IMPLANTATION OF NITROGEN: EFFECTS OF HYDROGEN AND IMPLANTATION ENERGY;Naoji Sugiura, Dept. of Earth and Planetary Physics, Univ. of Tokyo, Japan Tsuneji Futagami and Siro Nagai, Japan Atomic Energy Res. Inst., Japan

To solve the questions on solar nitrogen in lunar soils, i.e. variation in isotopic composition and apparently high retentivity compared with rare gases, nitrogen implantation experiments were conducted. At the Meteoritical Society Meeting in Copenhagen, we presented the results of stepped combustion of implanted nitrogen in ilmenite and olivine[1]. The degassing behavior of nitrogen (and also Ar) was quite different from that observed in the case of lunar soils. 1) Extraction temperatures are higher (>1100 C for ilmenite and 1500 C for olivine) than that for lunar soils. 2) Both nitrogen and Ar seem to be retained at the same efficiency. Therefore, additonal experiments were conducted to make degassing behavior of nitrogen more close to that observed in the case of lunar soils.

The experimental condition and the results of all the combustion experiments are summarized in the table. The samples of the new series of experiments are named by two digit numbers. For these samples, due to technical problems, nitrogen and hydrogen were accelerated as molecules. But this should not cause any difference compared with previous experiments, because as soon as the molecules enter the crystals they are expected to be dissociated into atoms. In many cases, the extraction of gases are not complete because heating to above 1200 C (or 1500 C) is not easy with our extraction systems. This is the reason that the recovery rates are given as lower limits. Implantation dose was estimated by monitoring ion current, and thus may have a relatively large error (>10 %). A recovery rate higher than 100% is attributable to this uncertainty of the implantation dose. Following features are observed.

1) In all experiments, degassing of nitrogen correlates well with that of Ar. (This is observed in the release pattern as a function of temperature of combustion.)

2) Presence of hydrogen promotes degassing at lower temperatures from olivine but not from ilmenite.

3) Presence of He slightly promotes degassing at lower temperatures in the case of olivine but does not affect the degassing from ilmenite.

4) Implantation energy affects the degassing temperature only slightly within the experimental range of implantation energy (from about 1KeV to 75KeV in the case of nitrogen). Nitrogen implanted at 0.9KeV is degassed mainly at 1000 C while nitrogen implanted at 75KeV is degassed at 1100 C from ilmenite. It seems that the degassing from ilmenite is mainly controlled by the oxidation process.

5) Retentivity (or recovery rate) of nitrogen and Ar are similar and at least one half of the implanted atoms seems to be retained.

6) The result for the H_2O_2 treated sample confirms that the gases are present very close to the surface.

Comparing the above results with those obtained from lunar soils, the following can be said.
1) Degassing temperatures (from 600 C to 1200 C) of nitrogen from lunar soils are yet slightly lower than that observed here in the case of olivine (the lowest main release temperature is 800 C) and much lower than that in the case of ilmenite (the lowest main release temperature is 1000 C). Since presence of hydrogen promote degassing at lower temperatures, additional presence of carbon may help lowering the degassing temperature further. Judging from the weak dependence of release temperature on implantation energy, low energy lunar wind probably can not explain the difference in the release temperature.
2) In the present experiments retentivity of nitrogen and Ar are rather similar both in ilmenite and in olivine, while in the case of lunar soils nitrogen is nearly one order of magnitude more abundant than Ar. At the moment there is no possibility of explaining this difference as due to the difference in implantation efficiency for these gases. It seems that either the abundance ratio of nitrogen to Ar of the solar wind was different or there was an additional source of nitrogen.

[1] Sugiura N., Futagami T., Zashu S. and Nagai S. (1992) Meteoritics, 27, 293.

	Sample	Gas species	Energy	Dose	Peak Temp.	Recovery
1			(KeV)	(1E14/cm2)	(C)	(%)
2	Ilmenite#1	He	20	110	1000	10
3		Ar	200	2.2	1000	>63
4		N	75	2.1	1000	>56
5	Ilmenite#2	Ar	200	2.2	1100	>85
6		N	75	2.2	1100	>70
7	Ilmenite#3	N	75	2.1	1100	>69
8	Ilmenite#6	N	20	2.1	1100	>41
9	Olivine #1	He	20	110	-	-
10		Ar	200	2.2	>1200	>18
11		N	75	2.1	>1200	>18
12	Olivine #2	Ar	200	2.2	1500	>48
13		N	75	2.2	1500	>62
14	Olivine #2,H2O2	Ar	200	2.2	-	0
15		N	75	2.2	-	0
16	Olivine #6	N	20	2.1	1400	>42
17	Ilmenite #11	H2	2	1000	-	-
18		Ar	40	2	1200	>56
19		N2	30	2.2	1200	>46
20	Ilmenite #12	H2	2	1000	-	-
21		Ar	1.5	5.7	1000	>42
22		N2	0.9	3.0	1000	>40
23	Olivine #11	H2	2	1000	-	
24		Ar	40	2.2	800	109.3
25		N2	30	2.2	800	71.5