Geochronological Constraints on Granulite Formation in Southern India: Implications for East Gondwana Reassembly

C. Unnikrishnan-Warrier\(^1\), M. Yoshida\(^1\), H. Kagami\(^2\) and M. Santosh\(^3\)

(With 1 Table and 3 Figures)

Abstract

The granulite grade metamorphic terrains of southern India form an integral part of East Gondwana. The geochronologic data distribution in these terrains show granulite facies events at ca. 2500 Ma, 1000 Ma, and 500 Ma each marking the predominant latest granulite facies metamorphism in the Northern Granulite Segment (NGS), Eastern Ghats Granulite Segment (EGS), and the Southern Granulite Segment (SGS) respectively. These events have traceable counterparts in Sri Lanka and East Antarctica, which form the East Gondwanian assembly with southern India. Thus, the Napier Complex of the Enderby Land in East Antarctica is comparable with the Northern Granulite Segment in South India, because both these segments record sporadic precursory 3000 Ma and older events. The Rayner Complex of the Enderby Land has almost continuous geochronologic sequence from the Late Archean through Early Proterozoic to Pan-African. The EGS and SGS in Peninsular India preserve similar pre-1000 Ma geochronologic record, comparable to the Rayner Complex of Antarctica. The ca. 1000 Ma event is more predominant in EGS while the SGS largely correspond to Pan-African. The radiometric data distribution suggests repeated thermal reworking of once stabilized Archean crust in many segments of East Gondwana.

Key Words: Granulite, Geochronology, Pan-African, Precambrian, Peninsular India.

Introduction

The earth's middle to lower crust is thought to be predominantly of granulite grade. Hence, studies of granulite facies rocks exposed on the surface of the earth are fundamental to our understanding of the early evolutionary history of the earth. Deeper portions of the earth's crust are exposed in some Precambrian metamorphic terrains such as South India. Reliable radiometric dates for evaluating the complex history and different modes of charnockite occurrence are sparse from southern India. Most of the previous studies show the earliest granulite facies metamorphism to have been at ca. 2500 Ma. Recent geochronologic studies (Unnikrishnan et al., 1992, and in preparation) trace a pre-2500 Ma

---

1) Department of Geosciences, Faculty of Science, Osaka City University, Sugimoto, Sumiyosihiku, Osaka 558, Japan.
2) Institute for Study of the Earth's Interior, Okayama University, Misasa, Tottori 682-01, Japan.
3) Centre for Earth Science Studies, P.B. 7250, Akkulam, Thiruvikkal Post, Trivandrum-695 031, India.
metamorphic event.

Peninsular India was an integral part of East Gondwana, interpreted to have been juxtaposed with Antarctica (Yoshida et al., 1992). Reconstructions of Precambrian Gondwana as well as its amalgamation tectonics are still in a preliminary stage due to lack of geochronologic data, especially from the Indian subcontinent; such data may provide a key to the evaluation of the tectonothermal history of East Gondwana. This work aims to determine the geochronology of the granulites in Peninsular India and to correlate the results with those of the other parts of East Gondwana.

**Geological Setting of Peninsular India**

Peninsular India comprises a granite-greenstone terrain in the north which grades into granulite terrain in the south, separated by an orthopyroxene isograd. The granite-greenstone terrain consists largely of tonalite-trondhjemite gneisses called the Peninsular Gneiss, associated with Archean supracrustals, granite gneisses and a number of postkinematic granitic plutons. The high-grade terrain comprises granulite facies rocks, represented largely by charnockites (orthopyroxene-bearing rocks of acid to intermediate compositions having greasy appearance) and minor supracrustals. This high-grade terrain is dissected by a number of mega-faults/lineaments which divide the terrain into different blocks (Fig. 1). All these lineaments are believed to be Late Proterozoic in age (Drury and Holt, 1980). The granulite terrain north of the Palghat-Cauvery Shear Zone and south of the orthopyroxene isograd is called the Northern Granulite Segment (NGS); it includes the Northern, Madras and Nilgiri blocks. The Northern Block is bounded by a narrow transition-zone south of the orthopyroxene isograd and north of the Moyar Shear Zone, and includes the Coorg and Biligirirangan Hills. The high-grade rocks of the Nilgiri Block are juxtaposed with the Biligirirangan Hill massive charnockites of the Northern Block along the Moyar Shear Zone. Blocks of the Southern Granulite Segment (SGS) are the Periyar, Madurai and Trivandrum blocks. The Madurai Block is separated from the Periyar Block by a belt of NE-SW trending zone rich in metasupracrustals; and the above two are separated from the Trivandrum Block by the Achankovil Lineament, which is considered to be a major strike-slip shear system truncating the earlier structures (Drury et al., 1984). The Trivandrum Block is formed of the vast pelitic supracrustal sequence called the Kerala Khondalite Belt (KKB, Chacko et al., 1987). The extreme south of the Peninsular India comprises the Nagercoil Block largely represented by massive charnockites (Srikantappa et al., 1985) where it is associated with syenite plutons. The relationship of this with the KKB has not been resolved. The arcuate belt of high-grade terrain along the east coast of India, which is separated from the granite-greenstone terrain to the west by a Proterozoic shear zone, and which merges with the Madras Block in the south, is called the Eastern Ghats Granulite Segment (EGS). It is often referred to as the 'coastal granulites'.

Charnockite studies in southern India are complex because of repeated events of charnockite-making, breaking and re-making (Pichamuthu 1953; Yoshida and Santosh
Charnockites in all these blocks occur either as regional units or as incipient phenomena. The former are mappable; the latter are not mappable and develop as over-

Fig. 1 Generalised geologic map of southern India showing the granite-greenstone terrain and the granulite terrain. KKB-Kerala Khondalite Belt, BR Hills-Biligirirangan Hills. The granulite blocks are (1) Northern Block, (2) Nilgiri Block, (3) Madras Block, (4) Periyar Block, (5) Madurai Block, and (6) Trivandrum Block. The Proterozoic shear zones are MO-Moyar, BH-Bhavani, P-C-Palghat-Cauvery and AC-Achankovil.
rints along small pods and shears within the precursor gneiss. Both froms may also be present.

Regional Geochronology

The list of published and unpublished geochronologic data from Peninsular India are given in Table 1, and some of the selected data are assembled in the form of a histogram (Fig. 2) to summarize the geochronologic data distribution.

Northern Granulite Segment (NGS)

Northern Block: In northern Peninsular India, the earlier continental nuclei are represented by the tonalite-granodiorite-trondhjemite gneisses and granodiorite-adamellite gneisses called Peninsular Gneiss, associated with Archean supracrustals. Both the gneisses and the supracrustals suffered greenschist to amphibolite facies metamorphism and are intruded by a number of post-kinematic granites. Towards the south, the amphibolite facies basement gneisses grade into orthopyroxene-bearing granulites which constitute the major portion of the Northern Block. Classical examples of \textit{in situ} charnockite formation ('incipient charnockite') are also present in the Northern Block.

The Rb-Sr systematics of BECKINSALE \textit{et al.} (1980) on Archean gneisses from the Gorum-Hassan area indicate that the gneissic precursors might have stabilized at about 3300 Ma. The oldest model Nd age (~3300 Ma) is reported from the Karnataka craton by DRURY \textit{et al.} (1983). The older zircon components of the greenstone basement give 3300 Ma (BUHL, 1987). PEUCAT \textit{et al.} (1989) reported a model Nd age of 2.8 Ga for the massive charnockites of Biligirirangan Hills and argued that this charnockite differs from other transition-zone charnockites. MAHABELESWAR and PEUCAT (1988) reported an imperfect Rb-Sr whole-rock isochron age of ca. 2900 Ma from the granulite facies rocks of Satnur-Halagur area south-west of Kabbaldurga. Rb-Sr and Sm-Nd whole-rock isochron ages of VIDAL \textit{et al.} (1989) indicate that the last dominant metamorphism in the transition-zone was at ~2500 Ma. GREW and MANTON (1984) reported that the incipient charnockites were formed at around 2500 Ma (U-Pb allanite), whereas BUHL (1987) reported ~3400 Ma for the zircon cores from the incipient charnockites. FRIEND (1981) suggested that the Closepet granite and the incipient charnockite formation were contemporaneous processes.

All these suggest that in the Northern Block the ~3300 Ma older crust had undergone regional metamorphism at ~3000 Ma, and that granulite facies metamorphism was associated with the incipient charnockite formation at ~2500 Ma.

Madras and Nilgiri Blocks: The Madras and Nilgiri blocks have identical Archean histories. Lithological units in the Madras Block are the massive charnockites, khondalites, leptynites, and associated metabasalts and norites. The charnockites range from acid to basic varieties. The Nilgiri Massif consists predominantly of enderbitic charnockites, including garnetiferous and non-garnetiferous varieties, the former being
<table>
<thead>
<tr>
<th>AUTHORS</th>
<th>ROCK/AREA</th>
<th>METHOD</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chacko (1987)</td>
<td>Metasediments/S. Kerala</td>
<td>Rb-Sr WR isochron</td>
<td>2100 Ma</td>
</tr>
<tr>
<td>Chaudhary et al. (1992)</td>
<td>charnockite/Ponmudi</td>
<td>Model Nd age</td>
<td>2500-2700 Ma</td>
</tr>
<tr>
<td>Santosh et al. (in press)</td>
<td>Charnockite/Nellikala</td>
<td>Sm-Nd (Ga-Wr)age</td>
<td>560 Ma</td>
</tr>
<tr>
<td>Hansen et al. (1985)</td>
<td>B.Gneiss/Madurai</td>
<td>Rb-Sr Biotite</td>
<td>480±9 Ma</td>
</tr>
<tr>
<td>Unnikrishnan-Warrier et al. (in Prep.)</td>
<td>Charnockite/Ottappalam</td>
<td>Sm-Nd Mineral isochron</td>
<td>~539 Ma</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rb-Sr Mineral isochron</td>
<td>505±41 Ma</td>
</tr>
<tr>
<td>Crawford (1969)</td>
<td>Charnockites/Gneisses/Nilgiri</td>
<td>Rb-Sr WR isochron</td>
<td>2560±80 Ma</td>
</tr>
<tr>
<td>Buhl(1987)</td>
<td>Granulites/Nilgiri</td>
<td>U-Pb Zircon, Monazite</td>
<td>~2550 Ma</td>
</tr>
<tr>
<td>Spooner&amp;Fairbairn (1970)</td>
<td>Charnockite/Nilgiri Mts.</td>
<td>Sr Model Age</td>
<td>~2500 Ma</td>
</tr>
<tr>
<td>Crawford (1969)</td>
<td>charnockite/Madras</td>
<td>Rb-Sr WR isochron</td>
<td>2525±125 Ma</td>
</tr>
<tr>
<td>Bernard-Griffiths et al. (1987)</td>
<td>Granulites/Madras</td>
<td>Sm-Nd WR isochron</td>
<td>2555±140 Ma</td>
</tr>
<tr>
<td>Vinogradov et al. (1964)</td>
<td>Charnockite/Madras</td>
<td>U-Pb Zircon</td>
<td>2600 Ma</td>
</tr>
<tr>
<td>Ben Othman et al. (1984)</td>
<td>Charnockite/Madras, Mysore</td>
<td>Sm-Nd(TDM)</td>
<td>2723 Ma</td>
</tr>
<tr>
<td>Unnikrishnan-Warrier et al. (in Prep.)</td>
<td>Granulite/Madras</td>
<td>Sm-Nd Mineral isochron</td>
<td>~3000 Ma</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rb-Sr Mineral isochron</td>
<td>~2500 Ma</td>
</tr>
</tbody>
</table>
Table 1  (continued)

<table>
<thead>
<tr>
<th>AUTHORS</th>
<th>ROCK/AREA</th>
<th>METHOD</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Videl et al. (1986)</td>
<td>Granulites/Transition-zone</td>
<td>Sm-Nd &amp; Rb-Sr WR isochron</td>
<td>~2500 Ma</td>
</tr>
<tr>
<td>Peucat et al. (1989)</td>
<td>Charnockite/S. of Krishnagiri</td>
<td>Rb-Sr WR isochron</td>
<td>2452±72 Ma</td>
</tr>
<tr>
<td></td>
<td>charnockites/BR Hills</td>
<td>Sm-Nd isochron</td>
<td>2440±155 Ma</td>
</tr>
<tr>
<td>Grew &amp; Manton (1984)</td>
<td>Granulite/Kabbal</td>
<td>Model Nd age</td>
<td>2800-2600 Ma</td>
</tr>
<tr>
<td>Mahabaleswar &amp; Peucat (1988)</td>
<td>Granulite/Satnur-Halagur</td>
<td>U-Pb Allanite</td>
<td>2530 Ma</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rb-Sr WR isochron</td>
<td>~2900 Ma</td>
</tr>
<tr>
<td>Vinogradov et al. (1964)</td>
<td>Khondalites/Puri</td>
<td>U-Pb Zircon</td>
<td>2600 Ma</td>
</tr>
<tr>
<td>Perraju et al. (1979)</td>
<td>Khondalites/Puri,Kasipatnam</td>
<td>Rb-Sr Model Age</td>
<td>3025 &amp; 2430 Ma</td>
</tr>
<tr>
<td>Aftalion et al. (1988)</td>
<td>Charnockites/Angul</td>
<td>U-Pb Zircon</td>
<td>1088 Ma</td>
</tr>
<tr>
<td>Rao et al. (1980)</td>
<td>charnockite/Visakhapatnam</td>
<td>Lead-Alpha Allanite</td>
<td>~1000 Ma</td>
</tr>
<tr>
<td>Grew &amp; Manton (1986)</td>
<td>Charnockites/Visakhapatnam</td>
<td>U-Pb Zircon</td>
<td>2000±100 Ma</td>
</tr>
<tr>
<td>Paul et al. (1990)</td>
<td>Charnockites/Visakhapatnam</td>
<td>Pb-Pb isochron</td>
<td>1200±200 Ma</td>
</tr>
<tr>
<td></td>
<td>Charnockites/Phulbani</td>
<td>U-Pb Monozite</td>
<td>985±5 Ma</td>
</tr>
<tr>
<td></td>
<td>Charnockite/Visakhapatnam</td>
<td>Sm-Nd (TDM)</td>
<td>2600 Ma</td>
</tr>
</tbody>
</table>
dominant in the Nilgiri Hills. These granulites record the highest P-T conditions in Peninsular India (HARRIS et al., 1982). Lenses and pods of pyroxenite and gabbro are also present in this area. Charnockites of Madras give a model Nd age of 2600 Ma (BEN OTHMAN et al., 1984) and a Rb-Sr whole-rock isochron age of 2525±125 Ma (CRAWFORD, 1969) identical to the Sm-Nd whole-rock isochron age (2555±140 Ma) obtained by BERNARD GRIFFITHS et al. (1987). VINAGRADOV et al. (1964) and BUHL (1987) reported U-Pb zircon ages of 2550 Ma and 2600 Ma for the Madras and Nilgiri charnockites, respectively. These dates suggest that initial crustal growth, including the charnockite formation and the regional granulite facies metamorphism took place at about 2550-2600 Ma. Our recent attempt on a sample collected from the Madras area give an Sm-Nd mineral isochron age of ~3000 Ma and Rb-Sr ages of ~2500 Ma (UNNIKRISHNAN-WARRIER et al., in prep.); these suggest pre-2500 Ma event in the Northern Granulite Segment.

Southern Granulite Segment (SGS)

The Trivandrum Block of the Southern Granulite Segment is composed predominantly of a charnockite-khondalite-leptynite association, locally interlayered with basic granulites, calc-silicates and quartzites. Progressive (SRIKANTAPPA et al., 1985) and retrogressive (SANTOSH and YOSHIDA, 1986; YOSHIDA and SANTOSH, 1987) transformations of the amphibolite facies gneisses to charnockites and vice versa are recognised in this block. Cordierite-bearing charnockites are reported proximal to the Achankovil Shear Zone (NANDA-KUMAR et al., 1991). The Periyar and Madurai blocks are composed mainly of massive charnockites, with minor granites and pegmatites.

Geochronologic data from the southern blocks are broadly concentrated in the Trivandrum Block, and there are only a few published reports from the Periyar and Madurai blocks, including a Rb-Sr isochron by HANSEN et al. (1985). CHACKO (1987) described an ill-defined Rb-Sr whole-rock isochron age of about 2100 Ma from the metasediments of the Trivandrum Block. From the Ponmudi Quarry, BUHL (1987) reported zircon growth at 1970 Ma. CHOUDHARY et al. (1992) reported an older crustal component of 2500–2700 Ma (model Nd ages) from the incipient charnockites of Ponmudi. Cordierite-bearing charnockite from Nellikala, proximal to the Achankovil Shear Zone gave an Sm-Nd mineral isochron age of 539 Ma (SANTOSH et al., in press). This, along with monazite and zircon growth ages of 550 Ma reported by BUHL (1987), as well as inclusion-free garnet ages of 560 Ma (CHOUDHARY et al., 1992), reflect charnockite formation in the Southern Granulite Segment. Subsequent uplift is believed to have been at 480 Ma, from a Rb-Sr biotite age (CHOUDHARY et al., 1992). The basement gneisses near Madurai provided an Rb-Sr whole-rock age of 550±15 Ma, isotope exchange is considered to have continued up to 425±55 Ma (HANSEN et al., 1985). Charnockite from Ottapalam, Periyar Block, gives Sm-Nd and Rb-Sr mineral isochron ages of ~500 Ma (UNNIKRISHNAN et al., 1992, and unpubl. data). These dates provide compelling evidence for the manifestation of Pan-African thermal event in the Southern Granulite Segment.

In contrast to the Northern Granulite Segments, several alkaline and sub-alkaline
granites and syenites of 500–750 Ma are reported from Kerala (Santosh and Drury, 1988) and from near Madurai (Deans and Powell, 1968).

**Eastern Ghats Granulite Segment (EGS)**

The Eastern Ghats form an arcuate belt of high-grade terrain parallel to the east coast of India. This belt is composed of metamorphosed supracrustals, mainly khondalites (granet-sillimanite gneiss), charnockites and migmatitic gneisses, with minor amounts of calc-silicatess, marble and quartzite. Anorthosite and alkaline intrusions represent a younger phase (Sarkar et al., 1981). Charnockites occur in these areas as massive bodies, and also as patches developed across the foliation of the gneiss. A U-Th-Pb age of 2600 Ma (Vinogradov et al., 1964), and a model Nd age (TDM 2600 Ma) for the charnockites of Visakhapatnam and 2350 Ma for Phulbhani (Paul et al., 1990) indicate the incorporation of Archean components into this mobile belt. Spooner and Fairbairn (1970) reported a Sr model age of ~2000 Ma from the charnockites/pyroxene granulites of Eastern Ghats, whereas Rao et al. (1980) reported ~2000 Ma for Allanites from apatite veins and charnockite pegmatites from Visakhapatnam. The Chilka Lake Anorthosite is believed to have been formed at ca. 1400 Ma (Sarkar et al., 1981).

Aftalion et al. (1988) summarized the polyphase history around Angul, Orissa, into four phases of deformation (D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub> and D<sub>late</sub>) and three phases of metamorphism (M<sub>1</sub>, M<sub>2</sub>, and M<sub>3</sub>). The D<sub>late</sub> phase is correlated with local charnockite formation and granite pegmatite intrusion. The charnockite is dated between 1100–950 Ma (U-Pb Zircon) and the granite emplacement at 957 Ma.

Grew and Manton (1986) report 979 Ma for zircon from charnockites of Visakhapatnam and a similar age for the sapphire-bearing granulites from Anakapalle. This, together with zircon (U-Pb) and monazite (U-Pb) ages of 990–950 Ma from the charnockites of the Visakhapatnam and the Phulbani areas respectively (Paul et al., 1990), correspond to the charnockite formation event for the Eastern Ghats.

**Discussion**

The radiometric data distribution in different granulite segments of southern India is shown in Fig. 2, which shows three dominant events each predominant in every segment.

The Northern Granulite Segment is characterised by dominant ca. 2500 Ma crust formation and granulite facies metamorphic event having precursors of ca. 3000 Ma–3300 Ma granulites.

The Eastern Ghats Granulite Segment is characterised by charnockite formation at ca. 1000 Ma over precursor granulites of 2000 Ma and/or 2500 Ma. The Southern Granulite Segment is supposed to be similar in geochronologic sequence to that of the Eastern Ghats Granulite Segment with regard to its pre-1000 Ma history. But the Southern Granulite Segment lacks an ca. 1000 Ma event, but is characterised by
Fig. 2 Histogram showing the geochronologic data distribution in different granulite segments in southern India.

Geochronological Constraints on Granulite Formation in Southern India
ca. 500 Ma charnockite formation over the precursor granulites of ca. 2000 Ma and/or 2500 Ma. It is suggested that the granulite terrains of Peninsular India are composed of successively reworked crustal fragments which suffered regional metamorphism during Archean and Early Proterozoic times.

These granulite segments with characteristic geochronologic imprints have common features with some other geologic units in Gondwanian fragments surrounding India (Fig. 3). The Napier Complex of Enderby Land in East Antarctica is characterized by a granulite facies events at ca. 3000 Ma on which was superimposed amphibolite to granulite facies events at ca. 2500 Ma (SHERATON et al., 1987). This complex is thus comparable

![Fig. 3 The juxtaposition of India-Sri Lanka-Antarctica in East Gondwana showing the geochronologic data distribution. Abbreviations are EGS-Eastern Ghats Granulite Segment, NGS-Northern Granulite Segment, SGS-Southern Granulite Segment, KKB-Kerala Khondalite Belt, WC-Wanni Complex, HC-Highland Complex, VC-Vijayan Complex, NC-Napier Complex, RC-Rayner Complex, POC-Prince Olav Complex, OSG-Ongul and Skallen Group, YBC-Yamato Bulgica Complex, TVG-Teltet Vengen Group, NLG-Nils Larsenfjellet Group, SPC-Southern Prince Charles Mountains. Broken lines show estimated fault boundaries. The framework of the juxtaposition of the continents is after YOSHIDA et al. (1992). The geochronologic data presented are compiled from Table 1, YOSHIDA et al. (1992): and the geology of Enderby Land and Western Kemp Land, Australian Antarctic Territory (SHERATON, 1985).]
to the Northern Granulite Segment of southern India.

The Rayner Complex of Enderby Land in East Antarctica has sporadic precursors of ca. 2000–2500 Ma and suffered mostly the ca. 1000 Ma granulite facies event, with later modifications during the Pan-African period (SHERATON et al., 1987). A broadly similar sequence is reported from the Highland Complex of Sri Lanka as well as the Ongul and Skallen groups of the Lützow Holm Bay area of East Antarctica (YOSHIDA et al., 1992). It is pointed out that the Eastern Ghats Granulite Segment (EGS) and the Southern Granulite Segment (SGS) may have pre-1000 Ma histories broadly similar to these areas. But in India the ca. 1000 Ma event affected only the Eastern Ghats Granulite Segment and the ca. 500 Ma event took place only in the Southern Granulite Segment.

YOSHIDA and SANTOSH (in press) stressed the geochronologic-tectonic division of the formation of incipient charnockites in East Gondwana. Incipient charnockite formation took place at ca. 2500 Ma, 1000 Ma and 500 Ma and the principal characteristic is that there was thermal reworking at every stage in already stabilized metamorphic belt. A polarity in age, with younging outwards from the core of the Archean nuclei of Peninsular India can be noticed. This study supports their view.

It is pointed out that the correlation of the younger Pan-African events in crustal fragments from East Gondwana are commonly been accepted, but that of the earlier events are not well constrained. Detailed metamorphic, structural and geochronologic studies are needed to resolve this aspect.

**Acknowledgements**

This work forms part of the first author's doctoral programme at Osaka City University. He is thankful to the Ministry of Education, Science and Culture (Monbusho), Government of Japan, for the research fellowship. The encouragement and assistance of Yasutaka Tani is appreciated. This work is a contribution to the Monbusho International Research Project ‘Proterozoic Mobile Belts of Gondwana’ (No. 04041090) led by M. Yoshida and also to IGCP-288 led by R. Unrug. An earlier version of this manuscript benefitted from the careful review and helpful comments of Dr. Ken Shibata of the Geological Survey of Japan, Dr. A.T. Rao of Andhra University, India and Dr. N.B.W. Harris of The Open University, England.

**References**


BUHL (1987): U-Pb and Rb-Sr Altersbestimmungen und untersuchungen zum strontiumisoto-
penaustausch an granuliten sudindiens, Thesis Ph. D., University of Munster, FRG (unpublished)


