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**STALKING THE LREE-ENRICHED COMPONENT IN UREILITES.** \*Cyrena Anne Goodrich and \*\*Günter W. Lugmair. \*Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721. \*\*Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093.

*Ureilites contain a LREE-enriched component whose origin and identity are unknown, but which may have been introduced into 4.55 Ga olivine + pyroxene assemblages at various times in the period 4.55-3.74 Ga [1]. This component is volumetrically minor, inhomogeneously distributed, and can be removed with concentrated HNO<sub>3</sub> [1,2,3], which suggests that it may be contained in minor, interstitial phases not previously recognized in ureilites. There is evidence, however, that not all of this component is leachable. Whole rock samples of Kenna, Novo Urei, and ALHA77257 form a <sup>143</sup>Nd/<sup>144</sup>Nd-<sup>147</sup>Sm/<sup>144</sup>Nd line (Fig. 1) with a slope corresponding to an age of 3.74 Ga [1]. Although this line could be a mixing line, with one end-member being the LREE-enriched component and the other being a 4.55 Ga olivine + pyroxene assemblage, the observation that a pyroxene separate from Kenna plots on the line suggests that the LREE-enriched component at least partially equilibrated with the olivine and pyroxene and that the line is an isochron [1]. We performed a leaching experiment on Kenna, using various acids and concentrations, in an attempt to isolate the LREE-enriched component and differentiate between possible hosts for it, and to determine whether all of it is leachable. Our results suggest that most of the LREE-enriched component is surface-sited, rather than contained in a discrete mineral. However, some of it is not readily leachable because it equilibrated with Kenna olivine + pyroxene at 3.79±0.05 Ga.*

**EXPERIMENTAL PROCEDURES:** Two new samples of Kenna ("A" and "B") were ground in a boron carbide mortar. Nd and Sm concentration determinations on small aliquots indicated that they contained significant amounts of LREE and, therefore, would be appropriate for leaching experiments. "A" was divided into a whole rock aliquot (63.4 mg) and an aliquot for leaching (66.6 mg). A whole rock aliquot of "B" (79.5 mg) was also prepared. Reagents used for the seven progressive leaches of "A" are summarized in Table 1, and were designed to progressively remove surface contaminants and various possible trace phases. All leachates, the residue, and both whole rock samples were analyzed for Nd and Sr isotopic composition and Nd, Sm and Sr concentrations (Table 2).

**RESULTS:** "A" is very similar in Nd and Sm concentrations and Nd isotopic composition to the previously-analyzed whole rock samples K1 and K3 [1], which plot at the LREE-enriched end of the Kenna "isochron" (Fig. 1). Samples such as these probably represent the maximum amount of LREE-enriched component in Kenna. "B" contains slightly less of this component. Addition of these samples to the Kenna line results in slight revision of the line, giving an age of 3.79±0.05 Ga (Fig. 2; note change of scale). The first three leaches did not dissolve measurable amounts of material. The 2M HNO<sub>3</sub> leach dissolved 11.3% by mass of the original material; since known interstitial phases soluble in HNO<sub>3</sub> in ureilites (carbon, sulfides, metal) generally constitute <5-7%, some olivine + pyroxene must have dissolved in this leach. The 2.5M HCl and 6M HCl leaches dissolved respectively 15.7% and 19.7% by mass of the original material, probably largely olivine. The 13M HNO<sub>3</sub> leach dissolved negligible mass, demonstrating that no HNO<sub>3</sub>-soluble phases remained. The residue contained only 42.3% of the original material. If the HCl leaches dissolved principally olivine, and the sample had a typical Kenna olivine/pyroxene ratio, then the residue contains ~65% olivine and 35% pyroxene. The thoroughness of the leaching procedure and the large amount of material dissolved suggests that the residue is devoid of leachable LREE-enriched component. The residue is similar in Nd and Sm concentrations and Nd isotopic composition to whole rock sample K2, which plots at the LREE-depleted end of the Kenna "isochron" (Fig. 1), confirming that K2 was nearly devoid of leachable LREE-enriched component [1].

Progressively more aggressive leaches show progressively higher Sm/Nd ratios (Fig. 2), indicating progressive dilution of the LREE-enriched component. However, neither all of the leachates nor the residue plot strictly within error of the 3.79 Ga line, which suggests some differential leaching of Sm and Nd, as suspected in previous leaching experiments [1]. The 6M HCl leachate contained only 5%, the 13M HNO<sub>3</sub> leach 0.2%, and the residue 1.6% of the total Nd, indicating that most of the LREE-enriched component had dissolved in earlier leaches. The 2M HNO<sub>3</sub> and 2.5M HCl leachates have lower <sup>147</sup>Sm/<sup>144</sup>Nd ratios than the whole rock and the Nd concentrations of the masses they represent (432 and 289 ppb, respectively) are higher than that of the whole rock, indicating that they are still dominated by LREE-enriched component. The 0.04M HNO<sub>3</sub> and 0.2M HNO<sub>3</sub> leachates have even lower <sup>147</sup>Sm/<sup>144</sup>Nd (0.112) and the highest Nd concentrations. If either of these represents 1 mg of material, then the Nd concentration of that material is ~19.5 ppm. These leachates represent our best estimate of the composition of the leachable LREE-enriched component. Our previous estimate was [Nd]=8 ppm and <sup>147</sup>Sm/<sup>144</sup>Nd=0.115 [1].

**CONCLUSIONS:** The concentration of LREE-enriched component in the weaker leaches coupled with its continued but progressively diminished appearance in the stronger leaches suggests that most of it is surface-sited and loosely bound, rather than contained in a discrete mineral phase. However, the possibility that minute amounts of a

phosphate host were dissolved in the 0.2M HNO<sub>3</sub> leach cannot be ruled out. The observation that our fully-leached residue is no more LREE-depleted than K2 strengthens the interpretation that the Kenna 3.79 Ga line is an isochron. If it were a mixing line then a sample completely devoid of leachable LREE-enriched component would be expected to have <sup>147</sup>Sm/<sup>144</sup>Nd~0.51 (the intersection of the Kenna line with the 4.55 Ga chondritic evolution line [1]). We conclude that some of the LREE-enriched component equilibrated with Kenna olivine and pyroxene at 3.79±0.05 Ga. The geologic nature of this component remains open to speculation. Investigation of what other elements may be coupled with the LREE in the leachates may shed some light on this problem.

[1] C.A. Goodrich *et al.* (1991) *Geochim. Cosmochim. Acta* 55, 829. [2] W.V. Boynton *et al.* (1976) *Geochim. Cosmochim. Acta* 40, 1439. [3] A.H. Spitz and W.V. Boynton (1986) *Meteoritics* 21, 515.

Table 1: Kenna "A" leach experiment

leaching agent	conditions	mass fraction of original sample
H <sub>2</sub> O	10 min. ultrasound.	unmeasurable
0.04M HNO <sub>3</sub>	10 min. ultrasound, H <sub>2</sub> O rinse.	unmeasurable
0.2M HNO <sub>3</sub>	10 min. ultrasound, H <sub>2</sub> O rinse.	unmeasurable
2M HNO <sub>3</sub>	1 hr. ultrasound, 0.2M HNO <sub>3</sub> rinse, 0.1M HNO <sub>3</sub> rinse, H <sub>2</sub> O rinse.	11.3%
2.5M HCl	1 hr. ultrasound, 0.5M HCl rinse, H <sub>2</sub> O rinse.	15.7%
6M HCl	10 min. ultrasound, 1hr. low heat, 0.5M HCl rinse, H <sub>2</sub> O rinse.	19.7%
13M HNO <sub>3</sub>	45 min. ultrasound, 1M HNO <sub>3</sub> rinse, H <sub>2</sub> O rinse.	<0.3%
residue		42.3%

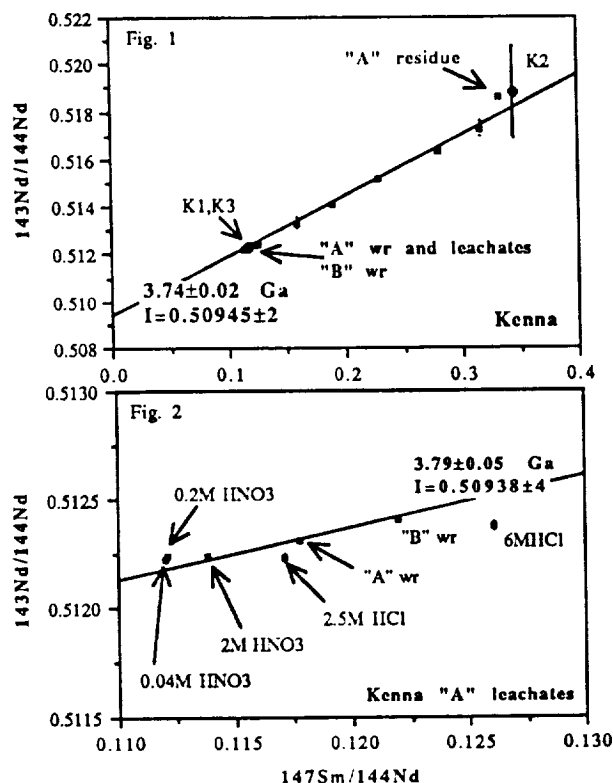


Table 2: Nd and Sr isotopic data for Kenna "A" and "B"

sample	<sup>143</sup> Nd/ <sup>144</sup> Nd	<sup>147</sup> Sm/ <sup>144</sup> Nd	Nd	Sm	<sup>87</sup> Sr/ <sup>86</sup> Sr	Sr
"A" whole rock	0.512312±11	0.1177	222.9 ppb	43.4 ppb	0.708624±18	4.647 ppm
"B" whole rock	0.512407±11	0.1220	125.5 ppb	25.33 ppb	0.708628±17	3.834 ppm
<b>"A" Leach Experiment</b>						
H <sub>2</sub> O leachate	nm	nm	nm	nm	0.708613±18	80.2 ng
					0.708590±20	
0.04M HNO <sub>3</sub> leachate	0.512225±11	0.1120	19.5 ng	3.625 ng	0.708644±22	600.8 ng
0.2M HNO <sub>3</sub> leachate	0.512241±10	0.1121	19.4 ng	3.586 ng	0.708637±18	397.1 ng
2M HNO <sub>3</sub> leachate	0.512237±17	0.1138	32.17 ng	6.055 ng	0.708600±18	720.7 ng
					0.708625±21	
2.5M HCl leachate	0.512232±18	0.1171	30.18 ng	5.83 ng	0.708619±26	401.0 ng
6M HCl leachate	0.512379±19	0.1261	5.469 ng	1.141 ng	0.708669±17	302.7 ng
					0.708664±15	
13M HNO <sub>3</sub> leachate	0.51242±12	nm	237 pg	nm	0.708650±32	27.8 ng
residue	0.518608±63	0.3326	1.772 ng	0.975 ng	0.708434±18	85.7 ng