Rb-Sr AND Sm-Nd STUDY OF THE D'ORBIGNY ANGRITE. E. K. Tonui[1], H. H. Ngo[1], and D. A. Papanastassiou[1,2], [1]The Lunatic Asylum, Division of Geological and Planetary Sciences, M/C 170-25, Caltech, Pasadena, CA, 91125 (etonui@gps.caltech.edu), [2]Earth and Space Sciences Division, M/S 183-335, Jet Propulsion Laboratory, Caltech, 4800 Oak Grove Drive, Pasadena, CA, 91109-8099.

Introduction: D'Orbigny, is a relatively a new angrite find [1]. Angrites are achondrites that show unique mineralogy and typically ancient crystallization ages. D'Orbigny has been described extensively by [2]. We have initiated a study of D'Orbigny. A Pb-Pb model age of 4559 Ga has been reported [3]. The presence of ^{244}Pu fission Xe in D'Orbigny has also been reported [4]. We present Sm-Nd and Rb-Sr results and a ^{53}Mn-^{53}Cr study is in progress. We had expected to find a relatively well-behaved Sm-Nd system, and distinct evidence for the ^{146}Sm-^{142}Nd system. Emphasis in this study was placed on the precise measurement of initial ^{87}Sr/^{86}Sr, since primitive initial ^{87}Sr/^{86}Sr may be characteristic of the angrite parent body. Sr isotope measurements were obtained in the recently completed laboratories at JPL, using the ThermoFinnigan Triton mass spectrometer. Due to lower amounts of Nd and Sm, Sm-Nd data were obtained on the Lunatic I spectrometer at Caltech, due to established high ionization techniques, on this instrument using light rare earth oxide ions.

D'Orbigny is an unshocked, unmetamorphosed medium to coarse-grained and vesicular igneous rock, composed of two dense crystalline fractions, separated by a more porous fraction, and glass [2]. These observations indicate some significant complexity in this rock. It consists of Ca-rich olivine, Al-Ti-diopside-hedenbergite, subcalcic kirschteinite, hercynitic spinel and anorthite, with the mesostasis phases ulvöspinel, Ca-phosphate, a silico-phosphate phase and Fe-sulfide [2, 5]. For this work, we used the coarser-grained part of the rock. A fragment with minimal evidence of rust was crushed gently. Material in the range 75-200 μm was used for mineral separations. Clinopyroxene was obtained by handpicking (larger grains). The rest of the material was processed through density (methylene iodide and acetone) and magnetic separations. Fractions of the handpicked pyroxene and of the plagioclase obtained by density separation were leached in warm dilute HCl for 10 minutes, in order to help remove alteration. These leached samples were then processed through the chemistry. The leaches did not contain detectable amounts of the trace elements of interest in this work. In addition, a total rock sample of Angra dos Reis (ADOR) was processed through the chemistry, for reference, and analyzed following the same analytical procedures.

Sm-Nd. For ADOR, we obtained ^{147}Sm-^{143}Nd results, which are consistent with earlier data [6, 7]. The "whole rock" analysis falls on the 4.56 Ga isochron defined by the Sm-Nd CHUR average composition (Fig. 1), but with higher ^{143}Nd/^{144}Nd and ^{147}Sm/^{144}Nd. For D'Orbigny, we obtain a reasonable range in ^{143}Nd/^{144}Nd and ^{147}Sm/^{144}Nd, similar to that obtained for ADOR pyroxene and whitlockite [6, 7]. The D'Orbigny pyroxene data also fall closely on the 4.56 Ga isochron, indicating an undisturbed system. However, the plagioclase data fall far off this isochron. The pyroxene plagioclase tie-line yields a slope corresponding to an age of 3.08±0.05 Ga. While D'Orbigny is described [1, 2, 5] as unshocked, unbrecciated, unmetamorphosed and only moderately altered, the Sm-Nd suggest that the rock has been disturbed recently. It is possible that only the plagioclase has been affected. Such circumstances have been observed by us in mesosiderite basalt clasts [9], suggesting that plagioclase is less resistant to metamorphism than clinopyroxene. In Fig. 2, we show the ^{142}Nd/^{144}Nd data. It is apparent that the effects in ^{142}Nd/^{144}Nd are very small, with pyroxene showing no effect and with plagioclase showing a slight (and not clearly resolved) deficit in ^{142}Nd/^{144}Nd, consistent with the lower Sm/Nd for plagioclase. A tie-line for D'Orbigny plagioclase and pyroxene shows no clearly defined evidence for the preservation of ^{146}Sm effects (initial ^{146}Sm/^{144}Sm< 0.000147).

Rb-Sr. We show the ^{87}Sr/^{86}Sr in D'Orbigny plagioclase and pyroxene data in Fig.3. We have measured also, for reference, samples of Moore County plagioclase, ADOR (TR), and the NBS (NIST) 987 Sr standard. The greatly improved precision of the Triton can be seen, relative to our earlier study, using the F/MAT 262 [8]. Typical precision for ^{87}Sr/^{86}Sr is ±7 ppm (2σ). In Fig. 4, we show the area near the origin of the ^{87}Rb-^{87}Sr evolution diagram. The D'Orbigny plagioclase Sr data are very near the origin and permit the definition of primitive ^{87}Sr/^{86}Sr, well below BABI, largely independent of the age of D'Orbigny. The D'Orbigny data are consistent with our earlier ADOR pyroxene data [10], and with results in [11]. It is clear that samples with extremely low Rb/Sr, define the initial ^{87}Sr/^{86}Sr essentially independently of Rb-Sr systematics. By contrast, the ADOR total rock ^{87}Sr/^{86}Sr, in this work, is sufficiently radiogenic (with higher Rb/Sr) so that it

does not provide a useful estimate of the initial $^{87}Sr/^{86}Sr$ in ADOR, independently of the Rb-Sr age relations in ADOR. The agreement in initial $^{87}Sr/^{86}Sr$ for D'Orbigny (plagioclase) and ADOR (pyroxene) provides a clear characteristic for the parent sources of these meteorites and provides a strong connection between D'Orbigny and Angra dos Reis. The case for ADOR having originated on the same parent body as the other angrites is strengthened. It is clear also from the results on the initial Sr of eucrites, the Moon, Moore Co., ADOR, and D'Orbigny, that low Rb/Sr planetary bodies are not rare.

The current data establish: a) uniquely primitive, characteristic initial $^{87}Sr/^{86}Sr$ in angrites; b) a significant disturbance for Sm-Nd in the D'Orbigny plagioclase, which may not have affected the pyroxene; c) the possibility of a more complex history for angrites, as more members of this rare class are found and investigated.

Acknowledgements. We thank Dr. Gero Kurat for the sample of D'Orbigny. This work is supported by NASA Cosmochemistry RTOP344-31-55-01. Division Contribution 8903(1105).

References. [1] Kurat *et al.* (2001) *LPSC 22,* 1753. [2] Mittlefehldt *et al.* (2002) *MAPS, 37,* 345-369. [3] Jagoutz *et al.* (2002) *LPSC 33*, 1043. [4] Eugster *et al.* (2002) *LPSC 33*, 5077. [5] Mikouchi *et al.* (2001) *LPSC 32,* 1876 [6] Lugmair and Marti (1977) *EPSL 35*, 273-284. [7] Jacobsen and Wasserburg (1984) *EPSL 67*, 137-150. [8] Stewart *et al.* (1993) *LPSC 24*, 1357. [9] Stewart *et al.* (1994) *GCA 58*, 3487-3509. [10] Wasserburg et *al.* (1977) *EPSL 35*, 294-316. [11] Lugmair and Galer (1992) *GCA 56*, 1673-1694.

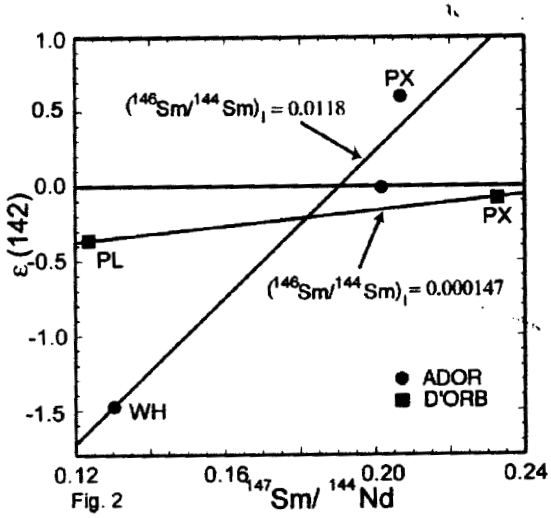

Fig. 2

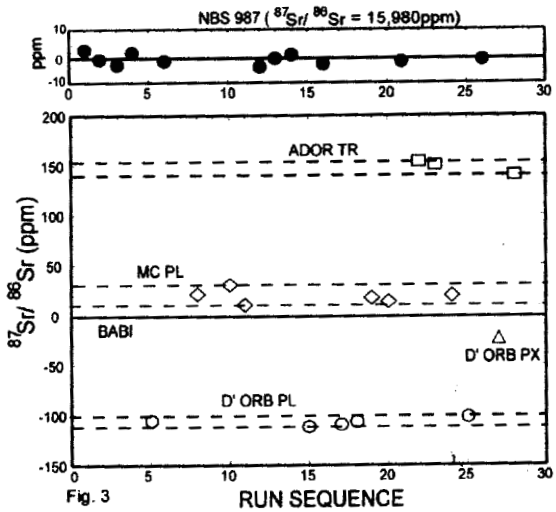

Fig. 3

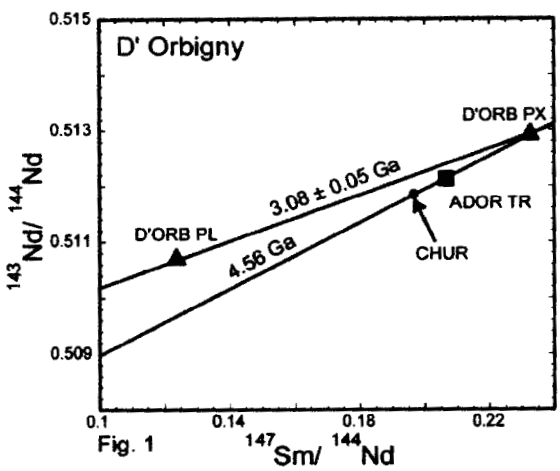

Fig. 1

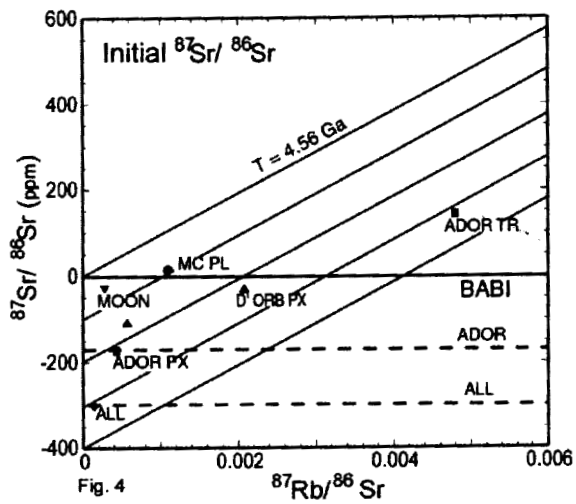

Fig. 4