Resorbed diamond surfaces: A tool to investigate oxidizing fluids

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Resorption features on diamonds develop by oxidation in H-C-O fluid in kimberlite magma or in the mantle source. The development of etch pits depends on temperature (T), oxygen fugacity (fO2) and H_2O:CO_2 ratio of the reacting fluid. We examine a relationship between composition of the fluid, T, P, fO_2 and the development of different types of surface features to develop methods for predicting the diamond quality in kimberlites, for using diamonds to constrain crystallization history of kimberlites and to investigate the fluids in kimberlite magmas and in the mantle.

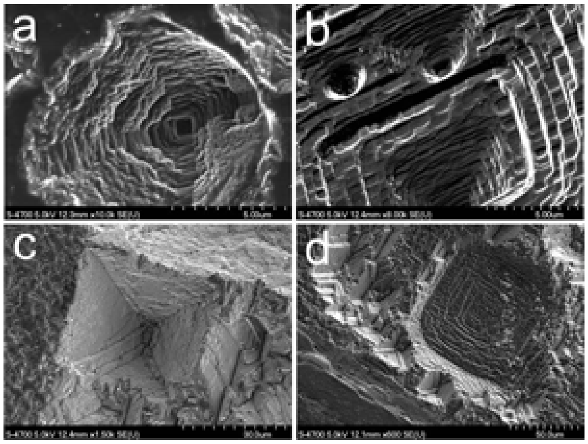

Figure 1: Different types of square etch pits experimentally produced at 100 KPa at various T and fO_2.

We investigated diamond faces experimentally oxidized at 100 KPa and 1 GPa, in a range of T and fO_2 in H-C-O fluids and CO-CO_2 gas mixture. The resorption forms were examined with field emission SEM for the presence of the main crystallographic faces [100], [110] or [111]. We found no consistent correlation between type of the etch pits and T, fO_2 or reaction rates at 100 KPa, but evolution of irregular cavities into pits with [100] faces and further more regular forms with [111] faces as CO_2/CO ratio of the gas increases. At 1 GPa oxidation rate in [111] direction is also faster in CO_2 than in H_2O. The results suggest that diamond oxidation features are determined by relative reaction rates in different directions of diamond lattice as dictated by the molecular composition of the oxidizing fluid (or gas).

Constraints on deep Earth heterogeneities from mineral physics data

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The observed mantle phase transformations and measured physical properties of mantle minerals at high pressure and temperature are the essential data for interpreting the seismic observations of the Earth's interior. It is generally accepted that the phase transformations of $(Mg,Fe)_2SiO_4$ from olivine to wadsleyite and from ringwoodite to $(Mg,Fe)SiO_3$-perovskite plus (Mg,Fe)O-ferropericlase are responsible for the observed seismic discontinuities near 410 and 660 km depth, respectively. The D" layer is likely associated with the recently discovered post-perovskite transition at *P-T* conditions corresponding to the base of the lower mantle. Although the major structure features of the mantle derived from seismic data correlate well with the petrologic and mineral physics data, increasingly detailed image of the mantle with seismic tomography and sophisticated geodynamic modelling demand more high-quality mineral physics data in a realistic mantle composition over a wide *P-T* range.

Significant advances in in situ measurements at high *P* and *T* have led to high-precision phase equilibrium data and *P-V-T* equations of state of mantle minerals. In this talk, we review experimental data on mantle phase transformations including the post-spinel and post-perovskite transitions and the transitions associated with the thickness of the transition zone, and critically access the uncertainties associated with the measurements. Such an assessment bears important implications for geodynamic and geophysical models, in particular concerning the pressures and Clapeyron slopes of the phase transformations. In terms of modelling mantle density, we present *P-V-T* equations of state of silicate perovskite, ferropericlase, and mantle peridotite. The latest measurements cover the *P-T* conditions of the entire mantle. We can now model the density profile of the mantle without any extrapolation. These data support some degree of chemical stratification between the upper and lower mantle, and compositional gradient of the lower mantle. Finally, we present spin transition data in ferropericlase and discuss their implications for mantle models.