with satellite observations of comparable accuracy it should be possible to obtain meteorologically usable atmospheric temperature profiles. The U.S. Weather Bureau on the basis of these results has undertaken continued development of the instrument for a satellite experiment.

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GEOLOGY

Age Determinations on Three African Carbonatites

Carbonatites have been a normal part of the magmatic history of east, central and southern Africa over a long period of geological time. They range in age from those associated with Tertiary volcanoes of the Elgon group to the pre-Karroo carbonatites of Spitzkop and Loolekop in the north-eastern Transvaal. The salient features of most of the known African carbonatites have been summarized by Campbell Smith[1].

Table 1. Potassium–Argon Age Determinations

Nature and location of sample	K (%)	Radiogenic ^{40}Ar	Age (m.yr.)
Mbeya	6·51	0·054 p.p.m.	113 ± 6
Kangankunde	7·59	0·069 p.p.m.	123 ± 6
Nkumbwa Hill	7·94	0·460 p.p.m.	680 ± 25

Decay constants: $\lambda\beta$ $4{\cdot}72 \times 10^{-10}$ yr.$^{-1}$. $\lambda_e = 0{\cdot}584 \times 10^{-10}$ yr.$^{-1}$. Isotopic abundance of $^{40}K = 0{\cdot}0119$ atom per cent.

This communication gives the results of three K–Ar age determinations on micas from the carbonatites of Panda Hill (Mbeya, Tanganyika), Kangankunde (Chilwa Series, Nyasaland), and Nkumbwa Hill (Northern Rhodesia).

Mica concentrates were prepared using magnetic methods of separation so far as possible. Potassium was determined with an Eel flame photometer; argon was determined by isotope dilution using a 4¼ in. radius, 60° Reynolds-type glass mass spectrometer. The argon was extracted by fusion of the mica sample in a glass vacuum system attached directly to the mass spectrometer. The calculated ages are believed to have an uncertainty of no more than ± 4 per cent (95 per cent confidence level).

The Mbeya carbonatite. Originally called the Panda Hill pyrochlore deposit, this carbonatite is 13 miles W.S.W. of Mbeya, near the south-west border of Tanganyika. It has been described in detail by Fawley and James[2]. The complex consists of a central plug and steeply inward-dipping outer ring of carbonatite and includes tuffs and agglomerates and an explosion-vent breccia; it also has a pyrochlore-rich zone with the form of an incomplete ring dyke. Much of the structure has been complicated by metasomatic and tectonic activity.

The carbonatite is overlain by Cretaceous sediments, and in the nearby Songwe River valley Karroo sediments are brecciated by minor explosive vents thought to be of the same age as the Panda Hill volcanicity. Thus, geological evidence indicated a Jurassic or Cretaceous age. The K–Ar age determination gives an age of 113 million years, which in terms of present estimates of the geological time scale corresponds to the Cenomanian stage at the base of the Upper Cretaceous (Table 1).

Age determinations have also been made by the uranium–lead method on two samples of pyrochlore from this carbonatite complex by Schurmann *et al.*[3]. The ages as calculated are discordant and range from 68 to 273 m.yr. However, it is impossible to tell from Schurmann's results whether the discordance reflects chemical alteration or is due to the use of the wrong isotope ratios when correcting for common lead contamination. Fortunately, since two samples have been analysed which can safely be assumed to be of the same age, and were in all probability contaminated by common lead having the same isotopic composition, it is possible to calculate ages independent of any assumptions regarding the isotopic composition of the common lead component. These ages are listed in Table 2 and are still discordant. Thus, it must be assumed that one or both of these pyrochlores have suffered chemical alteration and no other geological significance can be attached to these results.

The Kangankunde carbonatite. Kangankunde Hill, formed by an erosion-resistant carbonatite complex, is 50 miles west of Lake Chilwa in the Lower Shire area of southern Nyasaland. This ankeritic carbonatite complex is a member of the Chilwa Series (Dixey *et al.*[4]). The Chilwa Series comprises a group of vents, pipe-like in form, infilled by carbonatite and/or feldspathic breccia; syenite and nepheline–syenite intrusions; and a varied suite of minor intrusions, mainly in the form of dykes. The largest of these vents, namely, Muambe, intersects Karroo sediments and is in part overlain by the Lupata sediments and volcanics of Cretaceous age. The K–Ar age as determined on a phlogopite corresponds to the Albian stage of the Lower Cretaceous.

The Nkumbwa Hill carbonatite. This complex forms a hill of limestone rising more than 1,000 ft. above the surrounding country in the Isoka district of Northern Rhodesia (Reeve and Deans[5]). The carbonatite cuts biotite-gneisses of unknown age. The K–Ar age determination on phlogopite from adjacent metasomatized country rocks indicates a late Precambrian time of emplacement.

Table 2. Uranium–Lead Age Determinations, Mbeya Carbonatite

Sample	%U	%Th	%Pb	^{204}Pb	^{206}Pb	^{207}Pb	^{208}Pb	$t_{\frac{206}{238}U}$	$t_{\frac{207}{235}U}$	$\frac{^{208}Pb}{^{232}Th}$
Pyrochlore, Museum Zone	0·022	1·60	0·081	1·17	21·83	18·32	58·68	73 m.y.	147 m.y.	185 m.y.
Pyrochlore, Chloritic Zone	0·311	0·71	0·099	1·27	26·47	20·17	52·09			

Decay constants: $^{238}U = 1{\cdot}5369 \times 10^{-10}$ yr.$^{-1}$; $^{235}U = 9{\cdot}7216 \times 10^{-10}$ yr.$^{-1}$; $^{232}Th = 4{\cdot}8813 \times 10^{-11}$ yr.$^{-1}$; $^{238}U/^{235}U = 137{\cdot}7$.

Conclusions. Age determinations on the Mbeya and Kangankunde carbonatites give results indicating emplacement during the Cretaceous. Such geological evidence as is available indicates an Upper Jurassic or Lower Cretaceous age. Bearing in mind the experimental errors and the possibility that one or both of the analysed micas may have suffered slight argon loss, it is reasonable to suggest that these complexes are actually of the same age. In contrast, the Nkumbwa Hill carbonatite is much older.

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