CHEMICAL VARIATIONS AMONG THE MOLDAVITE TEKTITES: MAJOR-ELEMENT DATA.

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INTRODUCTION: Moldavite tektites are situated in three strewnfields within Czechoslovakia. They have an age of 15 Ma [e.g. 1], which is indistinguishable from that of the Ries Crater in Germany. Most investigators believe that these tektites are genetically related to the Ries event, despite the fact that the moldavites occur up to 415 km eastward from that crater.

The present study involved the chemical analysis of 101 moldavites for major elements by electron microprobe (Delano) and for trace elements by INAA (Bouska) in order to (a) place additional constraints on the source-materials of the moldavites and (b) to better understand the complex chemistries of terrestrial- and extraterrestrial-impact glasses.

RESULTS: The vast majority of moldavite specimens used in this investigation were observed to be optically and chemically heterogeneous. This fact is wholly consistent with the view that they are impact glasses.

Moldavites collectively exhibit prominent compositional variations that provide information about their pre-impact source-materials [e.g. 2]. The new data collected during this study (Figure 1) have extended the known limits of chemical variations among these tektites. The two-component mixing-hyperbola in Figure 1 was calculated using the method of Langmuir et al. [3] and has the following equation: $7.20x - 9.14xy - 1.03y + 34.5 = 0$ where $x = CaO/K_2O$ and $y = Al_2O_3/MgO$.

One moldavite specimen from Lhenice that was observed to be most nearly homogeneous, both optically and chemically, was used as a working standard during the microprobe analyses. Nearly 10 hours of X-ray counting-time was acquired on this one sample, thereby allowing a detailed determination of the analytical precision achieved for all other samples. The symbol labelled "18K" in Figure 1 is the $\pm 2\sigma$ precision attained on this working standard based on a total of 176 complete analyses. On average, 8 analyses were performed on each of the remaining 100 samples.

Factor analysis was used on the major-element data generated in this study (Table). Strong correlations exist within two sets of elements: (a) Ca and Mg; and (b) Fe, Al, and K. According to the results evident in the Table and Figure 2, 87% of the compositional variation in these 101 samples is explained by 3 components composed of the following elements:
(a) Al + Fe + K ± Na ± Ti; (b) Ca + Mg; and (c) Si. These elemental groupings furnish strong new evidence in support of the view [e.g. 2, 4-9] that terrestrial sediments dominated by argillaceous (Al, Fe, K), calcareous (Ca, Mg), and siliceous (Si) components were the source-materials for the moldavites.

The moldavites possess K_2O/Na_2O ratios (by weight) with highly fractionated values ranging from 5 to 10. This strong depletion of Na relative to K is a common feature of mature, continental sediments on Earth. It is caused during weathering by a higher solubility of Na relative to K in aqueous solutions [e.g. 10]. In addition, moldavites have molar ratios of Al/(K + Na + Ca) > 1, which is also a frequent characteristic of terrestrial sediments.

The variation in abundance of Fe in moldavites provides additional insights into the nature of the source-materials. Iron is strongly correlated with Al but is not correlated with Ca, Mg, or Mn (Figure 2). This behavior is compelling evidence that Fe was present in the pre-impact source-materials in the 3+ valence-state. For example, extreme fractionation between Fe and Mn during weathering is a well-known phenomenon [e.g. 11]. The ferric iron was, however, reduced to the ferrous state during the glass-forming event. Dehydration and decarbonation also accompanied reduction.

CONCLUSIONS: The elemental variations defined by these new data demonstrate that the moldavites were formed by impact fusion of a complex target containing argillaceous, calcareous, and siliceous components deposited in an aqueous, oxidizing environment. These source-materials were mature sediments on Earth.

Contrary to the observation that impact events generate large volumes of chemically homogeneous melt [e.g. 12], the cratering regime responsible for tektites does not produce homogenization. The moldavites possess an elegantly preserved record of the geochemical diversity of their source-materials (Figures 1,2). Chemical trends also occur in impact glasses from the Moon [e.g. 13, 14]. In the same way that the moldavites provide major constraints on the nature of their sources, detailed study of impact glasses on the Moon should reveal surprising information about their targets. Since impact glasses and tektite-like objects should be present in the regolith of Mars, the ability to interpret the complex chemistries of impact glasses should prove increasingly desirable.

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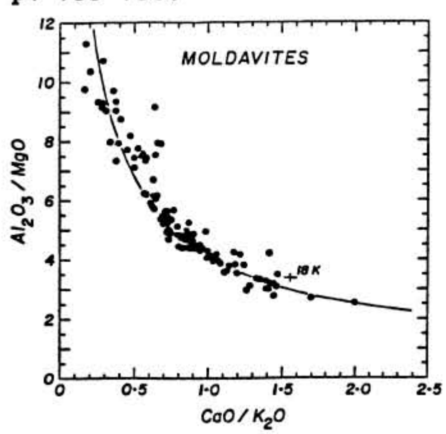
Fig. 1



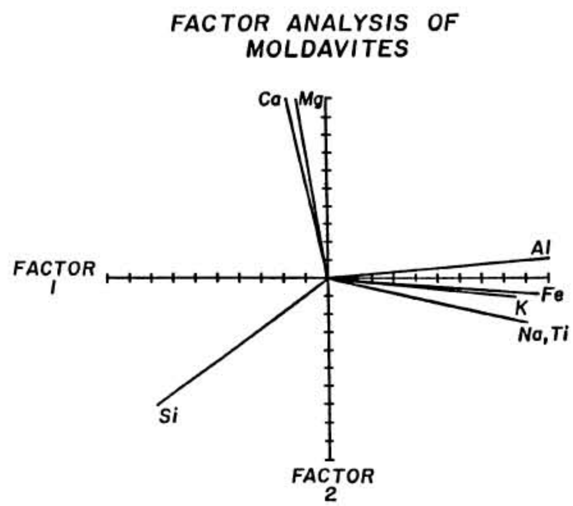


Figure 2

Table. Factor analysis

	EIGENVALUE	% VARIANCE
FACTOR 1	4.53	57
FACTOR 2	2.37	30
FACTOR 3	0.63	8