ORIGIN OF STOICHIOMETRIC FELDSPATHIC GLASSES IN ALH84001 BY MIXING OF PLAGIOCLASE AND ORTHOCLASE DURING MULTIPLE SHOCK EVENTS. James P. Greenwood and Harry Y. McSween, Jr., Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996.

Feldspathic glasses in ALH84001 have previously been described as being nonstoichiometric [1,2]. Loss of alkali elements during electron microprobe analysis of alkali-rich glasses is a notorious problem [3,4] and may be the cause of the perceived nonstoichiometry. Also, K-rich glasses have been described as evidence for these glasses to have been derived as shock melts rather than mobilized monomineralic melts [2]. We describe here for the first time relict areas of essentially stoichiometric orthoclase composition in glass pockets. Also, we find that the mixed K-rich glasses [1,2] are generally stoichiometric as well. Our analyses of stoichiometric plagioclase glass agree with the results of [2]. All the feldspathic glasses can be described as either endmember plagioclase or orthoclase composition glasses, or a mixture of these endmember compositions (Fig. 1). Dissolution of minor amounts of orthopyroxene (or carbonate) may be needed to explain some of the glasses.

Analytical: Analyses were obtained with the University of Tennessee Cameca SX-50 electron microprobe. An accelerating potential of 15keV with beam currents ranging from 5nA to 10nA, beam diameters of 5µm to 15µm and counting times of 10 seconds for each element analyzed (20 seconds for Fe) were used. Na, Al, Si, and K were analyzed first on separate spectrometers. In order to minimize beam induced damage to the glasses not all elements were analyzed (Ti, Mn, and P were excluded). Also, the 10 second counting times at low currents caused a loss of precision for elements at low concentration. Tests were performed on glasses of similar composition in ALH84001 to determine beam conditions which showed no apparent alkali loss.

Results: Representative analyses are shown in Table 1. Glass analyses agree with the ideal plagioclase formula of $M_xT_4O_8$ where x is ≥ 0.975 [5] indicating that previous studies [1,2] suffered from alkali loss. A significant component of Fe is found in the analyses, which is relatively constant for individual glass pockets, suggesting that the Fe is derived from the original feldspar grains instead of a dissolved orthopyroxene or chromite component [2]. The amount of Fe is similar to the amount analyzed in maskelynite from Zagami [6], as well as the amount found by [2] for stoichiometric feldspathic glasses in ALH84001. Some analyses of feldspathic glass contain Mg (e.g. analysis 2, Table 1), suggesting that minor dissolution of carbonate or orthopyroxene occurred during a melting event.

Discussion: The feldspathic glasses are best described as four separate groups: (1) ≈Euhedral Plagioclase Glass (Maskelynite?): Large glass areas of stoichiometric plagioclase composition are found which appear to be primary cumulate minerals (Table 1). (2) Mobilized Plagioclase Glass: Glass of identical composition as the euhedral plagioclase is found in veins and filling interstices of orthoclase glass and mixed feldspar glass. Occasionally, this glass may have higher Fe concentrations as well as minor Mg suggestive of minor dissolution of orthopyroxene or carbonate. (3) Mixed Feldspar Glass: In individual glass pockets there are K-rich areas (which are common) which compositionally seem to represent mixtures of endmember plagioclase and orthoclase compositions (Table 1; Fig. 1). (4) Orthoclase Glass: Distinct areas are found of essentially stoichiometric orthoclase composition (Table 1, Fig.1).

The glasses found in ALH84001 are difficult to reconcile with one shock event. The Mixed Feldspar Glass commonly appears as clasts that have been intruded by the Mobilized Plagioclase Glass. The Mixed Feldspar Glass appears to be best described as a mixture of original plagioclase and orthoclase, as can be seen in Fig. 1. Two shock events are needed; the first one to mix the original plagioclase and orthoclase to form the Mixed Feldspar Glass clasts, and a later event which allows these clasts to be intruded by the Mobilized Plagioclase melts.

In one section of ALH84001, there is a large area which has been intruded by silica melts. There are some textural differences between the silica melt areas and the feldspathic melt areas. Orthopyroxene is appreciably more rounded in the silica melt areas compared to the feldspar melt areas. Preliminary analyses of the silica glass show them to have minor amounts of orthopyroxene and feldspar components. The feldspathic melt areas generally appear to have dissolved negligible amounts of orthopyroxene component (Table 1). These findings are consistent with expected phase equilibria;

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orthopyroxene is generally much more soluble in silica melts compared to feldspathic melts.

We also find no chemical or textural evidence to support the idea that carbonate has replaced feldspar or maskelynite [7,8]. In one area, carbonate seems to have been deposited passively around feldspathic glass; carbonate zoning does not seem to be affected by the presence of feldspathic glass. In this region, plagioclase glass and mixed feldspar glass seem to have been formed prior to carbonate deposition. A later shock event then remobilized the glass, as it now seems to intrude the carbonate.

References: [1] Mittlefehltdt (1994) *Meteoritics* **29,** 214. [2] Scott et al. (1997) *Nature* **387,** 377. [3] Greenwood et al. (1996) *LPSC* **27,** 457. [4] Devine et al. (1995) *Am. Min.* **80,** 319. [5] Smith (1974) *Feldspar Minerals* (Springer-Verlag, Berlin). [6] Stolper and McSween (1979) *GCA* **43,** 1475. [7] Treiman (1995) *Meteoritics* **30,** 294. [8] Gleason et al. (1997) *GCA* **61,** 3503.

Table 1. Representative analyses of feldspathic glasses in ALH84001.

	1	2	3	4	5
SiO2	59.28	58.37	64.04	62.56	64.75
Al2O3	25.38	24.88	21.51	21.95	19.01
Cr2O3	0.05	<0.05	<0.05	0.09	<0.05
FeO	0.28	0.44	0.55	0.45	0.50
MgO	<0.05	0.19	<0.05	<0.05	<0.05
CaO	6.93	7.00	2.52	3.23	0.51
Na2O	7.16	6.72	7.40	6.67	5.26
K2O	0.77	1.04	3.99	4.34	8.24
Total	99.85	98.64	100.03	99.29	98.35
M(Na+K+Ca)	0.999	0.993	0.989	0.990	0.975
T (Si+Al)	3.996	3.985	3.995	3.995	3.995
T (Si+Al+Fe)	4.006	4.001	4.016	4.012	4.014
Anal. Cond.	10nA,10µm	10nA,5µm	10nA,10µm	10nA,10µm	5nA,5µm

Description: 1: Euhedral Plagioclase Glass. 2: Mobilized Plagioclase Glass. This glass intrudes Mixed Feldspar Glasses. 3 and 4: Mixed Feldspar Glasses. 5: Orthoclase Glass.

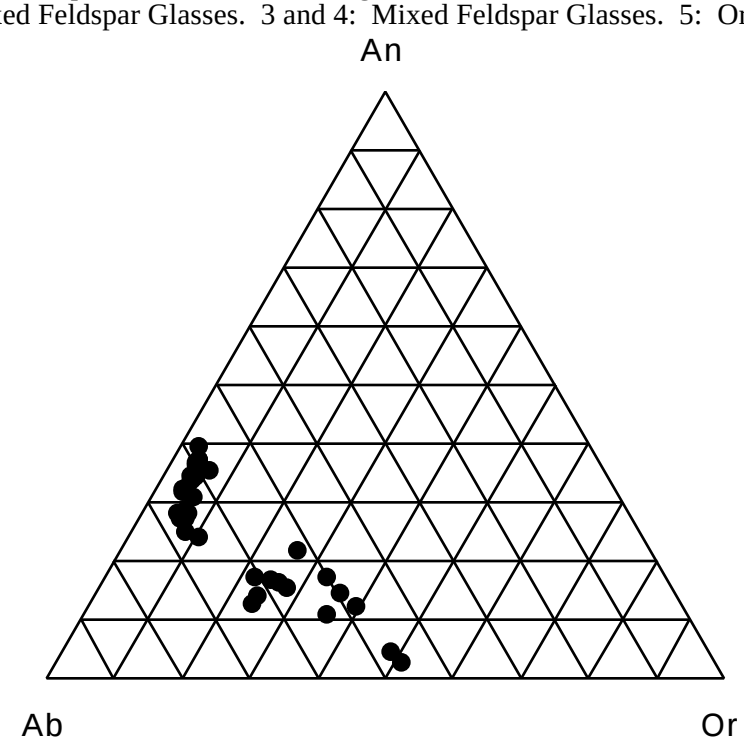

Figure 1: Compositions of feldspathic glasses in ALH84001.