

## Pressure influence on the solubility of N–C–H–O volatiles in FeO–Na<sub>2</sub>O–SiO<sub>2</sub>–Al<sub>2</sub>O<sub>3</sub> melts at 1400 (1550°C)

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Experimental data [Kadik *et al.*, 2011a; Kadik *et al.*, 2011b] on the nitrogen and carbon solubilities in model NaAlSi<sub>3</sub>O<sub>8</sub>(80мас.%) + FeO(20мас.%) melts at 1.5 and 4 GPa, 1400 and 1550°C correspondingly were analyzed to estimate the pressure influence on the solubility and speciation of N–C–H–O components in investigated melts at low values of oxygen fugacity ( $fO_2$ ) characteristic of the  $T$ – $P$ – $fO_2$  stability conditions of the metallic iron phase equilibrated with silicate substance ( $\Delta \lg fO_2(IW) = -2.1 \sim -3.7$ , where  $\Delta \lg fO_2(IW) = \lg fO_2(IW) - \lg fO_2^{exp}$  is the difference between the equilibrium oxygen fugacity of the Fe–FeO (IW) and oxygen fugacity in the experiment).

In addition to  $fO_2$ , pressure is another factor affecting on the formation of N–C–H–O compounds in reduced magmatic melts, but the character of this influence remains poorly understood.

Experiments at 1.5 GPa and 1400°C [Kadik *et al.*, 2011a] were performed in a piston–cylinder apparatus [Slutsky, 1962], at 4 GPa and 1550°C [Kadik *et al.*, 2011b] – in an anvil–with–hole apparatus and controlled hydrogen (oxygen) fugacity [Litvin, 1981; Kadik *et al.*, 2004]. Temperature was controlled using a Pt–Pt<sub>10</sub>Rh thermocouple with an accuracy of  $\pm(5-10)^\circ\text{C}$  and the uncertainty of pressure measurement was  $\pm 0.1$  GPa. A sample was loaded into a Pt capsule 5 mm in diameter and 10–15 mm high. A 0.2 mm thick graphite disk was placed under the sample. The sample was isolated from the walls of the Pt capsule with 0.05 mm thick tungsten foil for the elimination of interaction between iron–bearing melt and Pt [Litvin, 1981]. The experimental duration was 120 min. at 1.5 GPa and 30–60 min. at 4 GPa. The starting material was a finely dispersed mixture of synthetic albite glass (NaAlSi<sub>3</sub>O<sub>8</sub>, 80 mass.%) and ferrous oxide (FeO, 20 mass.%) to which it was added powdered silicon nitride Si<sub>3</sub>N<sub>4</sub> in amounts 1, 3, 5 and 7 mass. % as a source of nitrogen in the investigated system and to provide a low  $fO_2$  values in experiments. Carbon was not as a component of the starting material. During experiments it diffused from the graphite disk placed into the Pt capsule under the sample.

Experimental products are glasses containing metallic Fe–rich globules less than 30–100  $\mu\text{m}$  in size. They were investigated by electron microprobe analysis and by Raman spectroscopy.

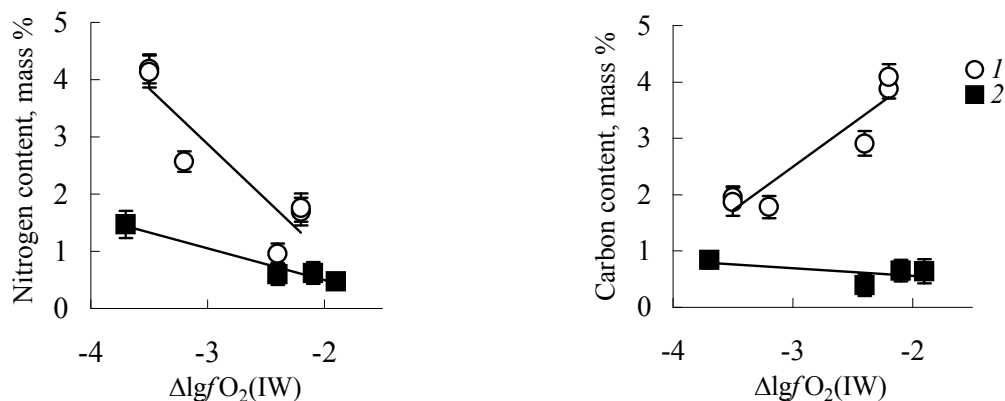
Analysis of obtained results indicates that at the same  $fO_2$  values the solubility of nitrogen and carbon higher at 4 GPa than that at 1.5 GPa (fig. 1).

This difference in the nitrogen solubility is especially essential at low  $fO_2$  values ( $\Delta \lg fO_2(IW) = -4$ ) and at higher  $fO_2$  values ( $\Delta \lg fO_2(IW) = -2$ ) for the carbon solubility.

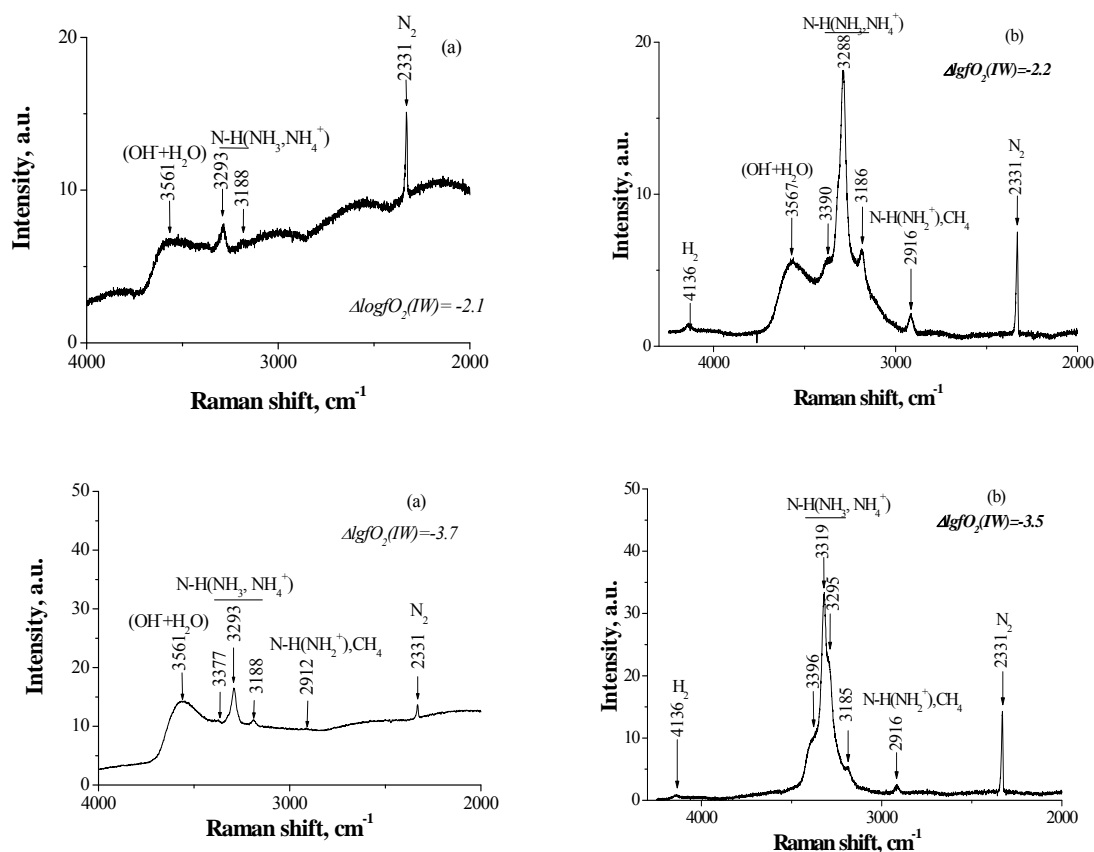
It is established that a pressure decrease from 4 to 1.5 GPa at constant  $fO_2$  does not affect the speciation of N–C–H–O volatiles in investigated melts. At 1.5 and 4 GPa there are formed identical compounds with N–H (NH<sub>3</sub>, NH<sub>2</sub><sup>-</sup>, NH<sub>2</sub><sup>+</sup>), O–H (OH<sup>-</sup>, H<sub>2</sub>O), C–H (CH<sub>4</sub>) bonds and molecular N<sub>2</sub> and H<sub>2</sub> (fig. 2).

However a pressure influences on the proportions of dissolved forms especially at low  $fO_2$  values. At 4 GPa,  $\Delta \lg fO_2(IW) = -3.5$  the contribution of hydrogen oxidized species (OH<sup>-</sup>, H<sub>2</sub>O) to the hydrogen solubility is significant in comparison with that at 1.5 GPa, whereas the solubility in the form of compounds with N–H type bonds increases significantly.

Thus pressure together with  $fO_2$  is a factor that essentially influence on the formation of N–C–H–O compounds in reduced magmatic melts.



**Fig. 1.** Nitrogen and carbon solubility in NaAlSi<sub>3</sub>O<sub>8</sub>(80mac.%) + FeO(20mac.%) melts as a function of the pressure and oxygen fugacity: 1- 4 GPa, 1550°C; 2 - 1.5 GPa, 1400°C.



**Fig. 2.** Raman spectra of N-C-H-O bearing glasses: a)  $P=1.5$  ГПа,  $t=1400^\circ\text{C}$ ; b)  $P=4$  ГПа,  $t=1550^\circ\text{C}$ .

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### References

Kadik A. A., Kurovskaya N. A., Ignatjev Yu. A., Kononkova N. N., Koltashev V. V., Plotnichenko V. G. (2011) Influence of oxygen fugacity on the solubility of nitrogen, carbon and hydrogen in FeO-Na<sub>2</sub>O-SiO<sub>2</sub>-Al<sub>2</sub>O<sub>3</sub> melts in equilibrium with metallic phase of iron at 1.5 GPa and 1400°C. *Geochemistry*. № 10. Pp. 451–461.

KADIK ET AL.: N–C–H–O VOLATILES IN FeO–Na<sub>2</sub>O–SiO<sub>2</sub>–Al<sub>2</sub>O<sub>3</sub> MELTS

Kadik A. A. & Litvin Yu. A., Koltashev V. V., Kryukova E. B., Plotnichenko V. G., Tsekhonya T. I., Kononkova N. N. PEPI. (2011) (in press.).

Kadik A.A., Pineau F., Litvin Yu. A., Jendrzewski N., Martinez I., Javoy M. (2004) Formation of carbon and hydrogen species in magmas at low oxygen fugacity. *Journal of Petrology*. V. 45. № 7. Pp. 1297–1310.

Litvin Ju. A. (1981) Technique of high pressure studies of phase equilibria with participation of Fe-bearing magmatic melts. *Geochemistry*. №8. Pp. 1234–1242.

Slutsky A. B. (1962) Device for geochemical studies under ultra-high pressure and temperature conditions. *In Experimental researches in the field of deep processes*. Moscow. PP. 212-215.