large positive shears persist in this layer for the longest duration.

9. Over Nagpur, the winter type of thermal gradient begins to appear in the lower troposphere towards the end of September and extends upwards to 200 mb. level by about the second week of October which is approximately the normal date of withdrawal of monsoon from this area.

10. At Trivandrum, the thermal gradient characteristic of the monsoon circulation begins to weaken by the end of September. By about the middle of November, the winter type of thermal gradients begin to appear in the upper troposphere and become increasingly prominent by the beginning of January. The normal date of withdrawal of monsoon rains from Trivandrum is about the beginning of December. However, it is more difficult to fix this date for Trivandrum than for Nagpur and New Delhi.

11. The main conclusions from the present study are the following :

(*i*) The onset of the monsoon rains at each of the three stations takes place when the meridional thermal gradients have reversed at all tropospheric levels between 200 and 700 mb.

(*ii*) The reversal starts in the upper troposphere about six weeks before the onset of the monsoon rains and progresses downwards, reaching 600 mb. level at about the time of onset of the monsoon rains.

(*iii*) The reversal of thermal gradient in the layer between 700 and 500 mb. takes place last and is almost simultaneous with the onset of the monsoon rains.

(*iv*) The pattern of thermal changes associated with summer-winter transition at Delhi has a broad similarity with the winter-summer transition. The similarity is less at Nagpur, while at Trivandrum there are substantial differences.

1. Sutcliffe R. C. and Bannon, J. K., *Sci. Proc. Int. Ass. Met. IUGG, Rome*, 1954, p. 322.
2. Staff Members, Academia Sinica, *Tellus*, 1958, **10**, 58.
3. Yeh Tu-Cheng, Dao Shih Yen and Li Mei-Ts'un, *The Atmosphere and the Sea in Motion* (Rossby Memorial Volume), Oxford University Press, 1959, p 249.
4. Ananthakrishnan, R. and Krishnan, A., *Curr. Sci.*, 1962, **31**, 133.
5. — and Ramakrishnan, A. R., *Proc. WMO/UNESCO Symp.*, Met. Results of *IIOE*, Bombay, 1965, p. 415.

THE EPARCHAEAN UNCONFORMITY AND THE ARCHAEAN-PURANA BOUNDARY

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THE eparchæan interval in Indian geology is defined as the gap between the Puranas and the Archæans. The Archæans are defined as those rock formations which occur below the eparchæan unconformity. Does the eparchæan unconformity become evident by recognising Archæan and Purana formations or are the Archæans and Puranas recognised by identifying the eparchæan unconformity ? These are questions for which we do not have definite answers.

The vast area of Peninsular India is by and large made up of Precambrian rocks. In these Precambrian provinces we do not have any definite demarcation between the Archæan and Purana rocks. Unlike the breaks that occur higher up in the geological time scale, the eparchæan break does not have the strong support that faunal evidence affords and we are obliged to depend entirely on geological evidence.

The main problem of these two groups of rocks is in their distinction. What are the diagnostic characters of the Archæans and Puranas and what differences are there in these characters which allow us to distinguish them ? The answer is indefinite and vague. We do not have any really diagnostic characters. However, metamorphic grade and intensity of diastrophism have served as a basis for the distinction of these two groups of ancient rocks. The result of this is that almost everything that is metamorphosed has been placed under the Archæan group. A careful consideration of the problem clearly shows that the two criteria are really inadequate and can never be of such importance as to unfailingly serve as a basis of differentiation of these two groups of rocks.

In Indian geology since the creation of the Dharwar system every other system or series in a similar stratigraphic situation was referred

to as Dharwarian although the rocks have their own identity.

This kind of usage was very common in spite of some resentment (West, 1939; Pichamuthu, 1963). Krishnan writes "the term has become so well entrenched in geological nomenclature that it is scarcely possible to discard it" (1956, p. 100).

If we consider the Precambrian provinces of peninsular India it becomes quite apparent that the major groups of rocks which are metamorphosed and structurally very much disturbed are included within the Archæan group, and the succeeding series or systems of rocks which are laid over the earlier with a clear cut erosion unconformity have been placed in the Purana group. In a general way the Puranas are less metamorphosed and less disturbed. (The Delhi system is however an exception). This uncertain basis of classification of rocks into the Archæan and Purana groups results in a number of problems. Certain groups of rocks like the Pakhals, Transition rocks in the Son Valley, Bijawars and many others are examples whose position is doubtful. The fact that any one of these groups of rocks rest over Archæan rocks with an unconformity does not afford ground to place them in the Puranas, for in the Archæans themselves we can have two or more major groups of rocks. In South India we have the Dharwar and Eastern Ghat rocks both belonging to the Archæan group.

We may summarise our understanding that till recently we believed that all Archæans are Dharwars which are followed by the eparchæan unconformity which in its turn is followed by the Purana group of rocks.

In the last two decades isotope ages of rocks have started appearing in Indian geology and this has completely changed our ideas of Precambrian geology. It must however be mentioned that these isotope ages have their own limitations and cannot be entirely relied upon. What have so far been considered as Archæans, range in age from 3000 m.y. to 900 m.y. The Cuddapahs have been thought to be the ideal representatives of the Purana group. The basic rocks in the lower Cuddapahs along the western margin of the Cuddapah basin have given (K-Ar ages) 1160 m.y. (Aswathanarayana, 1964).

These ages are probably much higher than what one would expect for the Cuddapahs, and are well within the range of the Archæans. The Delhi system of Rajasthan which is considered by Heron as the equivalent of the Cuddapahs dates 735 m.y. to 800 m.y. We can no longer consider the Delhis as the time equivalents of the Cuddapahs. The isotope age data also prove that all Archæan rocks are not the equivalents of Dharwars. It would be useful to tabulate these rocks in their geochronological order and see what we can gather from it.

TABLE I

1.	Vindhyans ..	1160 m.y. (?)	1.	Mathur, 1964, Vinogradov *et al.*, 1964
2.	Sausar-Satpura Gaya-Ranchi-Muri-Aravalli (?)	950 ,,		(Aravallis =1500 m.y. Vinogradov *et al.*, 1964)
			2	Sarkar *et al.*, 1964
3.	Sakoli ..	1335 ,,	3.	do.
4.	Amgaon ..	1434 ,,	4.	do.
		1630 ,,		
5.	Eastern Ghats ..	1600 ,,	5.	Aswathanarayana, 1964
6*a*.	Iron Ore Orogeny		6*a*.	Sarkar *et al.*, 1964
6*b*.	Upper Dharwar ..	2000 ,,	6*b*.	Aswathanarayana, 1967
7.	Middle Dharwar ..	2600 ,,	7.	do.
8.	Lower Dharwar ..	2900 ,,	8.	do.
9.	Older metamorphics ..	>3000 ,,	9.	Sarkar *et al.*, 1964

The dates given in Table I are those of the orogenies except in the case of the Cuddapahs and Vindhyans where they are the ages of sedimentation.

From Table I it seems that orogeny is repeating itself rhythmically. There does not seem to exist any common time gap for all regions which can be likened to that of the eparchæan interval. Further it also touches upon the controversial point whether orogeny and epeirogeny are episodic or continuous. From the spread of events recorded in Table I it appears more likely that orogeny is perhaps continuous. This continuous character is possibly obscured by the fact that this hypothesis is being examined on a limited scale.

The base of the Cambrian is estimated at around 600 m.y. The pre-Cambian is naturally anything over 600 m.y. The division of this long span of time (> 3000–600 m.y.) into Archæas and Proterozoic is convenient and necessary. If so where should we draw the demarcation line? If we agree that orogeny and epeirogeny are continuous then the demarcation line is arbitrary and we can perhaps adopt a scheme like the one given below where the divisions are more or less equal and also mark the end of some important orogenies in India.

	Cambrian	600 m.y.
Purana = Proterozoic	Upper	1,000 m.y.
	Lower	1,600 m.y.
Archæan	Upper	2,000 m.y.
	Lower	

If on the other hand we accept the premise that orogeny is episodic we can adopt the geochronological divisions arrived at by Voitkevich* on the basis of isotope ages from the Baltic, Ukranian and from the African, Indian and Australian shields. The boundaries are at 2650 ± 150 m.y.; 1800 ± 90 m.y.; 1030 ± 50; 550 ± 10 m.y. Stockwell* finds good support for the above divisions from the Canadian shield ages. Vinogradov and Tugarinov* propose > 2700 m.y. ± 150, Kata Archæan; 1900 ± 100 m.y. to 2700 ± 150 m.y. Archæan; 1100 ± 100 m.y. to 1900 ± 100 m.y. Lower proterozoic; 600 ± 50 m.y. to 1100 ±100 m.y. Upper proterozoic. These divisions are not much different from what Voitkevich proposed and any one of them should be quite adequate.

Stockwell (1964) following the 'American commission on Stratigraphic Nomenclature' pleads that the actual rock of a type area be used as the basis of a definition of a unit rather than isotope dates. He illustrates this by discussing the Precambrian structural provinces of Canada. It must be confessed that it is rather very doubtful whether such a scheme can be useful in building up the geochronological divisions in India.

The present need is the recognition of the subdivisions of the pre-Cambrian period and it does not very much matter which scheme is adopted. The subdivision of the pre-Cambrian period will enable us more precisely to state the horizon of the Archæan formations. The fallacy of equating an unknown with another unknown could thus be easily avoided.

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* These references are drawn from Prof. J. Sutton's paper in *Nature*, 1963.

1. Aswathanarayana, U., *Brochure, XXII Intern. Geol. Congr.*, New Delhi, 1964.
2. Krishnan, M. S, *Geology of India and Burma*, 1956.
3. Mathur, S M., *Ind. Minls.*, 1964, **18, 2**, 158.
4. Pichamuthu, C. S., *Jour. Geol. Soc, Ind.*, 1963, **4**, 79.
5. Sarkar, S. N., Polkanov, A. A., Gerling E. K. and Chukrov, F. V., *Sci. & Cult.*, 1964, **30**, 527.
6. Stockwell, C. H., In *Geochronology of Canada*, 1964, p. 52.
7. Sutton, J., *Nature*, 1963, **198**, 731.
8. Vinogradov, A. and Tugarinov, A., *XXII Intern. Geol. Congrs.*, New Delhi, 1964 (In press).
9. West, W. D., *Curr. Sci.*, 1939, **3**, 138.

MYCOFLORA OF THE ROOT REGION*

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THE root region comprises the most active zone of microhabitats in the heterogeneous soil structure. Some generalizations regarding the numerical and physical stimulation of micro-organisms in the root region have been feasible[1]; but little information is available on the initiation of rhizosphere effect on soil fungi, nor has qualitative studies on rhizosphere fungi been possible on account of limitations in techniques. The need for newer and improved techniques has been repeatedly emphasized.[1-3] Apart from the tedium of examining the slides, the difficulty of identifying the fungi present limit the usefulness of the direct observation techniques[4-10]; it is pointed out that the micro-environment itself gets perceptibly alltered,[11,12] *in situ* studies employing these methods. In the case of isolation methods[8,13-15] aside from other limitations ill

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