
- Howarth, G. H., & Harris, C. (2017). Discriminating between pyroxenite and peridotite sources for continental flood basalts (CFB) in southern Africa using olivine chemistry. *Earth and Planetary Science Letters*, 475, 143-151.
- Jamtveit, B., Brooker, R., Brooks, K., Larsen, L. M., & Pedersen, T. (2001). The water content of olivines from the North Atlantic Volcanic Province. *Earth and Planetary Science Letters*, 186(3-4), 401-415.
- Jennings, E. S., Gibson, S. A., MacLennan, J., & Heinonen, J. S. (2017). Deep mixing of mantle melts beneath continental flood basalt provinces: Constraints from olivine-hosted melt inclusions in primitive magmas. *Geochimica et Cosmochimica Acta*, 196, 36-57.
- Kamenetsky, V. S., Chung, S. L., Kamenetsky, M. B., & Kuzmin, D. V. (2012). Picrites from the Emeishan Large Igneous Province, SW China: a compositional continuum in primitive magmas and their respective mantle sources. *Journal of Petrology*, 53(10), 2095-2113.
- Kamenetsky, V. S., Maas, R., Kamenetsky, M. B., Yaxley, G. M., Ehrig, K., Zellmer, G. F., ... & Schilling, J. G. (2017). Multiple mantle sources of continental magmatism: Insights from “high-Ti” picrites of Karoo and other large igneous provinces. *Chemical Geology*, 455, 22-31.
- Krishnamurthy, P., Gopalan, K., & Macdougall, J. D. (2000). Olivine compositions in picrite basalts and the Deccan volcanic cycle. *Journal of Petrology*, 41(7), 1057-1069.

- Larsen, L. M., & Pedersen, A. K. (2000). Processes in high-Mg, high-T magmas: evidence from olivine, chromite and glass in Palaeogene picrites from West Greenland. *Journal of Petrology*, 41(7), 1071-1098.
- Li, C., Ripley, E. M., Tao, Y., & Hu, R. (2016). The significance of PGE variations with Sr–Nd isotopes and lithophile elements in the Emeishan flood basalt province from SW China to northern Vietnam. *Lithos*, 248, 1-11.
- Li, C., Tao, Y., Qi, L., & Ripley, E. M. (2012). Controls on PGE fractionation in the Emeishan picrites and basalts: constraints from integrated lithophile–siderophile elements and Sr–Nd isotopes. *Geochimica et Cosmochimica Acta*, 90, 12-32.
- Natali, C., Beccaluva, L., Bianchini, G., Ellam, R. M., Savo, A., Siena, F., & Stuart, F. M. (2016). High-MgO lavas associated to CFB as indicators of plume-related thermochemical effects: the case of ultra-titaniferous picrite–basalt from the Northern Ethiopian–Yemeni Plateau. *Gondwana Research*, 34, 29-48.
- Natali, C., Beccaluva, L., Bianchini, G., & Siena, F. (2011). Rhyolites associated to Ethiopian CFB: Clues for initial rifting at the Afar plume axis. *Earth and Planetary Science Letters*, 312(1-2), 59-68.
- Pedersen, A. K. (1985). Reaction between picrite magma and continental crust: early Tertiary silicic basalts and magnesian andesites from Disko, West Greenland.
- Ren, Z. Y., Wu, Y. D., Zhang, L., Nichols, A. R., Hong, L. B., Zhang, Y. H., ... & Xu, Y. G. (2017). Primary magmas and mantle sources of Emeishan basalts constrained from major element, trace element and Pb isotope compositions of olivine-hosted melt inclusions. *Geochimica et Cosmochimica Acta*, 208, 63-85.
- Rogers, N. W., Davies, M. K., Parkinson, I. J., & Yirgu, G. (2010). Osmium isotopes and Fe/Mn ratios in Ti-rich picritic basalts from the Ethiopian flood basalt province: No evidence for core contribution to the Afar plume. *Earth and Planetary Science Letters*, 296(3-4), 413-422.
- Sobolev, A. V., Krivolutsкая, N. A., & Kuzmin, D. V. (2009). Petrology of the parental melts and mantle sources of Siberian trap magmatism. *Petrology*, 17(3), 253-286.
- Starkey, N. A., Fitton, J. G., Stuart, F. M., & Larsen, L. M. (2012). Melt inclusions in olivines from early Iceland plume picrites support high $3\text{He}/4\text{He}$ in both enriched and depleted mantle. *Chemical Geology*, 306, 54-62.
- Starkey, N. A., Stuart, F. M., Ellam, R. M., Fitton, J. G., Basu, S., & Larsen, L. M. (2009). Helium isotopes in early Iceland plume picrites: Constraints on the composition of high $3\text{He}/4\text{He}$ mantle. *Earth and Planetary Science Letters*, 277(1-2), 91-100.
- Tang, Q., Li, C., Zhang, M., & Lin, Y. (2015). U–Pb age and Hf isotopes of zircon from basaltic andesite and geochemical fingerprinting of the associated picrites in the Emeishan large igneous province, SW China. *Mineralogy and Petrology*, 109(1), 103-114.
- Tao, Y., Putirka, K., Hu, R. Z., & Li, C. (2015). The magma plumbing system of the Emeishan large igneous province and its role in basaltic magma differentiation in a continental setting. *American Mineralogist*, 100(11-12), 2509-2517.
- Walker, J. A., Carr, M. J., Feigenson, M. D., & Kalamarides, R. I. (1990). The petrogenetic significance of interstratified high- and low-Ti basalts in central Nicaragua. *Journal of Petrology*, 31(5), 1141-1164.
- Xia, Y., Zhu, D. C., Wang, Q., Zhao, Z. D., Liu, D., Wang, L. Q., & Mo, X. X. (2014). Picritic porphyrites and associated basalts from the remnant Comei Large Igneous Province in SE Tibet: records of mantle-plume activity. *Terra Nova*, 26(6), 487-494.
- Zhaochong, Z., Yanli, H., Fusheng, W., & MAHONEY, J. J. (2004). Petrology, mineralogy and geochemistry of the Emeishan Continental Flood basalts, SW China: evidence for activity of mantle plumes. *Acta Geologica Sinica-English Edition*, 78(1), 40-51.
- Zhang, Z., Mahoney, J. J., Mao, J., & Wang, F. (2006). Geochemistry of picritic and associated basalt flows of the western Emeishan flood basalt province, China. *Journal of Petrology*, 47(10), 1997-2019.