WATER IN TEKTITIC AND IMPACTITIC GLASSES

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Introduction

Already the first determinations of water in tektitic glasses (Fridman, 1962; Gilchrist, 1967) showed that H_2O content in these glasses is very low (<0.03 wt. %) and significantly less, than one in volcanic glasses including obsidians (> 0.1 wt. %) that have a composition the most similar to tektites. The very low water concentration became one of important tektite signs and an argument for their extraterrestrial origin (O`Keafe, 1976). However at present time a majority of investigators arrived at a conclusion that tektites were formed as result of the terrestrial impact processes (see e.g. Koeberl, 1986; Feldman, 1990; Heinen, 1998). But by contrast with impactites their spatial and genetic connection with impact craters in most cases is not evident. Essential progress in H_2O investigations in tektites was achieved due to use of local IR spectroscopy. This communication based on new FTIR measurements of H_2O concentration in tektitic and impactitic glasses and also on the review of available data is aimed to consider the following problems: 1) the variations of H_2O content in different types of tektites and impactites, 2) possible accuracy of H_2O measurements in tectitic glasses; 3) the influence of tectitic and impactitic glasses alteration during their stay in the earth crust for a long time on water content in them.. Furthermore several features of H_2O behavior in impact processes using available physical-chemical and experimental data are discussed.

Results and discussion

Water contents in two moldavites (Koroseki, Czech), indoshinite (Vietnam) and irgizite - similar to tektitic glass from impact crater Zhamanschin (Kazakhstan) were determined by FTIR spectroscopy technique (fig.1).

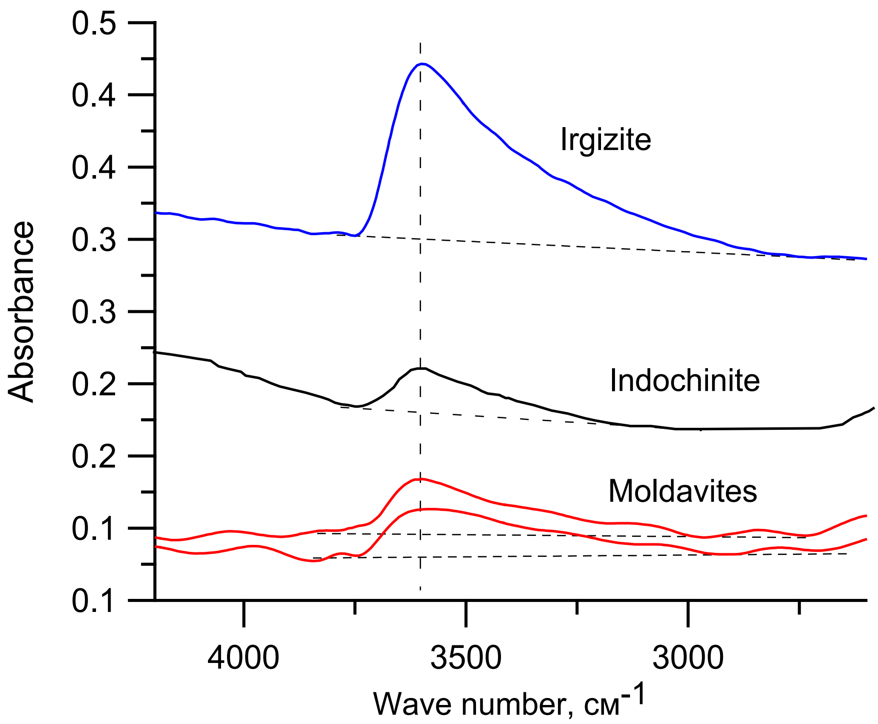

Fig. 1. IR (FTIR) absorption spectrums of investigated samples of tektites and irgizite glasses. It shows the spectrum area of main band of water absorption as OH^- group 3550 cm^{-1} that used for the measurement of H_2O concentration. The absorption intensities are given at the same thickness of glass plate equal to 300 microns.

Water concentration in moldavite is 0.0095 - 0.0111 wt. % and agrees well with earlier determinations (Gilchrist et. al., 1969; King, Arndt, 1977; Engelhardt et al., 1987). The average value for all moldavite samples of 0.010± 0.005 wt. % is close to our determinations (fig 2.). The measured concentration of H_2O in indoshinite sample 0.0038±0.0005 wt. % corresponds to the lowest concentrations in this tektite group 0.0047-0.031 wt. % and is significantly less than average value for indoshinites from various areas of Indo-China 0.0165±0.0009 wt. % (Gilchrist et. al., 1969; Beran, Koeberl, 1997; Newman et al., 1995). The irgizite glass has the highest H_2O concentration of all investigated samples and comes to 0.0348±0.0008 wt. %. This fact agrees with previous determinations that show the variation within range of 0.017-0.051 wt. % and the average value of 0.0322±0.0020 wt. % (King, Arndt, 1977; Beran, Koeberl, 1997). In general available data demonstrate wide variations of water contents in tektitic and impactitic glasses (fig 2 and 3). Impactites have significantly higher water contents as a rule in comparison with tektites. The average H_2O content in impactites (0.054 wt. %) in three times more then the average H_2O content in tektites (0.015 wt. %). However, there is wide enough range of overlapping of water concentrations in tektitic and impactitic glasses.

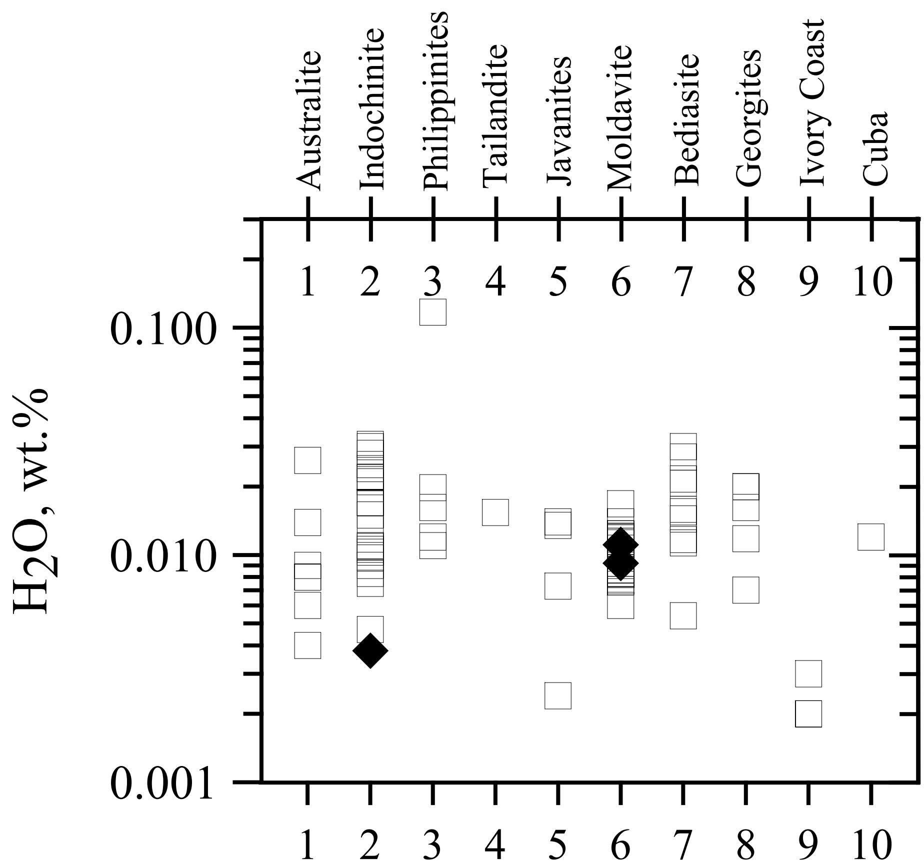

Fig. 2. Water contents in various types of tektitic glasses. Squares - available data from Gilchrist et. al., 1969; King, Arndt, 1977; Engelhardt et al., 1987; Koeberl, Beran, 1988; Newman et al., 1995; Beran, Koeberl,1997. Diamonds - the data obtained in this investigation.

The precision of IR spectroscopy measurement of H_2O in silicate glasses depends on determination accuracy of the absorption intensity and the thickness of glass plate, used for IR determinations, and also on extinction coefficients and glass density. The errors of water determination in tektite glass are usually < 10 relative %. However error value may reach 20-25 % in case of very low H_2O concentrations in tectitic glasses. One of unsolved problems is the calibration of the intensity of ~ 3550 cm^{-1} absorption band within water concentrations range typical for tektites. The errors of H_2O determinations in various works are similar because the authors use a like technique that gives an opportunity to compare the data presented in various works.

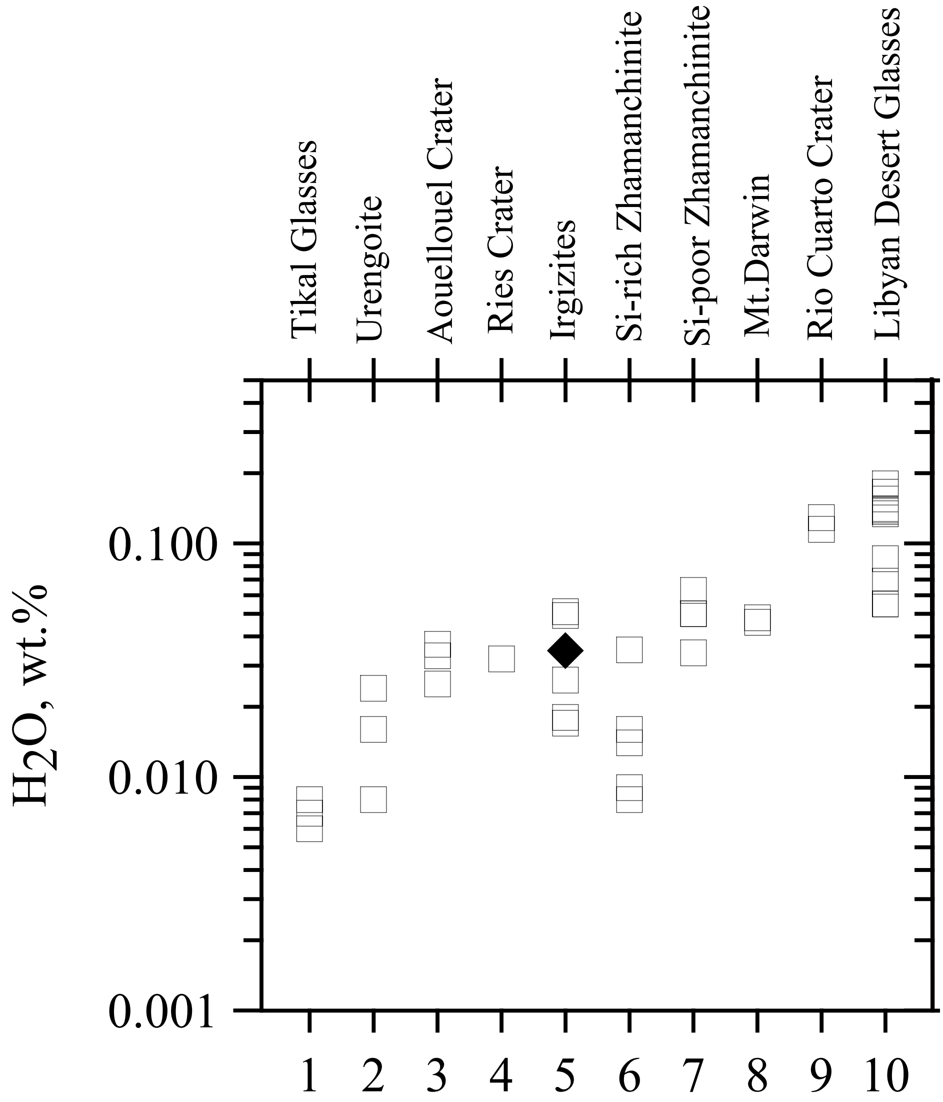

Fig. 3. The water contents in various types of tektitic (a) and impactitic (b) glasses. Squares - available data from Gilchrist et. al., 1969; King, Arndt, 1977; Frischat et al., 1982; Engelhardt et al., 1987; Koeberl, Beran, 1988; Beran, Koeberl,1997. Diamonds - the data obtained in this investigation.

The solubility rate of glasses in hydrous solution is faster than the diffusion rate of H_2O in these glasses at relatively low temperatures characteristic for nearsurface layers of the earth crust. This fact allows to conclude that in the most cases tektitic glasses were not undergone the hydration during their stay in the earth crust for a long time (Glass, 1984; La Marche et al., 1984; Barkatta et al., 1984; Mazer et al., 1992; Glass et al., 1997; and others). At the same time the glass interaction with hydrous solutions at elevated temperatures can cause a significant hydration and their essential alteration. These alterations are frequently observed in impactites that originally consisted completely or partially of glass. The reverse zonal distribution of water in tectitic samples (decrease of H_2O content to sample edges of the sample) apparently evidence the absence of tektitic glass hydration as result of their interaction with atmosphere on the fly stage after impact events.

Experiments conducted in order to understand the behavior of water and other volatile components in the powerful impact events (fast heating up to very high temperatures 2000-2500^oC, melting and evaporation of silicates in vacuum and others) appears to be not adequate model of impact processes. Evaporation of the matter and its subsequent condensation are undoubtedly the most effective processes of differentiation concerning volatile and other components. At so high temperatures that are necessary to provide complete melting and evaporation of silicate substance (>2500-3000 ^oC), the water in vapor phase should exist mainly in the form of H, H_2, O_2, O, OH, particles, but not in molecular form of H_2O [1]. It is possible that part of these particles altogether with petrogenetic elements may belong to more complicated groups (clusters) formed at evaporation of silicate substances. In the process of vapor cooling and condensation volatile components connected with large-scale clusters are included in silicate liquid first of all. Water and other volatile components in the form of more simple particles may be also partially captured from vapor phase during its condensation. It is possible that the formation of small silicate glass spheres (beards) with such a low concentration of water as for tektites (~ 0.01 wt. %) after test nuclear explosions [2] is more adequate model of volatiles behavior during formation of tektites as result of powerful impact events.

Conclusions

The most part of tektites are natural glasses of terrestrial origin with the lowest concentrations of water that basically reflect initial water contents in melts forming during impact explosions. The impactitic glasses preserved without alteration have higher water content as a rule in comparison with tektites. The H_2O concentration in impactitic glass varies within considerably wider range than that in tektites. At the same time there is wide enough range of overlapping of water concentrations in tektitic and impactitic glasses. The processes of evaporation and condensation of silicate liquid has the most influence on behavior of water and other components during impact events at extreme energetic effect on target rocks.

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References

1. *Kadik A.A., Lukanin O.A., Zharkova E.V., and Fel'dman V.I.* Oxygen and Hydrogen (Water) Regime during Tektite Formation // Geochemistry International, 2003. V. 41. N 9. PP. 865-880.
2. *Glass B.P., Senftle F.E.Muenov D.W., Aggorey K.E., Thorpe A.* Atomic bomb glass beards: Tektite and mikrotektite analogs // In: Proceedings of the 2nd International Conference on Natural Glasses (ed. J. Konta), Prague. The Czech Rep., 1988. PP. 361-369.

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