

MICRO-RAMAN STUDY OF SILICATE GLASS FROM Mt. OIKEYAMA, JAPAN. *K. Ninagawa¹, A. Guc-sik², H. Nishido³, T. Okumura³, M. Sakamoto⁴*, ¹Department of Applied Physics, Okayama University of Science, 1-1 Ridai-cho, Okayama, 700-0005; ²Max Planck Institute for Chemistry, Dept. of Geochemistry, Becherweg 27, D-55128, Mainz, Germany; ³Research Institute of Natural Sciences, Okayama University of Science, 1-1 Ridai-cho, Okayama, 700-0005, Japan; ⁴Shimohisakata, 80 Neba Village, Nagano, 395-0701, Japan;

Introduction: Mt. Oikeyama (1905 m above the sea level) on Shirabiso Highland lies in the southern part of the Akaishi Mountains, Nagano Prefecture in Central Japan. In the eastern side of this mountain, there is a semicircular topographic feature. The regional geology of this area consists of sandstone and mudstone interbedded with chert belonging to Chichibu Paleozoic terrain [1] (Fig. 1). The origin of this structure has been disputed for the last few decades. It has been known that Mt. Oikeyama formed by endogenetic processes such as tectonism, suggesting that this area was modified by main tectonic faults or movements. More recently, Sakamoto et al. [2,3] found planar and straight microdeformations in quartz grains from Mt. Oikeyama under petrographic observation including Planar Fractures (PFs) and Planar Deformation Features (PDFs). This fact suggests the formation mechanism by an impact event, while unambiguous evidence for such origin has not been obtained.

The purpose of this study is to provide further evidences on the impact origin of Mt. Oikeyama, using micro-Raman properties of silicate glass.



Figure 1. Geographic coordinates and structural geology of Mt. Oikeyama and its environment.

Experimental Procedure: Samples were collected from the inner rim of this structure (Fig. 2). Raman spectra were obtained by Laser Raman Spectrophotometer NRS-2100 (JASCO Corp.) with Ar laser (514.5 nm) excitation system and a cooled CCD detector at 202K. Spectral measurements were carried out between 120 and 3500 cm⁻¹, with 120 sec exposure time, and 400mW beam power.

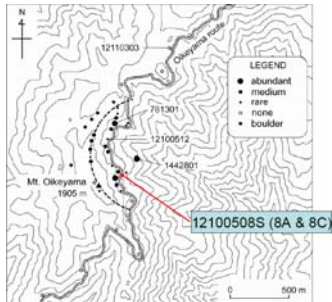


Figure 2. Sampling site of the glassy samples from Mt. Oikeyama.

Results:

EDS-data. The selected area (averaged from five analyzing points) contains SiO₂ (70.95 wt%), Al₂O₃ (17.08 wt%), K₂O (5.94 wt%), and Na₂O (5.94 wt%) (Table 1). Analyzing points #3, #4, and #7 belong to Na-rich plagioclase and points at #1, and #5 are related to K-feldspar glass (diaplectic?) (Fig. 3).

In general, diaplectic glass is formed at shock pressures in excess of about 35 GPa without melting by solid-state transformation and has been described as a phase intermediate between crystalline and normal glassy phases [4]. It is found at numerous impact craters and shows the original crystal defects, planar features, and absence of flow structures and vesicles.

Table 1. Seven analyzing points of the selected area and their EDS data.

Elements (wt%)	#1	#3	#4	#5	#7
Na ₂ O	1.9	10.1	9.5	1.2	9.8
Al ₂ O ₃	17.6	18.0	18.0	17.5	18.0
SiO ₂	68.4	70.6	70.4	68.9	70.6
K ₂ O	11.9	1.2	2.2	12.2	1.5
CaO*	-	-	-	-	-
Total	99.8	100.8	100.1	99.8	99.9

No.#-analyzing points; *under detection limit

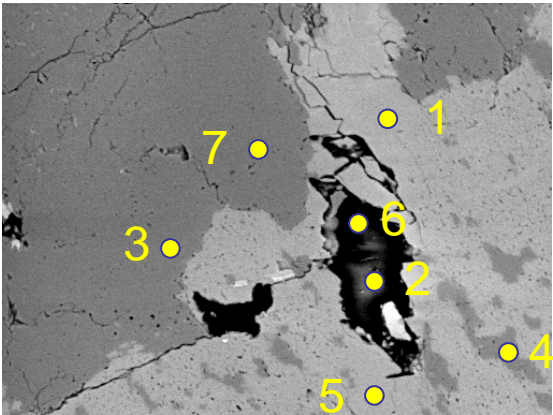


Figure 3. Backscattered electron image of silicate glass showing the EDS analyzing points (note: #2 and #6 points are in a hole).

Optical Microscope Observations. Both plane- and cross-polarized images show an isotropic nature of the glassy parts of thin sections. It appears as dark, and black parts of the samples corresponding to diaplectic glass (Fig. 4.).

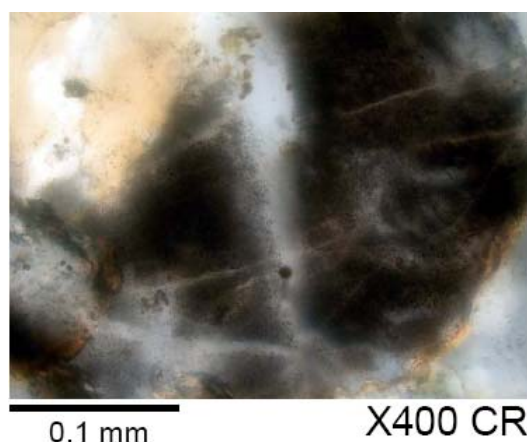


Figure 4. Optical Microscope image (cross-polarized) of glass from Mt. Oikeyama showing atypical isotropic character.

Raman spectroscopy. Raman spectra of the five analyzing points show typical vibrational modes of K-feldspar (green). Broad peaks at 1326 and 1602 cm^{-1} correspond to K-feldspar glass (Fig. 5).

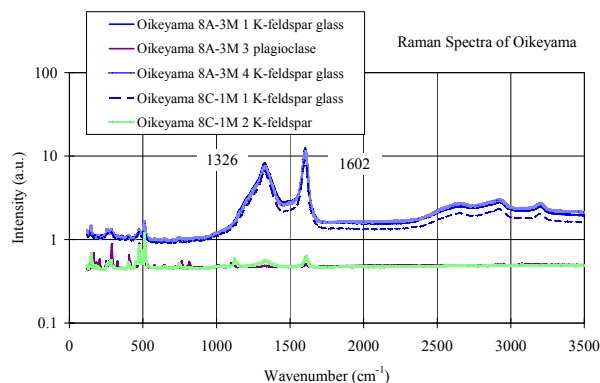


Figure 5. Raman spectra of K-feldspar and glass from Oikeyama structure.

Raman measurements are concerned with shifts in the frequencies of vibrations due to changes in inter-nuclear spacings coupled with the anharmonic nature of interatomic and inter- and intramolecular interactions. If a phase transition occurs, the Raman selection rules, which ultimately depend on crystal and molecular symmetries, will also change and new spectral features, characteristics for the new lattice, will appear.

Thus this method is not only of great help in elucidating crystal structures, but can also be used as a method of qualitative analysis (finger print), e.g., in determining the phases of small thin section areas without destroying them [5].

Discussion and Conclusion: McMillan [6], from his structural studies of silicate glasses and melts, suggested that the bands in the 1200-800 cm^{-1} region can be assigned to silicon-oxygen stretching vibrations of tetrahedral silicate units. The weak high-frequency bands of silica glass have been assigned to antisymmetric stretching vibrations of silicate tetrahedra within a fully polymerized tetrahedral silicate network. The strong bands in a glass at 1100-1050 cm^{-1} , 1000-950 cm^{-1} , 900 cm^{-1} , and 850 cm^{-1} have been attributed to symmetric stretching vibrations with, respectively, one ($\equiv\text{SiO}$), two ($=\text{SiO}_2$), three ($-\text{SiO}_3$), and four (SiO_4) non-bridging oxygen atoms. The bands in the 700-400 cm^{-1} region might be associated with the presence of inter-tetrahedral Si-O-Si linkages. White and Minser [7], in their Raman studies of natural glasses (e.g., desert glass, tektites and obsidians of various composition, and some lunar glasses), noted that the wavenumber of the 400-600 cm^{-1} band varies with the degree of polymerization of the network and with Si-O-Si (and Si-O-Al) bridging bond angles. These authors noted that the principal low frequency Raman band in the glass shows an anomalous increase in frequency with increasing temperature. This observation indicates that the average SiOSi angle decreases with increasing temperature due to anharmonic vibrational effects. We noted that our Raman spectral features are in a good agreement with previous Raman studies of the silicate glasses.

Consequently, the presence or occurrence of K-feldspar diaplectic glass would confirm the impact origin of Mt. Oikeyama structure.

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References: [1] Sakamoto M. (1980) *Res. Struct. Mov. Meso. Age*, 2, 31-36. [2] Sakamoto et al. (2001) *Ann. Meet. Jap. Soc. Planet. Sci.*, Abstract #56. [3] Sakamoto et al. (2003) *Int. Symp. Evol. Solar Syst. Mater.*, NIPR, Abstract #35. [4] Stöffler and Hornemann (1972) *Meteoritics*, 7, 371-394. [5] Roberts S. and Beattie I. (1995) In *Microprobe Techniques in the Earth Sciences*, (eds. P.J. Potts, J.F.W. Bowles, S.J.B. Reed and M.R. Cave), Chapman and Hall, London, pp. 387-408. [6] McMillan P.F. (1984) *Am. Mineral.* 69, 622-644. [7] White B.W. and Minser G.D. *J. Non-Cryst. Solids*, 67, 45-59.