The list of such transgressions is endless The story in Chennai after the December deluge follows a similar path as also in other cities in Tamil Nadu and Karnataka

The other image that illustrates the lawlessness that is the leitmotif of our cities is the bulldozer At the end of the year, the bulldozers were pulling down buildings of brick and concrete in Ulhasnagar, a town outside Mumbai Over 855 "illegal" constructions in Ulhasnagar could not have been built unnoticed if those in charge had not colluded in breaking the law In New Delhi, shops could not have materialized in residential areas if someone in authority had not endorsed the violation of planning norms

Can our cities survive if every law made to encourage orderly growth is defied with impunity?"

The challenge before urban planners is how to change this "rule of lawlessness' — *BPR*

SYMPOSIUM ON "SUPERCONTINENTS AND EVOLUTION OF EARTH" IN THE CONTEXT OF INDIAN SHIELD

The above symposium was held at Fremantle, Western Australia during 26-30 September, 2004 Sea floor spreading and plate tectonics have been on the central stage of earth sciences for over two decades Work at Lamont-Doherty Geological Observatory in mid-1980s paved the way for the current thinking of pre-Pangea supercontinents The seminal papers of SWEAT and the alternate hypotheses appeared in 1991 (*Geology*, v 19, pp 425-428, v 19, pp 598-601), and in (*Science*, v 252, pp 1409-1412) Since then vast amount of literature has appeared on Gondwana amalgamation and pre-Gondwana Rodinia configurations In recent years Prof Chris Powell seeing the potential of Australian geology in all reconstructions has established a Tectonic Special Research Centre (TSRC) with a mission to discover the supercontinents of which Australia has been part in the past three billion years, and to understand their amalgamation and dispersal history Prof Chris Powell unfortunately died in an air accident in 2001, but the TSRC has relentlessly pursued his mission with remarkable contributions to the understanding of supercontinents and earth evolution TSRC recently organized a symposium to review the efforts at global level and synthesize the present knowledge Indian shield shares with Australia the geology and therefore the proceedings of the conference are of great relevance in understanding and shaping new programs in the light of global efforts

The symposium preceded with two full-day pre-conference workshops on (a) Palaeomagnetism and (b) Precambrian time scale on 25th September Prof McElhinny and Prof Rob Vander Voo and researchers at University of Western Australia conducted the palaeomagnetism workshop and it was designed to cover fundamentals of palaeomagnetism and tectonic applications The second workshop was designed by the subcommission on subdivisions and calibration of Precambrian time scale spanning 88% of the earth's history Pre- and post-symposium visits were organized to Capricorn, Albany-Fraser and Pinjarra orogenic belts Participation in the workshops/fieldtrips was through prior (paid) registration

Following the workshops, the symposium was formally launched on the same day with an icebreaker reception and registration The technical sessions began with a formal welcome by Dr Peter Cawood, the Director of TSRC The symposium was meticulously designed with fourteen keynote presentations by leading scientists The developments on various facets of supercontinents and earth's evolution research were reviewed Over eighty other presentations were made covering various themes of the symposium The keynote speakers included Drs Dalziel (Rodinia 2005), David Scholl (subduction erosion and challenge to supercontinent reconstructions), David Yaen (superplumes and post perovskite transition), David Evans (Palaeoproterozoic Era-Global palaeogeography's final frontier), Rosell Korsch (assembling Australia), Paul Hoffmann (Neoproterozoic glacials), Michael Brown (metamorphic patterns in accretionary and collision zones-secular variation in metamorphic regimes and punctuated tectonic evolution of earth), David Groves (temporal distribution of mineral deposits in relation to tectonic and lithospheric evolution), Onno Oncken (controlling factors at convergent margins based on Andean case), Larry Brown (deep reflections, lithosphere structure and supercontinent evolution), Rob Vander Voo (palaeomagnetism and supercontinents with respect to Rodinia puzzle), Richard Hanson (Rodinia, the African perspective), Reinnhardt Fuck (Rodinia descendants in south America), and Sergei Pisarevsky (Late Neoproterozoic palaeogeography alternative models and problems)

First day and the initial session of the second day of the symposium were devoted to general principles and mantle processes in relation to supercontinents and the early

configurations of supercontinent earth. Some principal points highlighted were:

The supercontinent research is regarded as a multi giga year perspective in which Pangea and Rodinia constitute merely the starting point of the great endeavor. The study requires global advances and tectonostratigraphy, geochronology and palaeomagnetism. At our present understanding levels, Palaeoproterozoic Era will be the final frontier to global palaeogeography as long as palaeomagnetism remains the only quantitative tool for Precambrian plate reconstructions. There is optimism that reconstructions back to c. 2200 Ma are foreseeable within the century.

35 pieces of Archaean cratons of the many extant crustal fragments are regarded as of special interest for the supercontinental reconstructions as they have the largest memory. However, the main challenge was the older cratons retained relatively small volume of exposed old crust that remained. No Archaean craton was marked by subduction zone borders. Subduction erosion has been exemplified along the Mesozoic Arc from western South America. Thus attempts of older reconstructions over time rely on increasingly less surviving material to guide reconstructions. Some fragments may have been erased completely from the record causing preservational bias of geological record. Consequently, all reconstructions, including that of Rodinia, remain severely under-constrained. Defining Sclavia, Superia, Kenorland, and Vaalbara as supercratons or supercontinents present a greater challenge for deep time palaeogeographers. A strong agenda for more robust reconstructions, benefiting many scientific disciplines, has been set by a few presentations. These include concerted international effort in the next decade for integrated study of geochronology and palaeomagnetism to establish *key* poles, bar codes of LIP events for each craton, usage of linear/radiating dyke swarms as piercing points or to identify former conjugate margins.

Indian shield comprises a few oldest cratonic fragments and Palaeoproterozoic events and pervasive dyke intrusions; therefore there is great opportunity to make contributions to these global endeavours. A subsection is marked by the presentations of Indian data of 3 Ga old granulite facies event on the western border of Eastern Ghats belt with Bastar craton, geological details of Chotanagpur gneiss-granulite complex, palaeomagnetic results of the 1.65 Ga dyke intrusions on the western margin of Cuddapah basin and the interior of south Indian shield and glaciogenic diamictite in the lower parts of the Palaeoproterozoic Sausar Group in central India in relation to pre-Rodinia continental assembly.

The second day of the symposium was devoted for the presentation of new results on assembling Australia. The presentations covered the tectonic history of Pilbara, Yilgarn, Kimberley and Gawler cratons, significance of Capricorn orogen, Halls Creak orogen, Mt Isua inlier and the Proterozoic sedimentary piles. The presentations were overdosed with zircon *mantra* (newly produced zircon SHRIMP geochronology), to constrain tectonic events and sedimentary source and the attempts of Ar-Ar geochronology to trace the reworking of the regions. Further, the presentations depicted a series of time-space diagrams to track the geological events. Taking clue from the presentations, more efforts are needed to review, develop and improve the time space diagrams proposed along the Udupi-Kavali geotransect (Radhakrishna and Ramakrishnan, 1993), Nagaur-Jhalawar transect across Delhi/Aravalli fold belt (Tewari et al. 1998) and along many DSS traverses in the Indian shield, concerted new efforts on Cuddapah and other Proterozoic sedimentary basins to trace the sediment source and depositional history. In this context it is worth recognising that the scientific groups from abroad have already taken initiatives on the Cuddapah and Vindhyan basins.

The third day deliberations included supercontinents and evolving environments, orogenic processes and geophysical imaging of orogens. The very first talk in the forenoon by Paul Hoffmann was mainly focused on Neoproterozoic glacial events (Sturtian, Marinoan, and Gaskiers) and carbonates. Boron isotope data was presented suggesting lowering of pH during Marinoan glaciation, implying dramatic rise in atmospheric CO_2. Causal theories for the Neoproterozoic glaciation including U-Pb dating of all glacials, discovery of Ir spikes and determination of B isotopes from cap carbonates in Africa (Congo-Zambia and Namibia respectively). Another talk on Neoproterozoic glacials raised questions as to whether the Marinoan glaciation was a single event is valid and correlations solely made based on isotopic signals associated with Marinoan glaciation were tenable. Importance of detrital zircon ages for correlations was highlighted. A well-characterized cap carbonate was suggested to constitute the strongest circumstantial evidence, in the absence of geochronology, for stratigraphic control. One such carbonate over the Walsh tillite in Kimberley was used establishing the Marinoan age for the tillite. This suggestion was, however, inconsistent with the palaeomagnetic interpretations pointing to the need for further attention to understand the true meaning of the results in the context of Rodinia and global glaciations. Apart from these, some relationships are drawn between atmospheric N_2 and growth of continental crust and extended the temporal correlations between the LIPs and

episodes of dramatic environmental change (mass extinctions and marine anoxia) back in time to the early/ middle Cambrian (510 Ma) boundary based on S isotope stratigraphy of biostratigraphically constrained sedimentary sequences of Duchess phosphorite deposits from Australia In India studies on this subject are very limited and there exists a large scope in view of the reports of glaciogenic deposits and the occurrences of LIPs and type sections of many stratigraphic boundaries

Under orogenic processes, the highlights were (1) metamorphic patterns are characterized with special reference to the styles of orogenic systems, particularly the accretionary and collision orogenic systems (2) Secular changes in tectonometamorphic styles are brought out in the orogens from Archaean through Proterozoic to Phanerozoic linking them to punctuated tectonic evolution of earth in terms of cooling of mantle and development of whole mantle convection (3) SHRIMP and Ar/Ar geochronology combined with metamorphic PT estimates from eclogites of the Usagaran orogenic belt of Tanzania, which are one of the oldest eclogite facies rocks on earth, indicate rates of exhumation (~1 5 kbs/MY) and cooling (~25°C/MY), comparable with Tertiary subduction related eclogites suggesting plate tectonic processes, similar to those in modern earth acting 2 Ga ago Several microcontinetal fragments have been identified in the central Asian orogenic belt in the southern Kazakhstan suggesting a continuous accretion (1000-300 Ma) in contrast to the earlier single island arc model Large volumes of felsic volcanics in the Mangolian arc have Precambrian xenocrysts and detrital zircons indicating significant involvement of older material Similar heritance reported recently in Neoproterozoic felsic rocks of Arabian-Nubian shield was highlighted casting doubt on purely inter-oceanic development of this belt

The session on geophysical imaging made out a case, with examples across various orogenic belts, for deep seismic surveys to trace the evolution of continental lithosphere through supercontinent cycles Heterogeneity of reflection profiles is argued to be commensurate with the diversity of tectonic processes with key features preserved as testimony to the relative importance of mobilization and preservation of lithosphere components through time The presentations included results of (1) URSEIS '95 multiseismic experiment under international initiatives across Variscan Ural orogenic belt, (2) MT imaging along three profiles, and (3) deep crustal structure models based on recent reflection seismic imaging of the East European Craton (EEC) down to 80 km depth along the 3500 km long CDP geotransect 1-EU

The URSEIS '95 has located change in seismic signature at 125-150 km depth, which coincides with the depths of asthenosphere-lithosphere boundary estimated from DSS data Physical properties of the mantle rocks exposed at the surface outcrops indicate that compositional variations alone can account for the wide-angle reflectivity The MT surveys in Australia have substantiated the surface geology interpretations of Proterozoic sutures in southern Arunta and Gawlar craton while locating intra-cratonic reworking in the eastern Alice Spring orogen In this context, the recent efforts particularly under LEGENDS Project to initiate geophysical traverses across southern granulite terrain are laudable Such surveys and imaging of the crust is very important to evaluate and ascertain the role of several tectonic/shear zones not only in south India but also from other cratons in India

Fourth day was devoted to Rodinia assembly and break up The initial Keynote presented the confused situation with the existing palaeomagnetic data to constrain Rodinia and underlines that more palaeomagnetic data are essential to make progress Indian presentations include preliminary palaeomagnetic results from the Semri Formations of Vindhyan Supergroup and Nallamalai sedimentary history in relation to orogen along Eastern Ghats granulite belt Discussions on Africa centered on Mesoproterozoic tectonism that may bear models of Rodinia, convergent tectonics along the Namaqua-Natal Maud orogen on southern Kalhari, Kabiran belt, Damara – Zimbazi orogen Geological record from Africa on timing of igneous events has been reviewed to trace common history in the company of Rodinia but it is interesting that palaeomagnetic results require the cratons to have been separated Better-constrained palaeomagnetic pole along with high quality U-Pb single crystal beddeleyite/zircon date for 1 1 Ga Umkonda dolerites from the Kalhari craton were presented In the absence of Congo poles of this age, the Kalhari-Congo-Sao Francisco reconstructions rely on the San Francisco pole of same age, on the premise that the latter two cratons constitute a single tectonic block However, now vertical axis rotations are inferred between these cratons and the reconstructions seem to remain uncertain Another important aspect is the size and geometry of Kalhari craton The major part of Kalhari exposed today in southern Africa has been considered for many Rodinia reconstructions, it is argued that greater Kalhari configuration incorporating the pan African-rifted fragments is a significant task for Rodinia reconstructions Results presented from other continents included a review of Mesoproterozoic (1 5-1 0 Ga) events, which are useful to trace possible descendants of Rodinia, from South America in addition to

the commonly considered cratonic blocks of Amazonian, Sao Francisco and Rio de La Plaza Three Chinese presentations focused on Sibao orogen belt between Yangtze and Cathaysia blocks in south China with new SHRIMP geochronology of Felsic volcanism of Shuangxiwa Group (924+14 Ma, 897+12 Ma), adakitic granites with ultramafics of Jianxi ophiolite (968+23 Ma) and 880 Ma biotite granites that are melts of sedimentary rocks beneath ophiolite thrust sheets which place constraints for final amalgamation along the belt C 1 0 Ga Ar-Ar muscovite ages reported from Tianli muscovite schist (Sabao belt) suggesting Grenville age metamorphism possibly as a part of the assembly of the Rodinia supercontinent U-Pb SHRIMP dating of zircons has brought out two depositional episodes of late Mesozoic separated by a 140 Ma hiatus with distinct sedimentary sources from the Kunyang Group on the western margin of South China Block From the Antarctica, 1 1-1 0 Ga LA-ICPMS detrital zircon ages were reported from Neoproterozoic Sodruzhestvo series in Prince Charles Mountains This provides evidence for the continuation of Pinjarra orogen into Antarctica shield across Western Australia Finally the session ended with an overview of Rodinia construction based on the Geodynamic Map of Rodinia, a final product of UNESCO-IGCP 440 prepared by the members of the Rodinia map committee The presentation clearly stated the limitations and constraints and that it can be used as a guide by the researchers to make their own reconstructions using the compiled maps and new information as it becomes available At the present level of understanding, the position of India within the Rodinia assembly remains controversial Palaeomagnetic data from India are too meager and many reconstructions rely on Harohalli and Malani poles Even these poles could be further constrained averaging secular variations and with high precision dating Granulite metamorphism and associated igneous events and the structural framework have to be better constrained in the Eastern Ghats belt and other regions Tracing India's position within Rodinia would be an important forerunner for the endeavors to trace India in pre-Rodinia configurations

The fifth and last day of the symposium concentrated on Gondwana Assembly, the youngest supercontinent It is now well known that the break up of the remnants of Rodinia supercontinent gave way for the assembly of Gondwana land in the latest Neoproterozoic-early Cambrian The breakup or assembly histories are widely debated mainly because of scarce and the controversial nature of late Neoproterozoic palaeomagnetic data which has resulted in multitude of reconstruction models The very first keynote demonstrated the nature of inconsistencies in models with examples of four alternate Australia-Laurentia reconstructions and six alternate positions proposed for Siberia and similar problems with Baltica, Kalhari, Amazonia, Congo and India It was stressed that the proliferation of alternate models may continue till the problems with late Neoproterozoic palaeomagnetic data are resolved Of the two papers specific to India, one from south India suggested possible crustal-scale flower structure indicative of transpressive tectonics related to collision process during pan African times along the Cauvery shear zone system (CSS) The other presentation gave an account of 500 Ma felsic igneous activity from northwestern Himalaya in relation to the transition from Rodinia to Gondwana

Among the other presentations of interest, mention may be made of use of monazite dating to trace metamorphic history identifying discrete phases of metamorphism from the central African Fold Belts of Cameroon, Congo craton of Uganda These works have constrained pan African reworking and its implications to lithosphere evolution and are significant in view of the reported pan-African record across the continents The subduction, magmatic arc initiation and final collisional processes (900-600 Ma) described from Aracuai/Brazilia fold belts in the Sao Francisca basin in central Brazil Among the two presentations of Antarctica, one reported pan-African (530-490 Ma) reworking of c 1 1 Ga Droning Maud Land basement Melting of lower crustal rocks was also evident as a result of crustal thickening due to collision giving rise to granite-syenite-charnockite suite Zircon morphology, composition and SHRIMP dating from leuco- and melanosomes of migmatitic zones were reported from the Lutzou-Holm complex Zircon growth was linked to several stages of pan-African orogenesis (560-540 Ma) and highlighted the absence of igneous/metamorphic activity connected to Rodinia formation Three papers were centered on Neoproterozoic metamorphic, magmatic and detrital zircon/monazite ages from Madagascar The data traced an early subduction (> c 720 Ma) along a zone, where the Ambodiriana Group (520 Ma granulite belt) crops out, between Antananarivo block and Antongil block This subduction and collision event was followed by final collision (c 650-600 Ma) by closure of a strand of Mozambique Ocean, west of Itremo Group amalgamating Congo-Dharwar craton It also resulted in reworking of the crust to the east including the Ambodiriana zone An accompanying paper on the EAO, argued for amalgamation of the Indian shield with Congo craton (Congo-Tanzania-Bangweulu together named as Azania, orogeny named as Malagassy orogeny) coeval with Kuunga orogeny (550-500 Ma), which resulted in the amalgamation of the Indian

shield with the Australia-Mawson craton leading to final Gondwana assembly These studies suggest multiple sutures in the East African Orogen In situ U-Th-total Pb dates of monazite (717 Ma, 531 Ma and 504 Ma) were presented from the granulites on the southern part of Benarivo belt in northern Madagascar The older 717 Ma age on detrital monazite grains may suggest sediment source from the northern part of Benarivo and Seychelles while the 531 and 504 Ma ages correspond to the prograde garnet growth and peak metamorphism and decompression respectively associated with collision process related to Gondwana assembly Results presented in this section have an important bearing to the ongoing debate on disposition of the Indian shield within the Gondwana assembly Some of the 717 Ma detrital minerals in northern Madagascar even may have their source in the Aravali craton in India Multiplicity of ideas have been proposed for the high temperature migmatites, gneisses and shear zones of the southern granulite terrain linking them to the regional metamorphic and structural record across this continental assembly by drawing correlations with similar rocks in Madagascar, Sri Lanka and Antarctica

In summary, the workshop addressed key issues related to geodynamic history of various cratonic and orogenic belts spanning across the globe, deep in time of earth's evolution Indian shield comprises cratonic and orogenic elements critical for the understanding of supercontinental cycles and earth's evolution over long geological period and thus the ideas and results presented in the symposium have great relevance to future geological research in India This brief summary is an attempt to describe the aspects which are important in the Indian context, and it gives at least a glimpse of current trends and contemporary thinking across the world on this subject

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INTERNATIONAL SYMPOSIUM ON APPLIED GEOCHEMISTRY IN THE EVALUATION AND MANAGEMENT OF ONSHORE AND OFFSHORE GORESOURCES

A three-day international symposium on "Applied Geochemistry in the Evaluation and Management of Onshore and Offshore Geo-resources" was organized by the Indian Society of Applied Geochemists (ISAG) at Atomic Minerals Directorate for Exploration and Research (AMD), Begumpet, Hyderabad during 28-30 September 2005 175 delegates both from India and other countries participated in the symposium 118 abstracts were received out of which 61 were selected for oral presentation and the rest for poster presentation The symposium covered a wide spectrum of topics of current importance namely (1) Oil and Gas, (2) Coal and Coal Bed Methane (CBM), (3) Marine resources including Gas Hydrates, (4) Ferrous and Non-ferrous metals, (5) Gold, PGE and Diamonds, (6) Radioactive and other strategic minerals, (7) Water resources, (8) Environmental pollution

Dr A K Balyan, Director, HR, ONGC, New Delhi who inaugurated the symposium stressed on the importance of geochemical approaches and techniques in petroleum exploration He emphasized on the need for energy independence of our country in the coming 20-30 years and suggested integrating the available knowledge and interaction between industry and academicians to arrive at a more clear picture of our oil resources and their exploration He also put forward the importance of developing human resources and specialists in the field of geochemistry

TECHNICAL SESSIONS

Oil and Gas

Prof Jan Eric Sorlie of Norwegian Geotechnical Institute, Norway gave the keynote address, and talked about oil contamination and remedial measures He advised that India should take advantage of the knowledge and know-how of Americans and Russians in this regard A K Jain described in detail the history of microbial prospecting in India and suggested integration of microbial and soil gas studies He mentioned that KDMIPE is involved in a big way in microbial studies with a good success ratio G C Datta explained how aromatic biomarkers in crude oil from Bombay High and Bassein and of the western offshore basin give important clues to the lithology, thermal maturity and palaeo-environment of the source rocks S Pahari demonstrated how source potential of Mesozoic and Tertiary sedimentary deposits of Cauvery basin has been evaluated to identify the potential source rocks He suggested that the best targets for future exploration are the deep basin