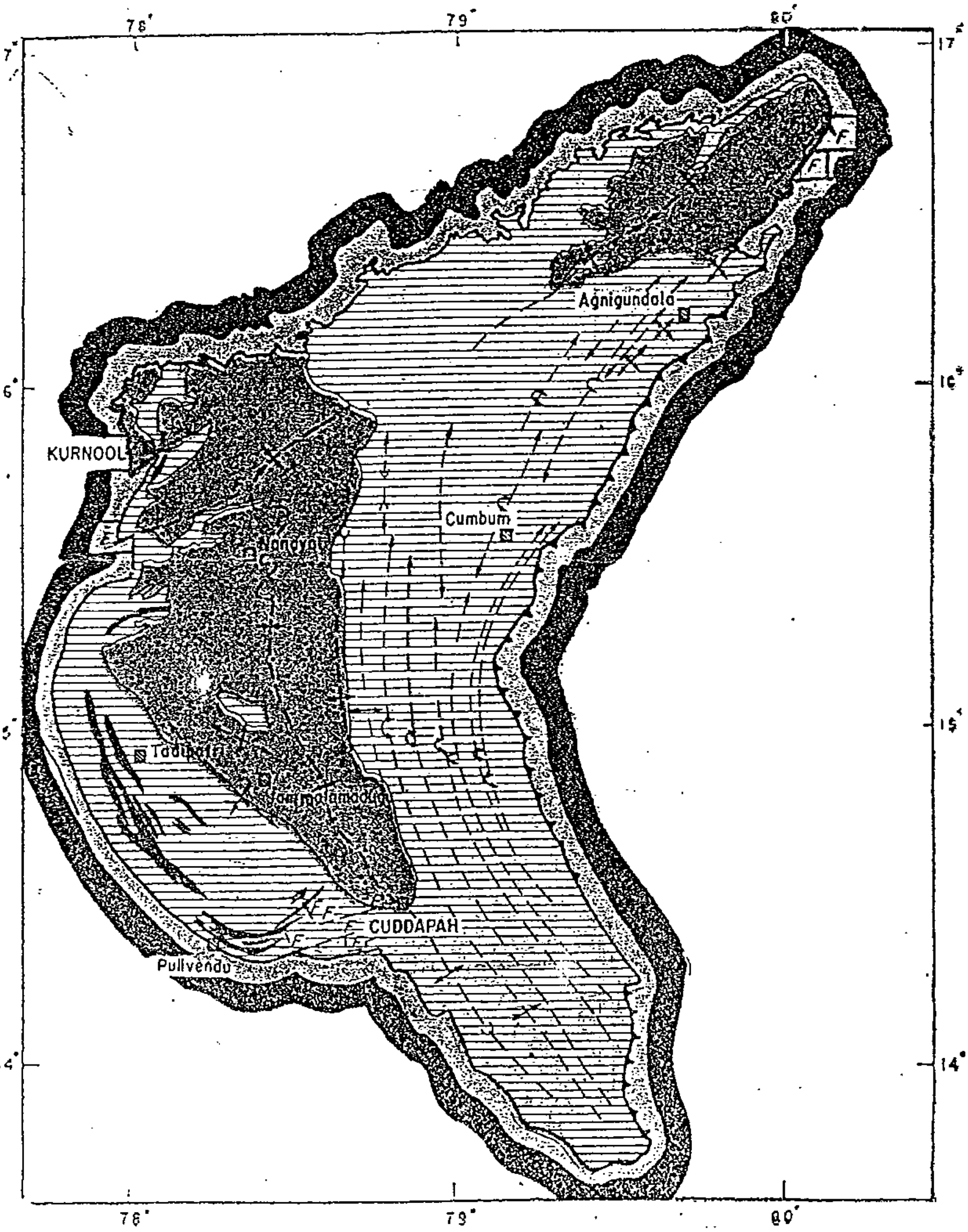
Monograph-2

on

EVOLUTION OF THE INTRACRATONIC CUDDAPAH BASIN

SOUTH INDIA



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Preface

A monograph on evolution of Cuddapah Basin was brought out in 1981 highlighting some of the recent investigations conducted in the Basin and also some of the unsolved problems regarding the evolutionary history of this Basin. In this second monograph an attempt has been made to review the work that has been done during the year 1981 and the same was reported in the 5th Workshop on Status, Problems and Programmes in Cuddapah Basin held in January, 1982. The papers presented in this workshop cover a wide range of subjects and update the information. A series of monographs are now planned jointly with the National Science Foundation, USA, and the Institute of Indian Peninsular Geology.

We wish to thank the National Science Foundation for their generous financial assistance in publishing this volume. We also wish to thank the National Geophysical Research Institute for giving aid in conducting the post-workshop excursions. The financial assistance given by the UNESCO and COSTED for bringing delegates from outside the country to participate in the workshop is gratefully acknowledged. The assistance given by the Andhra Pradesh Akademi of Sciences and the Government of Andhra Pradesh is also gratefully acknowledged. The conduct of this workshop was possible because of the assistance given by various organisations and the publication is mainly due to the financial assistance given by the National Science Foundation (USA).

It is earnestly hoped that the monographs in future will highlight the results of investigations carried out by International Scientists in this intracratonic Cuddapah Basin.

December 31, 1982.

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PRELIMINARY PALAEOMAGNETIC RESULTS FROM THE CUDDAPAH TRAPS OF ANDHRA PRADESH

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ABSTRACT

A total of 48 oriented block samples of dolerite sills and flows and 13 samples of baked country rock were collected at 23 sites in the Vempalle and Tadpatri formations of the Lower Cuddapahs. Stepwise thermal demagnetisation of igneous samples has isolated characteristic magnetisation components in samples from six sites. Both polarities of magnetisation are represented. The mean magnetisation direction after structural correction is (299°,-6°), a_{95}=16.3°, in good agreement with the reported directions from a ferruginous sandstone and a baked shale in the Tadapatri formation (Prasad and Damodāra Reddy, 1972). The palaeomagnetic pole position corresponding to this mean direction is 337°E, 27°N.

INTRODUCTION

Precambrian palaeomagnetism is afflicted by difficulties, the most important of which are:

(*i*) Uncertainty regarding the age of formation of the rock, the isotopic age and the age of magnetisation, which may all be different. In addition the age of folding events which can constrain the age of magnetisation may be poorly known

(*ii*) Multicomponent magnetisations reflecting complex geological histories In many cases different components of magnetisation have highly overlapped coer civity and/or blocking temperature spectra, hampering resolution of the components

(*iii*) The inherent polarity ambiguity of palaeomagnetic data. Substantial gaps in the palaeomagnetic or geochronological records, which are prevalent in the Precambrian, hamper reliable determination of apparent polar wander paths.

It is clear from these points that progress in interpretation of Precambrian palaeomagnetism is contingent on acquisition of high quality data with reliable age control (stratigraphic or geochronological) and definitive field tests of the primary nature of magnetisations.

SAMPLING AND FIELD PROCEDURE

Dolerite sill and flow and baked sediment samples were collected throughout the SW Cuddapah basin in order to obtain sufficient spread of bedding attitudes to

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enable a fold test. A variety of compositions and textures are represented in the samples from the dolerite sills and flows. The baked sediments are limestones, dolomites and shales.

Wherever possible samples were oriented using a sun compass as well as a magnetic compass. At a number of sites the sampled rocks were intensely magnetised and local declination anomalies up to 40° were observed. This demonstrates that use of a sun compass is essential for accurate orientation in this area.

LABORATORY PROCEDURE

Cores were drilled out of the block samples and sliced into a number of small cylindrical specimens for measurement on a Digico spinner rock magnetometer. One or two pilot specimens from each igneous sample were selected for alternating field (AF) demagnetisation, and similarly for thermal demagnetisation. The NRM intensities of the sediment samples were low and these samples are being reserved for measurement on a highly sensitive cryogenic magnetometer.

The results were plotted in the form of orthogonal projections (Zijderveld, 1967). Magnetisation components were recognised using principal component analysis (Kirschvink, 1980).

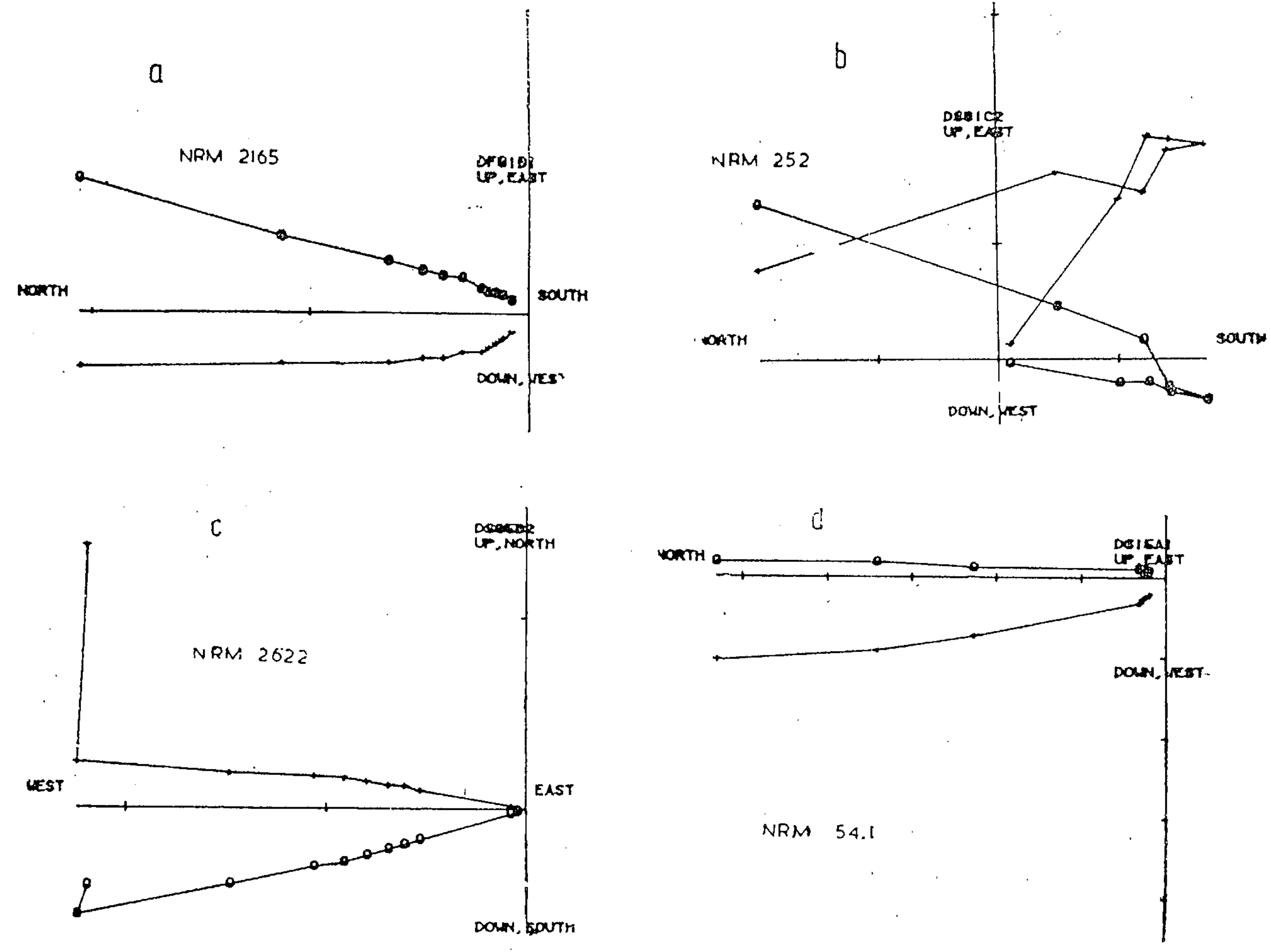
RESULTS

The NRM directions of the dolerite samples exhibit considerable scatter both within and between sites. In some cases very high NRM intensities ($>$10,000μG) and within-site scatter suggest the rocks may have been struck by lightning. AF demagnetisation has been only partially successful in removing intense but soft secondary components. At some sites the rocks may have been effectively remagnetised by very close lightning strokes. However, even where the effects of lightning are not so severe, thermal cleaning indicates the presence of at least two components of magnetisation which apparently have significantly overlapped coercivity spectra. This implies that AF cleaning is not particularly useful for defining a primary component in the majority of these samples.

Thermal demagnetisation, on the other hand, has successfully isolated stable characteristic magnetisations in samples from six sites. An overprint magnetisation directed northerly with negative inclination is consistently removed during demagnetisation up to 350-400°C. For the most stable component both polarities are found, although not within a single sill or flow. This magnetisation is directed NW with shallow negative inclination, or SE with shallow positive inclination.

Typical orthogonal projection plots are shown in Figure 1. All the plots exhibit two well-defined linear segments with the overprint magnetisation being demagnetised below 400°C, and a stable component which in 1(a), 1(c) and 1(d) is NW directed and in 1(b) is SE directed.

Fig. 1. Orthogonal projections of magnetisation vectors obtained during stepwise thermal demagnetisation of selected specimens from dolerite sills and flows, following the method outlined by Zijderveld (1967). Steps shown are NRM, 200°, 300°, 350°, 400°, 450°, 500°, 530°, 550°, 570°, 580° up to the point where the magnetisation becomes unstable. Crosses (circles) refer to the horizontal (vertical) plane. Directions are with respect to the present horizontal. After structural correction the shallow positive inclination indicated in (c) becomes shallow negative, in agreement with (a) and (d). The most stable component in 1(b) is reversed with respect to (a), (c) and (d). NRM intensities are given in μG.


a
NRM 2165
UP, EAST
NORTH
SOUTH
DOWN, WEST
b
UP, EAST
NRM 252
NORTH
SOUTH
DOWN, WEST
c
UP, NORTH
NRM 2622
WEST
EAST
DOWN, SOUTH
d
NORTH
UP, EAST
DOWN, WEST
NRM 54.1

DISCUSSION

Because the characteristic magnetisation components are found in widely separated sites with different bedding attitudes the possibility of a fold test presents itself. The sites are located in NW-, NE-, E- and S-dipping sills or flows, but the bedding dips are only about 15°. Therefore very good data or a large number of samples are required for a definitive fold test. When the observed stable directions are corrected to the palaeohorizontal the mean direction from the six sites is practically unaltered, but there is a slight decrease in scatter with k, the estimate of the Fisherian precision parameter, increasing from 14.9 to 17.8. When the rigorous form of the fold test, based on fold limbs (McFadden and Jones, 1981), is carried out the improvement after structural correction is not statistically significant at the 95% confidence level. Therefore more work must be carried out on the collection to define characteristic components in more samples, thereby improving the statistics. It is believed that combined AF and thermal cleaning will improve resolution of the multicomponent magnetisations in some of the samples which are affected by IRM noise. However, it can certainly be said that these preliminary results are consistent with pre-folding, possibly primary, acquisition of remanence.

For the stable component the mean direction after structural correction is (299°, -6°) (N=6, R =5.7195, K=17.8, a_{95}=16.3°). Note that with the present data there is no discernible difference between the sills and flows.

Arguments will now be given for the probable primary nature of the stable component :

(*i*) The dolerites would have acquired a thermoremanent magnetisation during initial cooling. The sills were intruded at very shallow depths (M.N. Rao, pers. comm.) and intrusion is therefore considered penecontemporaneous with sedimentation and with extrusion of flows at similar stratigraphic levels. Given the agreement between samples from widely separated localities local chemical remagnetisation appears unlikely. Any remagnetisation must therefore be a regional phenomenon, but the relatively unmetamorphosed nature of the dolerites and the enclosing sediments argues against such an event.

(*ii*) The observed directions agree well with those from a ferruginous sandstone band and a baked shale adjacent to a dolerite sill in the Tadpatri formation (Prasad and Damodara Reddy, 1972). This provides a consistency test of the stable ancient nature of the magnetisation. By itself this does not prove that the stable component is primary, but in view of (i) the consistency strongly supports interpretation of the magnetisation as primary.

(*iii*) The presence of both polarities constitutes a reversals test of the stable ancient nature of the magnetisation. Antiparallelism of the normal and reversed components establishes that the direction is "pure", i.e. that all less stable components have been successfully removed by cleaning.

It therefore appears that the thermally stable component may be tentatively accepted as primary. Further work should be able to test this definitively on the basis of a fold test and possibly a baked contact test.

The overprint component which is found throughout the area is quite distinct from the present field and present dipole directions, and appears to be Mesozoic in age. It is probably associated with a low grade thermal event. Klootwijk (1979) has noted that an overprint magnetisation contemporaneous with Deccan Trap volcanism is almost ubiquitous in the Indian subcontinent. The overprint direction in the Cuddapah Trap samples closely resembles Deccan Trap directions, suggesting that the thermal event may have been associated with Deccan Trap volcanism. Indeed the Cuddapah Basin may have been covered by Deccan Trap flows which have subsequently been eroded.

CONCLUSIONS

A probable primary magnetisation component has been isolated from the dolerite sills and flows of the Cuddapah Traps. The corresponding palaeomagnetic pole position is 337°E, 27°N. If subsequent work in this laboratory confirms this result, it will represent one of the few reliable poles from the Precambrian of India. An accurate age determination is therefore highly desirable. To this end Nd-Sm dating of the dolerite samples will be carried out by the CSIRO.

ACKNOWLEDGEMENTS

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REFERENCES

Kirschvink, J.L., 1980. The least-squares line and plane and the analysis of palaeomagnetic data. Geophys. J.R. astron. Soc., 62: 699-718.

Klootwijk, C.T., 1979. A review of palaeomagnetic data from the Indo-Pakistani fragment of Gondwanaland *in* Geodynamics of Pakistan, Abdul Farah and Kees A. De Jong (editors) Geological Survey of Pakistan, Quetta.

McFadden, P.L. and Jones, D.L., 1981. The fold test in palaeomagnetism. Geophys J. R. astron. Soc., 67: 53-58.

Prasad, C.V.R.K. and Damodara Reddy, V., 1972. Palaeomagnetism and geological correlation of certain Precambrian formations of Andhra Pradesh. Geol. Soc. India. 13: 160-164.