PETROLOGY AND BULK CHEMISTRY OF R CHONDRITES: NEW DATA. Junko Isa, Alan E. Rubin and John T. Wasson, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA 90095-1567, USA (jisa@ucla.edu).

R chondrites are characterized by a low chondrule/matrix abundance ratio (typically 0.2-0.4), moderately sized chondrules (~400 μm), abundant sulfides (typically 6-10 wt.% pyrrhotite and pentlandite), high $\Delta^{17}O$ (~2.9‰) and very rare refractory inclusions [1-9]. The high state of oxidation of R chondrites is reflected by the absence (or very low modal abundance) of metallic Fe-Ni [1-5], the high Ni contents of those metal grains (awaruite) that are present [2-5], the abundance of NiO-bearing olivine (Fa37-40) [5], the presence of Fe^{3+}-bearing, TiO_2-rich chromian spinel [5], the occurrence of magnetite in a few specimens [3], and in the case of R6 LAP 04840, abundant hornblende and minor biotite [10]. R chondrites range in petrologic type from 3.6 (ALH 85151) to 6 (e.g., LAP 04840; Y 980702) [1,10]. With increasing metamorphism, the modal abundances of low-Ca pyroxene and metallic Fe-Ni decrease; in many R chondrites these phases are absent [5]. Most R chondrites are brecciated; some are fragmental breccias, others are regolith breccias that contain solar-wind-implanted rare gases and a few R5 and R6 clasts. R-chondrite refractory lithophile abundances are at ~0.95×CI [5]; this is higher than those of ordinary chondrites (OC; ~0.90×CI). Refractory and common siderophile abundances in R chondrites are at CI levels; Se and Zn are significantly enriched relative to OC.

To enhance the R-chondrite data base, we report new petrological observations of two R chondrites (R3 PRE 95411 and R6 Y 980702), the reclassification of MET 01149 from CK3 to R3, and the bulk chemical compositions of seven R chondrites: LAP 04840 (R6), LAP 03639 (R4), NWA 2198 (R4), NWA 753 (R3.9), MET 01149 (R3), PRE 95411 (R3) and NWA 978 (R3.8). Bulk compositions were obtained on ~300-mg samples by instrumental neutron activation analyses (INAA); irradiation was at the University of California, Irvine.

PRE 95411 is an R3 fragmental breccia containing (in vol.%): 90.5 % silicate (Fa36-43 olivine, Fs2-31 low-Ca pyroxene, Fs8Wo44 Ca-pyroxene and Ab83Or6 plagioclase), 8.8% troilite, 0.4% pentlandite, 0.3% oxide (ilmenite, chromite, Al-chromite and Fe-rich chromite) and 0.04% awaruite (with 70 wt.% Ni). In contrast to most R chondrites (in which metal is absent), section PRE 95411,6 (113 mm^2) contains ~50 heterogeneously distributed metal grains. Olivine is not completely equilibrated; e.g., one 120×140-μm grain has a Fa10 core and a Fa45 rim.

Y 980702 is an R6 chondrite containing recrystallized 400-500-μm-size chondrules and 50-200-μm-size olivine grains separated by a recrystallized matrix. The matrix consists of patches of 15-25-μm-size olivine grains with 120º triple junctions that form a granoblastic texture. Pyrrhotite and chromian spinel are present; metal, hornblende and biotite are absent.

MET 01149 was originally misclassified as CK3 [11]. The rock is instead an R3 chondrite. It contains Fa39 olivine [11] and 400-μm-size chondrules. Also present are several cryptocrystalline chondrules, which are very rare in CK chondrites [12].

New bulk chemical composition data for seven R chondrites are presented in Table 1. Elemental abundances, normalized to Cr and to mean R chondrites, are plotted in Fig. 1.

Most elements in most samples deviate little from mean R chondrites. The similarities in bulk composition between R3 PRE 95411, R4 LAP 03639 and R6 LAP 04840 indicate that the group is generally isochemical, irrespective of petrologic type. The deviations among REE reflect uncertainties in the data. The high As content of NWA 753 and the high Au content of MET 01149 are probably due to contamination. Low Na in NWA 978 may be due to leaching during terrestrial weathering. We speculate that the low Sb in the hornblende-bearing R6 chondrite LAP 04840 may be due to the formation of Sb-rich sulfide, followed by dissolution and loss during terrestrial weathering.

The occurrence of chondrules containing magnesian olivine phenocrysts with ferroan rims in some R3 chondrites (e.g., PCA 91002) near other similarly sized, completely equilibrated, chondrules containing only ferroan olivine indicates that oxidation occurred on the parent body [3]. The oxidant was probably water, plausibly present in hydrated silicates within the modally abundant matrix. The high bulk $\Delta^{17}O$ in R chondrites suggests that this water was rich in ^{17}O. During fluid-assisted metamorphism, olivine equilibrated, metallic Fe-Ni became more Ni rich as Fe was oxidized, and metal and low-Ca pyroxene decreased in abundance as these phases reacted with water to form additional olivine (and H_2) [13]. In the case of R6 LAP 04840, an influx of water may have been required to form hornblende and biotite [10].

Table 1. INAA data for seven R chondrites.

	Na	K	Ca	Sc	Cr	Mn	Fe	Co	Ni	Zn	Ga	As	Se	Sb	La	Sm	Eu	Yb	Lu	Os	Ir	Au
	mg/g	µg/g	mg/g	µg/g	mg/g	mg/g	mg/g	µg/g	mg/g	µg/g	µg/g	µg/g	µg/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
LAP 04840	6.74	755	11.9	7.64	3.50	2.20	241	651	13.1	167	8.1	1.83	13.6	34	273	189	88	246	36	566	545	177
LAP03639	6.18	902	10.8	7.74	3.49	2.31	242	682	14.7	155	8.86	1.97	12.5	105	276	177	87	237	28	666	550	146
NWA2198	6.74	869	11.3	7.98	3.53	2.71	243	659	13.7	160	8.63	3.12	12.5	73	424	195	88	267	33	410	570	43
NWA753	5.57	1026	13.0	8.16	3.75	2.34	249	730	15.5	160	8.60	7.33	14.3	78	389	231	112	247	60	602	641	109
MET01149	6.22	737	10.1	7.70	3.46	2.34	245	742	15.2	147	10.8	1.97	14.2	51	303	187	92	117	36	746	631	265
PRE95411	6.71	707	11.8	7.29	3.37	2.05	221	768	17.3	149	9.58	1.86	12.4	95	245	158	84	175	24	607	547	46
NWA978	4.02	1054	10.4	8.02	3.64	2.09	239	499	10.3	159	8.23	2.68	10.6	80	482	156	88	273	39	700	618	142

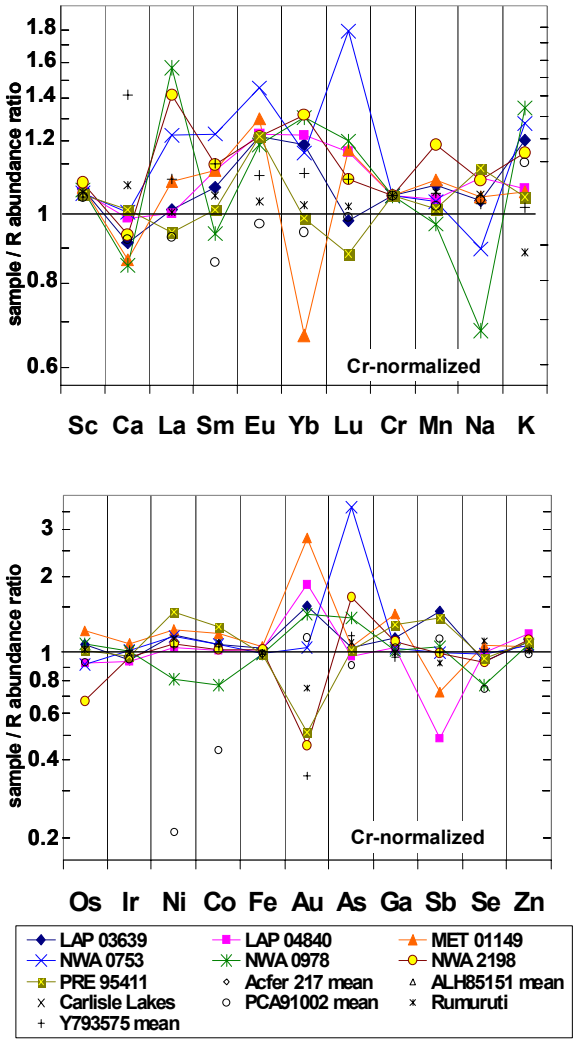

Fig. 1. New bulk compositional data for seven R chondrites, plotted along with six R chondrites from the literature [5]. The elements are arranged from left to right in order of increasing volatility. The data are normalized to Cr and to mean R chondrites.

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