DIRECT $^{207}Pb/^{206}Pb$ DATING BY ION MICROPROBE OF URANIUM-THORIUM-RICH PHASES IN ALLENDE CALCIUM-ALUMINIUM-RICH CLASTS (CARC's). J.F. Lovering, Department of Geology, University of Melbourne, Parkville, Victoria, Australia 3052; and J.R. Hinthorne and R.L. Conrad, Hasler Research Center, Applied Research Laboratories, 95 La Patera Lane, Goleta, California 93017.

Lovering et al. (1) have described a suite of primary uranium-thorium-rich (UTR) phases in calcium-aluminium-rich clasts (CARC's) from the Allende carbonaceous chondrite. These phases are usually less than 2 μm across and were recognized by "Lexan" particle track prints (2) and identified and analysed by SEM/Si(Li) X-ray analyser and electron microprobe as follows:

Phase I : Essentially a Ca, REE silicate with up to 30% ThO_2 (both calculated as at time of formation of the phase).

Phase II : A pyrochlore-like phase (i.e. essentially calcium niobate) with up to 20% ThO_2, 8% UO_2 and minor REE's.

Phase III: Thorianite with ∿75% ThO_2 and ∿18% UO_2.

Phase IV : Ti-bearing baddeleyite with ∿0.3% ThO_2 and ∿0.6% UO_2.

Only CARC's belonging to Grossman's (3) mineralogical group Type B contain these UTR phases. Type A CARC's are characterised by perovskite as a significant phase (3) and "Lexan" print studies indicate that, in these CARC's, the uranium (and thorium) only occurs in the perovskite.

The CARC's in the Allende carbonaceous chondrite are considered by a number of workers [see summary in (4)] to represent high-temperature condensates from a gas of solar composition during the very earliest stages in the formation of the solar system. Since both U and Th are relatively refractory trace metals, they would be expected to condense at relatively high temperatures (>1400°K) at an early stage during the condensation sequence of the solar nebula, and grossly separated in the temperature and time sequence from initial common Pb which should condense at $\lesssim$600°K. On this basis the phases identified in the Type B Allende CARC's should be ideal subjects for radiogenic $^{207}Pb/^{206}Pb$ dating since corrections for the isotopic composition of initial common lead incorporated at the time of condensation of the high-temperature UTR should be negligible. However the extreme rarity and micrometer dimensions of these UTR grains would militate against the direct measurement of $^{207}Pb/^{206}Pb$ ages for these minerals by conventional techniques. On the other hand the problem of their analysis is one which is eminently suited to the ion microprobe mass analyser (IMMA).

An IMMA study has been made of the lead isotopic composition of six separate micrometer-size UTR grains in two distinct Type B CARC's using methods developed by Andersen and Hinthorne and summarised in (5). Pb isotope ratios were measured in situ on several grains of both Phase I

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and II co-existing in Allende CARC No. 40A and of Phase III grains in CARC No. 20B-A. In all cases no ion peaks (other than ^{206}Pb, ^{207}Pb, ^{208}Pb) were observed in the mass region 202-210 so normal corrections for possible contaminants on the three Pb peaks using Andersen and Hinthorne's method (6) were not necessary. They also normally correct the measured lead istopic data for common lead assuming a common lead isotopic composition appropriate to the $^{207}Pb/^{206}Pb$ age by fitting the radiogenic $^{208}Pb/^{206}Pb$ to the observed Th/U ratio. However these common lead corrections are negligible for the analyses reported in Table 1 as was predicted previously in discussing the high-temperature condensation origin of the UTR phases.

The $^{207}Pb/^{206}Pb$ dates reported on the various UTR phases in the Allende CARC's (Table 1) are believed to be the first directly measured $^{207}Pb/^{206}Pb$ ages obtained on any primary UTR phases in meteorites. The average age for the 6 grains analysed is $4.60 \pm 0.09 \times 10^9$ years and this may be interpreted most simply as the time at which the various UTR phases formed from the solar nebula. This age is in good agreement with an isochron age of $4.553 \pm 0.004 \times 10^9$ years for the $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ plot for lead extracted from Allende CARC's, chondrules and matrix by Tatsumoto et al. (8) and another isochron age of $4.565 \pm 0.004 \times 10^9$ years for a similar study by Chen and Tilton (9).

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Table 1. IMMA analyses of lead isotopic composition and $^{207}Pb/^{206}Pb$ ages for uranium-thorium-rich (UTR) phases in Allende Type B calcium-aluminium-rich clasts (CARC's).

CARC No.	CARC Mineralogy (volume %)	Uranium-thorium-rich (UTR) phases.					
		Phase	Grain No.	Th/U (atomic)	$^{208}Pb/^{206}Pb$ (a)	$^{207}Pb/^{206}Pb$ (a)	$^{207}Pb/^{206}Pb$ Age (b) ($x10^9$ years).
40A	Melilite (35%) Ti-fassaite (35%) Spinel (15%) Anorthite (15%)	Phase I	58	6.26	1.391± 0.063	0.6591± 0.0369	4.64± 0.04
			120	7.16	1.577± 0.100	0.6642± 0.0537	4.65± 0.06
		Phase II	10b	3.42	0.976± 0.071	0.6462± 0.0535	4.62± 0.06
			52	4.53	0.755± 0.106	0.6176± 0.0944	4.55± 0.10
			105	7.51	1.607± 0.062	0.6088± 0.0308	4.53± 0.04
20B-A	Ti-fassaite (50%) Melilite (30%) Spinel (10%) Anorthite (10%)	Phase III (Thorianite)	1	7.70	1.953± 0.169 1.739± 0.094	0.6396± 0.0729 0.6351± 0.0450	4.60± 0.08 4.59± 0.05
		Average	–	–	–	–	4.60± 0.09

Notes: (a) All uncertainties are quoted ± 2 standard deviations and are calculated from counting statistics.

(b) $^{207}Pb/^{206}Pb$ ages calculated using constants in (7) and uncertainties quoted are ± 2 standard deviations.

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