MAC88105 - A NEW METEORITE FROM THE LUNAR HIGHLANDS: PRELIMINARY MINERALOGICAL, PETROLOGICAL, AND GEOCHEMICAL STUDIES.

Christian Koeberl[1], Gero Kurat[2], and Franz Brandstätter[2]. [1]*Institute of Geochemistry, University of Vienna, Dr.-Karl-Lueger-Ring 1, A-1010 Vienna, Austria;* [2]*Naturhistorisches Museum, P.O. Box 417, A-1014 Vienna, Austria.*

INTRODUCTION. The study of the rare lunar meteorites contributes essential details towards a better understanding of the composition and history of the lunar surface. So far eight samples from the Antarctic meteorite collection have been identified as lunar highland rocks (ALHA 81005, Y-791197, Y-82192, Y-82193, Y-793274, Y-86032, MAC88104, MAC88105). Recently, EET87521 has been found to be the first sample with lunar mare composition [1]. We report here the first results from our study of the new lunar meteorite MAC88105. Two samples, MAC88104 (61 g) and MAC88105 (662 g) have been collected during the 1988/89 Antarctic field season at the MacAlpine Hills blue ice field [2]. The two rocks are obviously paired [2,3], similar to Y-82192/3.

SAMPLE DESCRIPTION. We have received fragment ,28 (1.044 g) from the interior of MAC88105 for geochemical studies, and a PTS (,87) for microscopic and electron microprobe work. MAC88105 is a dense breccia consisting of lithic clasts, devitrified glasses, chondrule-like objects, and mineral fragments set in a fine-grained devitrified matrix. The matrix consists of mineral fragments, mineral precipitates, and devitrified feldspathic glass. Lithic clasts are small (<2.5 mm). The largest and most common clasts are plagioclase-rich devitrified vitric breccias which sometimes consist of two or more lithologies. Granulitic breccias are abundant and range in texture from hornfelsic to granulitic. They have variable plagioclase/mafics ratios and range in composition from anorthositic-troctolitic to anorthositic-noritic. Devitrified glass occurs as spheres and shards; feldspathic melt rocks are less common. A few lithic clasts resemble plutonic rocks: one spinel-norite, one norite, and one anorthosite have been identified. The rock is cut by inhomogeneous, brownish glass veins that also contain small mineral fragments.

MINERAL CHEMISTRY. Selected EPMA data are given in Table 1. Olivines are nearly equilibrated within a given rock and have a range of about Fa29-49. Their minor element contents are usually low and at similar levels; Ca can range up to 0.3 wt.%. Pyroxenes are predominantly low-Ca pyroxenes (pigeonites); the Ca contents vary within a small range (Fig. 1). The most magnesian pyroxenes were found in an anorthositic spinel-norite (Frag.A), the most Fe-rich pyroxenes in a norite (Frag.C). Only one granulitic breccia contains predominantly high-Ca pyroxenes (Frag.B). Plagioclase is highly anorthitic (An96-98; Frag.C) and contains some FeO (0.2-0.3 %). Spinel has been found in two lithic clasts one of which could be meta-igneous (Frag.A). In both cases, the Cr contents vary from center to surface (range: 9.9-12.5 wt.% Cr_2O_3). Minor phases: Small metal and sulfide grains are abundant in the PTS. One large metal grain within a devitrified vitric breccia has the composition of chondritic kamacite: Ni 5.8, Co 0.53 wt.%.

BULK CHEMISTRY. A glass vein (Tab.1) gives an indication of the bulk major element chemistry. Major and trace elements have been determined by INAA in two bulk samples (bulk2 = powder, bulk1 = fragments), one fine-grained meta-breccia, and two small greyish-white clasts. Preliminary results are given in Table 2. The chemical data leave no doubt that MAC88105 is a lunar highland anorthositic breccia. The bulk Fe/Mn ratio varies between 60-65, which is close to typical lunar highland rocks. The bulk chemistry is similar to the other lunar meteorites [4]. Like Y-86032, MAC88105 is rather iron-poor (this is evident not only from the bulk composition, but also from mineral abundances). Compared to Y-86032 [4,5], MAC88105 has similar contents of Na, K, Sc, Cr, Ni, Ir, and Au; Co is slightly, and Zn significantly higher in MAC88105. The REE contents in MAC88105 are higher than in Y-86032 (or Y-82192/3)(and the positive Eu-anomaly is less pronounced) and resemble Y-791197; this meteorite may contain a small KREEP component.

DISCUSSION AND CONCLUSION. MAC88105 is clearly a regolith breccia which has experienced some recrystallization and a late shock event during which anorthositic glass veins formed. The population of lithic clasts is comparable to other lunar highland breccias, with vitric breccias dominating over granulitic breccias and plutonic rock fragments. Lithic clast compositions are predominantly anorthositic noritic (or noritic anorthositic), and anorthositic troctolitic. Spinel-bearing rocks are present, but appear not to be members of the spinel-troctolite clan. Our spinel-bearing clast consists of anorthite+pigeonite+spinel and indicates a different heritage. However, the spinel composition is similar to that described from Apollo 17 [6]; however, in contrast to Apollo 17, our co-existing pyroxene is Al-poor. The pyroxenes have somewhat unusual compositions (Fig. 1) - orthopyroxenes and augites appear to be rare (cf.[7]). Most lithologies (breccias and igneous rocks) contain solely pigeonite. The pigeonite is fairly equilibrated in respect to Fe/Mg, but not in Ca contents. All clasts seem to have witnessed the same high-T event. This holds also for the only clast that contains predominantly Ca-rich pyroxene. Only one mafic rock was identified - a norite. It is a possible pristine rock and has the lowest *mg*-number encountered. The presence of a metal grain of H-chondritic composition (which is typical for most metal grains in lunar soil [8]) supports the interpretation of MAC88105 as a regolith breccia.

References: [1] P.H. Warren and G.W. Kallemeyn, GCA **53** (1989) 3323 [2] Antarct. Meteorite Newsl. **12**/2,3 (1989) [3] R. Score, M. Lindstrom, and B. Mason, Abstr. 52nd Ann.Mtg. Met.Soc., Vienna, 1989 [4] C. Koeberl, P.H. Warren, M.M. Lindstrom, B. Spettel, and T. Fukuoka, Proc. NIPR Symp.Ant.Met. **2** (1989) 15 [5] C. Koeberl, G. Kurat, and F. Brandstätter, Proc. NIPR Symp.Ant.Met. **3** (1990), in press [6] M.B. Baker and C.T. Herzberg, Proc. LPSC 11th (1980) 535 [7] C.E. Bickel and J.L. Warner, Proc. LPSC 9th (1978) 629 [8] P.H. Warren, G.J. Taylor, K. Keil, C. Marshall, and J.T. Wasson, Proc. LPSC 12B (1981) 21.

Table 1. Averaged and selected electron microprobe analyses of the lunar meteorite MAC88105. All data in wt.%.

	Glass vein	*Frag.I dev.gl.*	*Frag.A: sp-norite*			*Frag.C: norite*		*Frag.B: granulite*		
			Sp	*Px*	*An*	*Px*	*An*	*Ol*	*Px*	*An*
SiO_2	44.6	47.7	0.07	52.3	42.8	50.7	45.9	35.1	50.3	43.8
TiO_2	0.16	0.27	0.45	0.63	0.02	0.18	0.03	<0.02	0.83	0.02
Al_2O_3	31.9	27.0	56.4	0.79	36.3	1.42	33.6	0.15	1.53	36.2
Cr_2O_3	0.04	0.24	9.9	0.41	<0.02	0.67	0.02	<0.02	0.58	0.02
FeO	3.4	2.57	19.2	16.7	0.25	25.5	0.45	39.1	17.0	0.23
MnO	0.06	0.18	0.11	0.32	<0.02	0.44	<0.02	0.37	0.36	<0.02
MgO	2.40	5.7	13.7	22.2	0.03	16.2	0.03	23.5	13.4	0.09
CaO	17.3	13.9	0.02	5.3	18.9	3.7	18.6	0.30	14.7	18.7
Na_2O	0.35	0.56	<0.02	<0.02	0.25	<0.02	0.46	<0.02	<0.02	0.27
K_2O	0.04	0.11	<0.02	<0.02	0.02	<0.02	0.03	<0.02	<0.02	0.03
Total	100.24	98.24	99.85	98.65	98.57	98.81	99.12	98.52	98.70	99.36

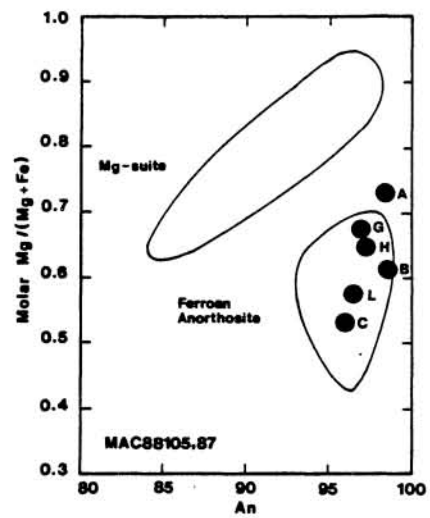

Figure 2.
An content of plagioclase vs. molar Mg/(Mg+Fe) ratio in mafic minerals for clasts in MAC88105,87. A: sp-norite, B, G, H, L: granulites, C: norite.

Table 2. Trace element contents of MAC88105 obtained by INAA (preliminary results; 1.+2. measuring cycles only). Data are in ppm, except where indicated.

	88105	88105	88105	88105	88105	Y86032
	bulk2	*bulk1*	*breccia*	*clast1*	*clast2*	*wgt.ave.*
wt. (mg)	*153.40*	*55.20*	*7.54*	*1.18*	*(0.09)*	*Ref.[4]*
Na (wt.%)	0.29	0.30	0.295	0.34	0.34	0.32
K	190	185				165
Sc	8.74	9.72	10.5	10.2	11.1	8.27
Cr	655	741	765	515	130	666
Mn	520	611	600	531	80	458
Fe (wt.%)	3.2	3.60	3.74	2.52	<0.6	3.27
Co	16.1	17.1	18.2	23.2	174	14.4
Ni	159	151	160	<220	<600	131
Zn	29		15	<50	<300	9.1
Ga	4.12	3.60	3.6	3.3	<10	3.66
As	0.06	0.08	<0.1	<0.4	<2	0.27
Se	<1	<0.5	<1			0.4
Br	0.12	<0.2	<0.2	<1	<5	0.12
Rb	<2	<4	<5			<1
Sr	160					161
Zr	30		<50	<150		27
Sb	0.04	<0.06	<0.1	1.2	<2	<0.015
Cs	<0.3					0.05
Ba	25	26		<150		27
La	2.54	2.87	2.96	1.40	1.2	1.33
Ce	6.51	7.48	7.61	3.5		3.51
Nd	4.1	5.0	5.2	-	-	1.88
Sm	1.22	1.46	1.52	0.70	0.82	0.63
Eu	0.77	0.82	0.91	0.77		0.93
Tb	0.27	0.34	0.32			0.15
Dy	1.71	2.11	2.06	1.1	-	1.05
Yb	1.05	1.23	1.18	<1		0.60
Lu	0.16	0.18	0.18	0.10		0.087
Hf	0.84	0.95	1.0	<1		0.47
Ta	0.07	0.09	<0.12			0.06
W	0.2	<0.3	0.29	<2	<8	0.36
Ir (ppb)	5.6	6.4				5.3
Au (ppb)	2.5	4	3.8	<15	-	2.4
Th	0.33	0.41	0.48	<0.6	-	0.22
U	<0.1	<0.2	<1	-	-	0.051

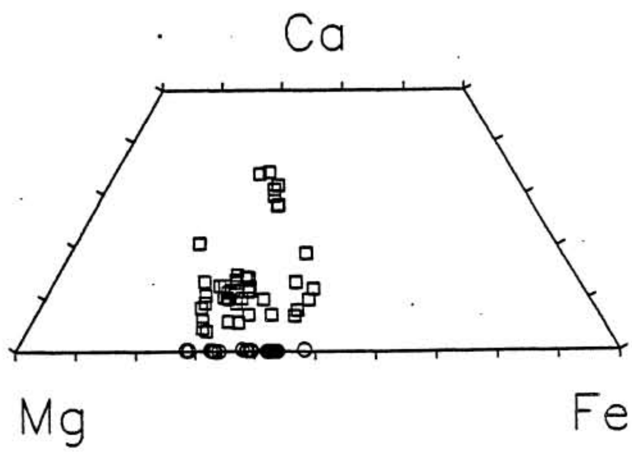

Figure 1.
Pyroxene (squares) and olivine (circles) compositions in MAC88105