

treated for a minimum of 200 hours at 450°C (723°K) and then air-cooled.

Since appreciable amounts of magnesium were lost during sample preparation it was necessary to analyze some of the specimens chemically to determine their compositions. The seven compositions given in figure 2 are based on chemical analysis.

Table I: Chemical analysis of cerium

Impurity	(w/o)	(a/o)
hydrogen	0.016	2.18
carbon	0.007	0.08
nitrogen	<0.001	<0.01
oxygen	0.008 ± 0.002	0.07 ± 0.02
magnesium	0.05	0.29
manganese	0.05	0.13
copper	0.001	0.02
lanthanum	0.05	0.05
cerium <sup>a</sup>	99.82	97.17

<sup>a</sup> Cerium content by difference.

The compositions of the other six specimens, which contained less than 6 a/o magnesium, were estimated from the lattice parameter-versus-composition curve (figure 2) in the single-phase  $\gamma$ -Ce region (this point is discussed later).

Filings taken from the sides of the heat-treated cylindrical specimens were sealed within evacuated capillary tubes and were further heat treated to remove any cold work. This second heat treatment consisted of holding the samples at 450° ± 10°C (723° ± 10°K) for 10 or 15 minutes and then quenching them in water. A 114.6 mm diameter Debye-Scherrer camera and Cu K<sub>α</sub> radiation were used in obtaining the X-ray powder patterns. The lattice constants were determined from the back reflection region doublets by using a  $\Phi \tan \Phi$  extrapolation method.<sup>8</sup>

The low-temperature dilatometric techniques<sup>9</sup> and the interpretation of the dilatometric-versus-temperature curves<sup>10</sup> are described elsewhere.

## RESULTS AND DISCUSSION

### X-ray data

*Pure Cerium.* The lattice parameter of the cerium stock used in this investigation is shown in Table II. Also shown in Table II are the data for two different cerium stocks used in previous studies.<sup>1,6,10,11</sup> It is interesting to note that there is essentially no

Table II: A Comparison of Some of the Properties of the Various Cerium Stocks Used in This and Previous Studies

Property	USBM-Ce <sup>10</sup>	This Study	CMC-Ce <sup>10,11</sup>
γ-Ce purity (a/o)	99.53	97.17	96.41
γ-Ce purity (w/o)	99.94	99.82	99.54
γ-Ce lattice constant (Å)	5.1601 ± 2 <sup>a</sup>	5.1602 ± 2 <sup>a</sup>	5.1599 ± 3 <sup>a</sup>
α-γ intermediate phase lattice constant (Å)	5.1233 ± 5 <sup>a</sup>	N.F. <sup>b</sup>	N.F. <sup>b</sup>
γ → α trans. temp. (°K)	116.3 ± 4.3	111 ± 2	106.4 ± 4.6
α → γ trans. temp. (°K)	178.7 ± 4.2	179 ± 1	174.2 ± 3.8
γ → α trans. length change (per cent)	3.40 ± 0.04	3.50	3.67 ± 0.20

<sup>a</sup> The shorthand notation is used here: 5.1601 ± 2 means 5.1601 ± 0.0002.

<sup>b</sup> N.F. means this phase was not found.

difference in the lattice constants for these three materials, even though the total impurity contents vary quite widely. This is in contrast with the  $\gamma \rightarrow \alpha$  transformation temperature and length change which are quite different for the three specimens.

*α-γ Intermediate Phase.* Gschneidner and co-workers<sup>10</sup> found a new face-centered cubic phase,  $a_0 = 5.1233\text{Å}$ , for cerium in a very high purity cerium specimen (see Table II, USBM-Ce), but were unable to observe this phase in a much less pure cerium sample (see Table II, CMC-Ce). Since the lattice parameter of this new phase lies between that of  $\gamma$ -Ce,  $a_0 = 5.1601$ , and  $\alpha$ -Ce,  $a = 4.85$ , they called it the "α-γ intermediate phase." The cerium stock used in this study, which has a purity intermediate between those used earlier, was examined to see if the α-γ intermediate