AGE LEVELS OF ARCHAEAN STRUCTURAL PROVINCES

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FERMOR[1] chose the association of certain parts of Archæans with characteristic groups of sediments as a major criterion for the correlation of ancient schistose formations of Peninsular Archæans. In contradistinction to this approach, Krishnan[2] and Holmes[3,4] tried to arrive at the relative ages of the orogenies which had produced the characteristic regional strikes of the structural provinces of the Archæans (N.E.-S.W. for Aravallis, N.N.W.-S.S.E. for Dharwars, N.E.-S.W. for Eastern Ghats and E.N.E.-W.S.W. for Satpuras).

With the objective of dating the pegmatitic cycles of these provinces, detailed investigations were undertaken on five radioactive minerals drawn from various parts of Peninsular India—namely, Samarskite from Nellore (Andhra State), monazite from Mewar (Rajputana), and allanites from Madura (Madras State), Purulia (Bihar) and Anakapalle (Andhra State). Their physical and optical characters, autoradiographic pattern and chemical composition were studied to examine their suitability for purposes of age determination. While Samarskite has been found to be highly suitable,[5] allanites from Purulia and Anakapalle are fairly so but allanite from Madura[6] and monazite from Mewar are undependable as age indicators, as they have suffered leaching. The age data on the three suitable radioactive minerals determined by the lead-uranium-thorium method together with some recent Alpha-Helium and Rubidium-Strontium ages are given below:

magnitude of variations in the age data available. Holmes[3,4] has dated the Satpura (955 ± 40 M.Y.) and Delhi (735 ± 5 M.Y.) cycles and has recently given an age of $2,300 \pm 100$ M.Y. to the Yediyoor monazite belonging to the Dharwar cycle and $1,570 \pm 70$ M.Y. to detrital monazite from Cuttack District of Orissa (personal communication). All the four ages given above are highly dependable, being based on the isotopic analysis of lead. It therefore follows that the Eastern Ghats cycle is younger than the Dharwarian and older than those of Satpura and Delhi.

The age of the Travancore phlogopite ($1,630 \pm 200$ M.Y.) which occurs in the pyroxenite dykes is interesting. The occurrence of the mineral in the junction zone of Dharwar and Eastern Ghats strikes and the general strike of the associated charnockites and leptynites (N.N.W.-S.S.E)[11] have rendered it difficult to place the mineral in either Dharwarian or Eastern Ghats structural province. As the phlogopite from Visakhapatnam belonging to undoubted Eastern Ghats province has given an age of $1,490 \pm 200$ M.Y. and in view of the fact that the strike of the formations associated with the Travancore phlogopite is more closely related to Dharwarian rather than that of the Eastern Ghats, it is suggested that the phlogopite may belong to the Dharwar cycle.

The quartz-magnetite rocks of Ongole and Salem belong respectively to Madras-Ongole Province (No. 12) and Salem-Arcot Province (No. 11) of Fermor.[1] Both of them belong to the iron-ore province of the charnockitic region[1] and both are characterised by the Eastern Ghats trend.[2] The remarkable similarity in their Alpha-Helium ages (1,350 M.Y.), though not dependable enough for dating the Eastern Ghats cycle precisely because of the loss of helium which may occur in ancient minerals,

No	Name of the cycle	Name of the mineral dated	Locality of the mineral	Method of age determination	Age (in M.Y.)	Degree of dependability
1	Dharwar	Magnetite	Holenarsipur, Mysore	Alpha–Helium	1740	Satisfactory
2	do (?)	Phlogopite	Neyyur, Travancore	Rb–Sr	1630 ± 200[7]	do
3	Eastern Ghats	Samarskite	Nellore, Andhra	Pb–U–Th	1625 ± 75	Good
4	do	Allanite	Anakapalle, Andhra	do	1585	do
5	do	Magnetite	Mayurbhanj, Orissa	Alpha–Helium	1200	Satisfactory
6	do	do	Ongole, Andhra	do	1350	do
7	do	do	Salem, Madras	do	1350	do
8	do	Phlogopite	Visakhapatnam, Andhra	Rb–Sr	1490 ± 200[7]	do
9	Satpura	Allanite	Purulia, Bihar	Pb–U–Th	880	do
10	do	do	Bahea, Bihar	do	880[8]	do
11	do	Monazite	Pichchli, Bihar	do	970[9]	Good
12	do	Magnetite	Singhbhum, Bihar	Alpha–Helium	970	Satisfactory

In the above table, the apparent lead ages are read from the family of curves given by Wickman.[10] The ages termed "good" are dependable and those termed "satisfactory" are of the expected order of magnitude.

The Eastern Ghats cycle is given an age of $1,625 \pm 75$ M.Y. taking into consideration the

is capable of suggesting that the iron ores of Ongole and Salem were deposited contemporaneously.

The similarity in the age-levels of Anakapalle (1,585 M.Y.) and Nellore pegmatites (1,625 ± 75 M.Y.) which are intrusive into khondalites and mica-schists respectively constitutes additional evidence in favour of the surmise[12] that the Nellore mica belt is a continuation of the khondalitic zone. The allanite-bearing pegmatites of Anakapalle and monazite-bearing pegmatites of Cuttack (which have yielded detrital monazite) are both intrusive into khondalites of Eastern Ghats and significantly enough, the apparent lead age of the former (1,585 M.Y.) is of the same order as the Pb_{207}/Pb_{206} age (1,570 ± 70 M.Y.) of the detrital monazite (207/206 age alone is dependable in the case of detrital radioactive minerals). Thus the radioactivity age data, besides indicating the continuation of the Eastern Ghats from parts of Orissa down to Nellore and beyond, also suggests that the pegmatitic display which marks the closing stages of the Eastern Ghats orogeny is contemporaneous in the various parts of Eastern Ghats.

The conclusions drawn on the age-levels of Archæan orogenic cycles on the basis of the radioactivity age data are fully supported by the structural evidence. Krishnan[2] suggests that (*i*) the Dharwarian trend is a continuation of that of Aravallis; (*ii*) the Eastern Ghats trend is younger than the Dharwarian as it is superposed on the latter; (*iii*) the Satpura trend is younger than that of Eastern Ghats as is evident from their interrelationships in Gangpur State

A tentative chronological succession of Peninsular Archæans, based on the available radioactive and structural data, is given below Besides ages based on mass analytical data, crude ages of Satpura (885 M.Y.)[4] and Dharwar (1,850 M.Y.)[13] cycles are also given to facilitate comparison with the crude age (ca) of Eastern Ghats cycle:

955 ± 40 M.Y (Ca 885 M.Y.[4])
Satpura cycle.

Ca 1,625 ± 75 M.Y.
Eastern Ghats cycle.

2,300 ± 100 M.Y (Ca 1,850 M.Y.[13]).
Dharwar cycle (= Aravalli cycle?).

The extent of time-lag between the three cycles indicates that the succession is incomplete.

The recent advances in the field of measurement of geologic time by radioactivity methods have greatly facilitated the bringing together of the two distinct, but nevertheless, mutually related approaches, *i.e.*, correlation of rock formations and dating of orogenic cycles, referred to at the outset. The K_{40}/A_{40}, K_{40}/Ca_{40} methods[14] of dating potassium-bearing rocks, lead method[15] for determining the ages of accessory zircons in the acid and intermediate rocks and Rb-Sr method[16] for dating accessory biotite in rocks have now made possible, the estimation of the ages of the rock formations directly, thus facilitating correlation in the sense of Fermor.[1] All these methods together with the modern Pb-210 method[17] can be used to date the pegmatitic minerals and from them the orogenic cycles, in the sense of Krishnan[2] and Holmes[3,4] It is pointed out that the two sets of data are directly comparable as they have been arrived at by the application of similar methods. Work is in progress on these lines.

A detailed paper will be shortly published elsewhere

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