Sulphur isotopes and helvine-group minerals of pegmatites in the Larvik Plutonic Complex (LPC), Norway

Emil H. Gulbransen[a,*], Henrik Friis[a], William Hutchison[b] and Tom Andersen[a]

[a]Natural History Museum, University of Oslo, P.O. Box 1172, Blindern, 0318, Oslo, Norway

* e.h.gulbransen@nhm.uio.no

[b]School of Earth and Environmental Sciences, University of St Andrews, KY16 9AL, United Kingdom

The Permo-Carboniferous Larvik Plutonic Complex (LPC) is part of the Permian Oslo Rift in the Southeastern part of Norway. The LPC consist of concentric ring plutons of different ages, commonly referred to as ring sections (RS). Broadly speaking, the age of the complex increases from east (302.0 Ma) to west (287.0 Ma), while the composition changes from quartz-bearing monzonite to felspathoid-bearing to the most evolved nepheline syenites in RS 9 and 10. The complex hosts numerous miaskitic to agpaitic pegmatites which origin and source is still uncertain. Alkaline pegmatites are intraplutonic and an important part of understanding the evolution of the complex as a whole. Sulphur isotope geochemistry can help unlock new aspects of pegmatite formation. Sulphur isotope methods have never been utilized on alkaline pegmatites, despite its mineralogy being suitable for it. Traditionally only sulphides and sulphates have been used for sulphur isotopes, however mineral groups such the helvine-group contains S as one of its main components and potentially enables the use of S-isotope geochemistry. Helvine-group minerals ($Be_3M_4(SiO_4)_3S$), where M = Fe, Mn or Zn, is a relative common mineral in the pegmatites of the LPC, and rarely occurs together with other S-bearing minerals. This is of major importance as being able to utilize a new mineral for S-isotope geochemistry would unluck previously unknown parameters for paragenesis where traditional sulphur minerals are absent. It is worth mentioning that although the helvine-group might be considered uncommon, it is actually occurring in various geological settings and not just alkaline pegmatites. As such this study provides a new set of tools for exploring pegmatites and other rocks.

The sulphides from the central pegmatites of the LPC (292.4 Ma) show primary magmatic source with galenas ranging from -0.65 to -0.23 $\delta^{34}S$ and sphalerites ranging from 0.46 to 1.57 $\delta^{34}S$. Comparatively, the helvines from the central pegmatites has a $\delta^{34}S$ of 0.30 to 0.89, correlating well with the recorded sulphide $\delta^{34}S$ values. Helvine from a pegmatite on the western boarder of the LPC (293.0 Ma) record a $\delta^{34}S$ value of 16.45. Just outside the western boarder of the LPC there are Proterozoic sediments which might have influenced the high $\delta^{34}S$ through crustal contamination. This is not unlike what we generally see from sulphides, indicating that helvine might record external influences on the source, similar to traditional sulphides. The first temperature calculations of the pegmatites of the LPC are given using geothermometry with well-known fractionation coefficients between coexisting sulphides (galena-sphalerite). With the utilization of S-isotope geochemistry on helvine-group minerals, a traditional analytical method can now be applied to completely different minerals from a varied range of parageneses, and thereby open for S-isotope studies in geological settings devoid of sulphides or sulphates.