



Fig. 1. Amplitude of the semi-annual variation in upper atmosphere density between 1958 and 1968, expressed in terms of the departure  $\Delta T$  of temperature from mean values given by Jacchia's model atmosphere. Values for 1958 to April 1966 are from ref. 1. Values for 1966 July and October are from ref. 5. Values for 1967 and 1968 are from ref. 6. Scale on right-hand side gives departure of density  $\rho$  at 500 km height from mean value  $\bar{\rho}$  (for  $\Delta T$  positive).

more striking feature is the periodicity apparent in  $\Delta T$ , the average period being  $2.72 \pm 0.15$  yr. The variations in the time intervals between successive peaks are not significant, because the points are at intervals of 3 months and the peaks are therefore subject to time errors of  $\pm 3$  months.

It should be emphasized that the 33-month periodicity apparent in Fig. 1 refers to the values after correction for solar activity. The variations dependent on solar activity, analysed by Jacchia, Slowey and Campbell<sup>1</sup>, will still be dominant in some years, and the 33-month periodicity can be regarded as being superposed on the 10 or 11 yr periodicity dependent on the sunspot cycle.

The 33-month periodicity may be related to what is often called the "26-month oscillation" in zonal stratospheric winds. At the 50 mbar level, a height of approximately 20 km, this variation in stratospheric winds<sup>9</sup> had an average period of about 30 months between 1961 and 1967, and the last three maxima have been in mid-1964, January 1966 and mid-1967 (private communication from J. S. Sawyer and R. A. Ebdon), in good agreement with the dates of the last three extrema in Fig. 1. If this correlation proves to be valid, it may provide an interesting link between the upper and lower atmosphere.

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Received July 12, 1968.

<sup>1</sup> Jacchia, L. G., Slowey, J. W., and Campbell, I. G., *Smithsonian Astrophysical Observatory Spec. Rep.*, 265 (1968).

<sup>2</sup> Cook, G. E., and Scott, D. W., *RAE Tech. Rep.*, 68162 (1968).

<sup>3</sup> King-Hele, D. G., and Hingston, J., *Planet. Space Sci.*, 16, 675 (1968).

<sup>4</sup> King-Hele, D. G., *Nature*, 217, 833 (1968).

<sup>5</sup> Cook, G. E., *RAE Tech. Rep.*, 68063 (1968); *Planet. Space Sci.* (in the press).

<sup>6</sup> King-Hele, D. G., and Walker, D. M. C., *RAE Tech. Rep.*, 68184 (1968).

<sup>7</sup> Jacchia, L. G., *Smithsonian Astrophysical Observatory Spec. Rep.*, 170 (1964).

<sup>8</sup> Cook, G. E., *Planet. Space Sci.*, 15, 627 (1967).

<sup>9</sup> Ebdon, R. A., *Weather*, 22, 245 (1967).

Pakistan. This work supports my conclusions from investigations in East Africa<sup>2</sup> in which I concluded that lanthanum was a critically significant element in carbonatites. Trace element analysis has now reached a stage where one or two elements can be shown to be diagnostic for carbonatites and there is now no doubt that lanthanum and cerium are probably the most significant elements in distinguishing carbonatites from limestones. I consider, however, that it is unnecessary to determine other elements such as strontium, barium, yttrium and niobium during routine investigations for the following reasons.

Strontium and barium serve no useful purpose; earlier ideas that the Sr/Ba ratio was diagnostic of carbonatites are now considered invalid.

Yttrium is undoubtedly low in most carbonatites. More recent evidence from rare earth distribution patterns<sup>3</sup> has shown that carbonatites are characterized by a marked concentration of the cerium subgroup indicating that elements similar in ionic size to yttrium are not normally abundant.

Niobium was shown to be of little value during an investigation of some East African carbonatites<sup>2</sup>. Despite this and other studies some workers continue to defend the use of this element<sup>4,5</sup>. The presence of niobium only shows that the carbonatite is mineralized. Low niobium concentration does not mean that the carbonate rock is not a carbonatite, any more than absence of tin prevents a non-stanniferous granite from being considered to be a granite.

The recent data presented by Deans and Powell support these conclusions. The isotopic distribution of boron in kimberlites<sup>5</sup> is sufficiently diagnostic to indicate that the boron distribution in kimberlite-carbonatite associations should be thoroughly investigated.

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Received July 9, 1968.

<sup>1</sup> Deans, T., and Powell, J. L., *Nature*, 218, 750 (1968).

<sup>2</sup> Bowden, P., *Nature*, 196, 570 (1962).

<sup>3</sup> Schofield, A., and Haskin, L., *Geochim. Cosmochim. Acta*, 28, 437 (1964).

<sup>4</sup> Gold, D. P., *Min. Soc. India IMA Volume*, 83 (1966).

<sup>5</sup> Heinrich, E. W., *The Geology of Carbonatites*, 229 (Rand McNally and Co., Chicago, 1966).

<sup>6</sup> Cherepanov, V. A., *Doklady Earth Sci. Sec.*, 173, 187 (1967).

## Trace Elements in Carbonatites and Limestones

THE recent article by Deans and Powell<sup>1</sup> has demonstrated that few selected trace elements can be used to distinguish carbonatites from limestones in India and