Comparative study of geospeedometry methods

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Limitations of classical geospeedometry

The natural cooling rate of natural glasses is an important parameter in the assessment of volcanic hazards because it influences the degassing and flow behavior of lava. Relaxation of enthalpy (ΔH) has been successfully used to estimate cooling rates of natural glasses. This method consists of heating and cooling a glassy sample at various rates and using the Tool-Narayanaswamy model (1971) to obtain a natural cooling rate. It is however challenging to apply this technique to some glasses where the heat capacity ($\Delta H/\Delta T$) curves are not reproducible due to possible degassing and/or the $\Delta H/\Delta T$ peaks are too small to be modelled.

An advanced dilatometric method

A method recently developed by Helo *et al*. (2006) considers the volume relaxation of multiphase samples during heating at a fixed rate, with the advantage of measuring samples containing only small amounts of glass. This method allows us to (1) estimate the calorimetric glass transition temperature (Tg_{cal}) and to (2) measure the dilatometric glass transition temperature (Tg_{dil}), which corresponds to the softening point of the material. A pantellerite from Pantelleria, Italy, was heated through the glass transition. From length changes, we estimated a Tg_{cal} of 521°C, and from enthalpy changes measured with a scanning differential calorimeter, we obtained a Tg_{cal} of 524°C. These temperatures are identical within the precision of the instruments.

An alternative to classical geospeedometry

Moreover, repeated dilatometric heating at 10 K/min and cooling at 15 K/min revealed a gradual exponential increase in the Tg_{dil} from 625°C to 649°C, possibly due to water degassing. The first heating of the sample produced a Tg_{dil} of 611°C, which plotted below the trend produced by the subsequent measurements. We attribute this gap to the natural cooling rate, which we estimate to be about 10 K/min. This is the first time that a geospeedometry method considers changes in material properties to estimate a natural cooling rate. Classical geospeedometry assumes that Tg does not change through a series of cooling and heating treatments. However, we show that for some glasses, another method is required because Tg may change due to a number of processes such as degassing.

References

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A thermodynamic model of uranium reduction by organic matter in the Proterozoic hydrothermal systems of Oklo (Gabon)

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Numerous geological, mineralogical, and geochemical studies have been carried out at and around Oklo (southeastern Gabon) over the last four decades, which have contributed to a better understanding of the reactions involved in the formation of these uranium deposits (e.g. Gauthier-Lafaye and Weber, 1989; Nagy *et al*., 1991; Cuney and Mathieu, 2000). The Oklo deposits represent one of the best examples of associations between uranium and organic matter, which raises the question of the role played by hydrocarbons in the reduction of uranium-VI to uraninite. The observation of uraninite crystals entrapped within solid bitumens in the Oklo uranium deposits led Nagy *et al*. (1991) to propose that a liquid, aliphatic-rich bitumen may have acted as a reductant to precipitate uraninite from hydrothermal solutions. Advances in theoretical organic geochemistry have led to the constitution of an extensive set of thermodynamic properties for solid and liquid organic compounds of geochemical interest (Helgeson *et al*., 1998; Richard and Helgeson, 1998), which makes it possible to investigate organic/inorganic interactions in geological processes.

A thermodynamic analysis has been made as a function of temperature, pressure, and oxygen fugacity of the reactions responsible for the formation of the uranium deposits at Oklo (southeastern Gabon). The generation of liquid hydrocarbons at 150°C as a result of the maturation of Proterozoic kerogens in the FB shales has been characterized and quantified with the aid of activity diagrams. Mass transfer calculations have been carried out to describe the alteration of U-bearing monazites and the mobilization of uranium by oxidizing hydrothermal fluids circulating in the FA sandstones, as well as the reduction of aqueous uranyl by the liquid hydrocarbons as a result of the mixing between the hydrothermal fluids and the petroleum. The latter calculations resulted in the simultaneous precipitation of uraninite and pyrobitumen, in agreement with the petrographical observations.

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