

An Experimental Delineation of the Oxygen Fugacity of Moissanite (SiC) bearing Silicate Systems

Ulmer, G.C.¹, Grandstaff, D.E.¹, Göbbels, M.² and Woermann, E.³

1. Geology Department, Temple University, Philadelphia, U.S.A.

2. Mineralogisches Institut, Universität Erlangen, Erlangen, Germany

3. Institut für Kristallographie, RWTH Aachen, Aachen, Germany

The mineral moissanite, SiC, has been found worldwide, though in very low concentrations, in kimberlites and lamproites. Thus kimberlitic magmas seem to have tapped moissanite bearing source materials in the Earth's mantle.

In silicate and oxygen bearing surroundings SiC may be oxidized according to



The oxygen fugacities of these buffer reactions thus indicate the limiting oxygen fugacities in the source regions of moissanite-bearing kimberlitic or lamproitic magmas in the mantle.

Thermodynamic calculations resulted in oxygen fugacities of (MsCQ)- and (MSOCP)-assemblages of six to eight log units below the generally accepted Earth's upper mantle models with $\Delta(\text{FMQ}) = +2$ to $\Delta(\text{FMQ}) = -3$. Their oxygen fugacities were calculated to be lower than the (Cr-Cr₂O₃) buffer and even slightly lower than the (Mn-MnO) buffer, but higher than the (V-VO) buffer.

For the experimental determination of the oxygen fugacity of the above moissanite bearing silicate systems the oxygen membrane cell (Woermann et al., 1982) was employed. It utilizes cubic ZrO₂ as an inert, semipermeable membrane for oxygen exchange, where the membrane separates the unknown substance from a known buffer. Under the conditions of the experiment oxygen is transported from the side with the higher $f\text{O}_2$ through the membrane to the side with the lower $f\text{O}_2$. Thus it is possible to compare the $f\text{O}_2$ of the substance, here a SiC-bearing silicate system, with the $f\text{O}_2$ of the buffer employed. The oxygen membrane cell was exposed to a temperature of 1500°C and pressures of 15 kbar in a piston cylinder press in Aachen and of 90 kbar in a multi-anvil device in Bayreuth.

The experimental results show :

- For the buffer pair (MsOCP)/(Cr-Cr₂O₃): graphite and enstatite formed on the (MsOCP)-side and chrome metal was precipitated on the (Cr-Cr₂O₃)-side. (MsOCP) is thus more reducing.
- For the (MsOCP)/(Mn-MnO) pair: graphite and enstatite formed on the (MsOCP)-side while manganese metal precipitated on the (Mn-MnO)-side, demonstrating that (MsOCP) is more reducing.
- For the (MsOCP)/(V-VO) pair: SiC and olivine formed from the phases enstatite and graphite/diamond, showing the the (V-VO)-buffer is more reducing.

In summary the sequence of oxygen fugacities is:



The normal run duration was 23 hours. Even at 1500°C no reaction was going to completion, but a distinct corrosion of the starting phases and the formation of minor amounts of reaction products were sufficient to determine the direction of the reaction.

The experimental results thus clearly confirmed the thermodynamic calculations in the entire pressure range 15-90 kbar at a temperature of 1500°C.

Since moissanite has been identified as a mineral in kimberlites, and since moissanite requires low oxygen fugacities even below those of the (Mn-MnO)-buffer it follows that in the source region of kimberlitic magmas at least locally corresponding low oxygen fugacities must be verified.

References

Woermann,E., Stier,B. and Rosenhauer,M. 1982, The oxygen membrane cell - a device for controlling the oxygen fugacity in water-free high pressure systems. In: High Pressure Researches in Geoscience, ed.: W.Schreyer, Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 519-528.

Ulmer, G.C., Grandstaff,D.E., Woermann,E., Göbbels,M., Schönitz,M. and Woodland,A.B., 1998, The redox stability of moissanite, SiC, compared with metal-metal oxide buffers at 1773K and at pressures up to 90 kbar. N.Jhb.Min., in press.