



Fluid inclusion studies in the Ivigtut intrusion, South Greenland

J. Koehler, G. Markl

Eberhard-Karls-Universitaet Tuebingen, Institut fuer Geowissenschaften, AB Mineralogie und Geodynamik, Wilhelmstraße 56, 72074 Tuebingen, Germany

markl@uni-tuebingen.de / Phone: +49-7071 2972390

The mid-Proterozoic Ivigtut intrusion is one of the smallest alkaline complexes in the Gardar Province in South Greenland. The Gardar Province (1350-1140 Ma) represents a failed-rift structure between the Archean craton in the north and the 1850-1720 Ma old Ketilidan orogen in the south. Its granitoid basement was intruded by 12 major alkaline to peralkaline complexes and numerous dyke swarms [1].

The 1170 Ma old Ivigtut intrusion itself is world-famous for its cryolite [Na_3AlF_6] deposit that is now mined out. The complex consists of an A-type granite stock which is surrounded by an intrusion breccia. A second breccia called "Bunkebreccia" is adjacent to the intrusion and joins the granite stock at depth. The granite body is 300 m across and can be divided into an upper hypersolvus and a lower subsolvus granite. The granite was strongly metasomatised by F- and alkali-rich fluids. This led to sericitisation of the feldspars, to greisenitisation and to the formation of the cryolite. The cryolite deposit is about 150 m across and separates the upper from the lower granite. The main mass of cryolite is largely associated with siderite, but also with sulfides and fluorides ([2] and [3]).

We present fluid inclusion data from quartz, cryolite, siderite and fluorite from ten different samples taken from the mine's dump (including two breccias, a granitic sample, fluorite in association with flint and sulfides, quartz associated with galena, quartz associated with cryolite, pure quartz, pure cryolite, pure siderite and quartz in association with cryolite and cassiterite). All double-polished wafers were prepared with normal water, but since cryolite is water soluble, the pure cryolite sample was made with alcohol.

The fluid inclusions are mostly 7-20 μm in size (longest axis) and usually have a regular, i.e. rounded or rectangular, shape. Three different fluid inclusion types can be distinguished. Pure CO_2 inclusions (type 1) mainly occur in cryolite where they are usually of primary origin. They melt at $-56.6\text{ }^\circ\text{C} \pm 0.1\text{ }^\circ\text{C}$. (Pseudo)Secondary CO_2 fluid inclusions also appear in quartz and rarely in fluorite. Secondary saline $\text{CO}_2\text{-H}_2\text{O}$ inclusions (type 2) are predominantly concentrated in quartz. They consist of two gas bubbles and a liquid. While the CO_2 bubble melts at $\pm 56.6\text{ }^\circ\text{C}$, the saline liquid usually shows its final melting between -22 and $-18\text{ }^\circ\text{C}$. Saline aqueous inclusions (type 3) are most abundant, occur in all analysed minerals and are of secondary origin. The final melting temperature ranges from 0 to $-27\text{ }^\circ\text{C}$. But the great majority of inclusions melts between -11 and $-14\text{ }^\circ\text{C}$. During the melting process, types 2 and 3 sometimes contain clathrates. These gas hydrates melt from -9 to $+3\text{ }^\circ\text{C}$.

All analysed inclusions exclusively homogenise to the liquid phase. Type 1 inclusions homogenise between -14 and $+27\text{ }^\circ\text{C}$ whereas the majority of the type 3 fluid inclusions have homogenisation temperatures from 90 to $140\text{ }^\circ\text{C}$. Type 2 inclusions usually decrepitate between 200 and $300\text{ }^\circ\text{C}$, i.e. before complete homogenisation.

In summary, cryolite is dominated by type 1 inclusions while types 2 and 3 usually occur in quartz, fluorite and siderite.

Raman spectroscopy was carried out on distinct fluid inclusions. The presence of H_2O and CO_2 was confirmed. In quartz, some inclusions of type 3 additionally contain propane. According to the different Raman band positions, we were able to distinguish between present $^{12}\text{CO}_2$ and $^{13}\text{CO}_2$. Preliminary results show that ^{12}C and ^{13}C are not distributed equally in fluid inclusions in the different minerals. Further measurements are in progress in order (1) to determine the various $^{12}\text{C}/^{13}\text{C}$ ratios in the distinct minerals and (2) to quantify the amounts of CO_2 and propane so that the salinity can be calculated from the clathrate melting temperatures.

We suggest that the fluid was originally rich in either H_2O or CO_2 and exsolved during cooling. The influence of meteoric or marine water might also be possible at a later stage.

In order to obtain more information about the origin and development of the Ivigtut fluid, isotopy studies (C, H) will be carried out using gas chromatography.

[1] Upton, B.G.J., Emeleus, C.H., Heaman, L.M., Goodenough, K.M., Finch, A.A., 2003. Magmatism of the mid-Proterozoic Gardar Province, South Greenland: chronology, petrogenesis and geological setting. *Lithos* 68, pp. 43-65.

[2] Pauly, H. & Bailey, J.C., 1999. Genesis and evolution of the Ivigtut cryolite deposit, SW Greenland. *Meddelelser om Grønland, Greenland Geoscience* 37, p. 60.

[3] *Goodenough, K.M., Upton, B.G.J., Ellam, R.M., 2000. Geochemical evolution of the Ivigtut granite, South Greenland: a fluorine-rich “A-type” intrusion. Lithos 51, pp. 205-221.*