

DECOMPRESSIONAL MECHANISM OF Fe^{3+} REDUCTION DURING TEKTITES FORMATION IN THE IMPACT PROCESS

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The composition of tektitic glasses formed as the result of impact events is characterized by significantly low $\text{Fe}^{3+}/\text{Fe}^{2+}$ ratios in comparison with that of target rocks that are the initial material for tektites. Possible reasons of iron valency change during impact process are the object of discussion [1-3]. Authors of this communication suppose that the reducing reactions with the assistance of ions of iron and other elements may be the result of appropriate change of oxygen regime in the process of adiabatic decompression of matter after its impact compression. The main condition for reducing reactions to proceed is full melting of matter, involved in the impact process, and the attainment of very high temperatures (1700-2000°C) that are characteristic for tektite formation at the unloading stage. In this case oxygen partial pressure ($p\text{O}_2$) during the adiabatic decompression of the melt approaches the value of total pressure in the system (P_{tot}). At the moment when $p\text{O}_2 \cong P_{\text{tot}}$, subsequent pressure decrease of total pressure causes inescapable decrease of $p\text{O}_2$. That leads to partial reduction of Fe^{3+} in the melt. It should be noted, that in this case reducing reactions run in closed system and they don't require oxygen to move away from the system.

Fig. 1 explains the decompression mechanism of Fe^{3+} reduction in impact melt. This figure shows the change of impact melt $p\text{O}_2$ depending on P_{tot} , T and $\text{Fe}^{3+}/\text{Fe}^{2+}$ ratio in the melt. It is proposed that with temperature and pressure increase the $p\text{O}_2$ value of impact melt with given $\text{Fe}^{3+}/\text{Fe}^{2+}$ ratio increases just in the same manner as $p\text{O}_2$ of magnetite-wustite buffer (MW). This assumption is based on two observations. 1) Electrochemical measurements of intrinsic $f\text{O}_2$ of tektitic glasses within range of 800-1050°C show that temperature dependence of tektite $p\text{O}_2$ is similar to that for MW buffer [3]. 2) The data on the redox state of iron ions in basic silicate melts evidence that pressure increase (T and $\text{Fe}^{3+}/\text{Fe}^{2+}$ in the melt are constant) leads to increase of $p\text{O}_2$ value in the melt approximately to the same magnitude as the one for QFM and MW buffer [4,5].

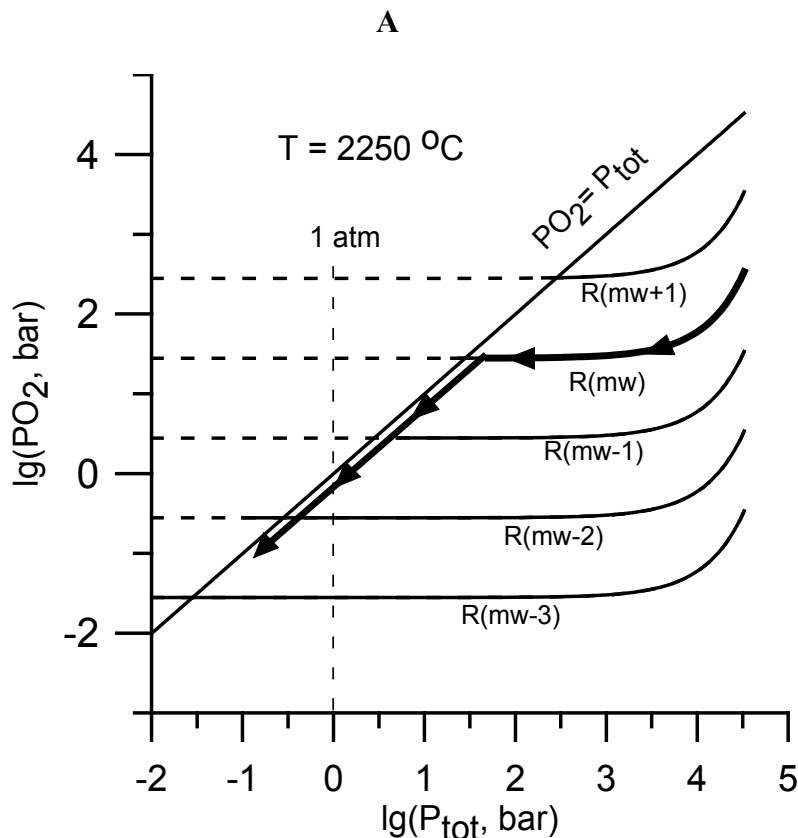
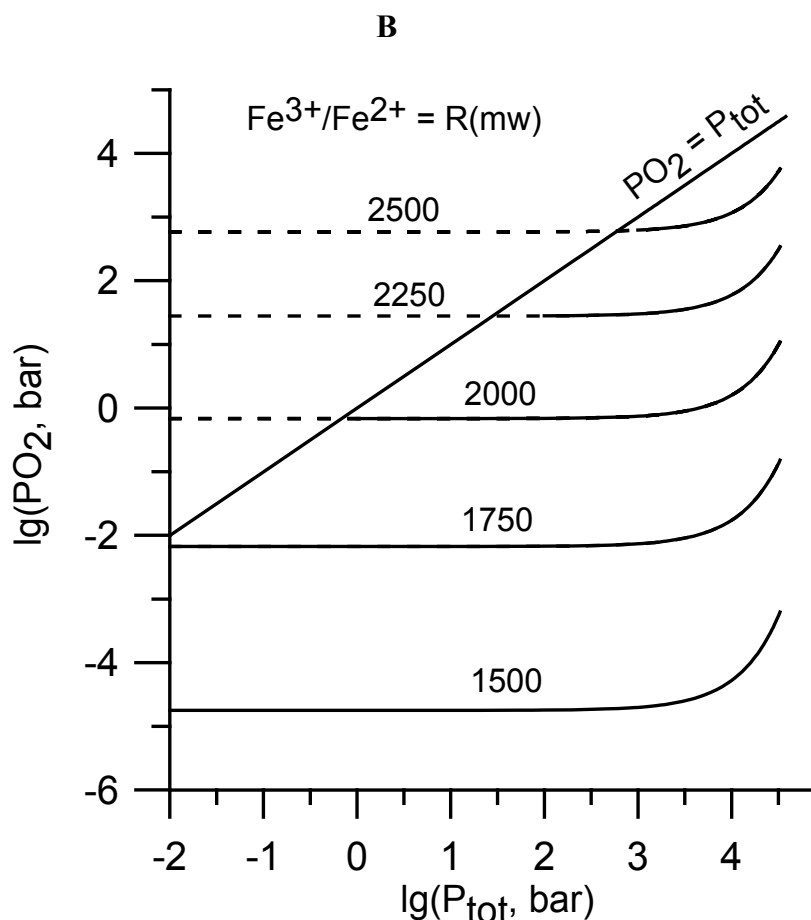


Fig.1. Scheme of "decompressional" reduction of impact melt.

A - The change of $p\text{O}_2$ depending on total pressure (P_{tot}) for melts with various $\text{Fe}^{3+}/\text{Fe}^{2+}$ ratios under isothermic conditions ($T=2000^\circ\text{C}$) is shown. $R(\text{mw})$, $R(\text{mw} \pm n)$ - $\text{Fe}^{3+}/\text{Fe}^{2+}$ ratios in the melt correspond to (or n orders more/less as that of) $p\text{O}_2$ of MW - buffer. ($R(\text{mw}+2) > R(\text{mw}+1) > R(\text{mw}) > R(\text{mw}-1)$). Thick lines with arrows are trajectories of $p\text{O}_2$ in the process of decompression.



B - The change of $p\text{O}_2$ depending on temperature of melt with $\text{Fe}^{3+}/\text{Fe}^{2+} = R(\text{mw})$. Numbers at curves are temperature in $^{\circ}\text{C}$. Additional explanations see in the text.

Let the temperature of impact matter at the unloading stage under $\geq 30\text{-}40$ kbar is $\sim 2250^{\circ}\text{C}$ and the matter is completely melted. The $\text{Fe}^{3+}/\text{Fe}^{2+}$ ratio in the melt is equal to $R(\text{mw})$ and corresponds to $p\text{O}_2$ value of MW buffer. Adiabatic gradient of silicate melt is $\sim 1^{\circ}\text{C}/\text{kbar}$ because the melt adiabatic decompression can be considered to the first approximation as isothermal process. Consequently as P_{tot} decreases, $p\text{O}_2$ value of the melt with $\text{Fe}^{3+}/\text{Fe}^{2+} = R(\text{mw})$ changes accordingly to the trajectory that is similar to the one on the fig.1A (thick line). The $p\text{O}_2$ becomes equal to P_{tot} , when P_{tot} is ~ 50 bar. Therefore subsequent P_{tot} decrease (< 50 bar) must be accompanied with $p\text{O}_2$ decrease and consequent reducing of Fe^{3+} in the melt resulting in $\text{Fe}^{3+}/\text{Fe}^{2+}$ change from $R(\text{mw})$ to $R(\text{mw}-2)$. The higher the temperature is the higher is P_{tot} when the $P_{\text{tot}} \cong p\text{O}_2$ condition is realized, and the degree of melt reduction can be more significant at final stages of adiabatic decompression (fig 1B).

If residual temperature at the certain stage of decompression reaches the values of full vaporization of impact melt ($> 2500\text{-}3000^{\circ}\text{C}$), the melt, that is formed in the process of condensation during subsequent decompression and cooling of the system can be more reduced than initial impact melt was before its vaporization. It is possibly that during the processes of full vaporization and subsequent condensation of impact melt the proposed reducing mechanism is realized the most effectively, because the reactions in vapor phase proceed essentially faster and redox state of the condensed liquid is closer to equilibrium conditions. Thus essential reducing of high-temperature impact melts can be expected under adiabatic decompression without resorting to the assumption that oxygen is removed from the system together with vapor phase or selectively dissipates from the vapor.

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