

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 GEORESOURCES

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

reservoirs of Ariyalur-Pondicherry sub-basins for gas and conventional accumulations of Nagapattinam and Palk Bay sub-basins in Andimadam Formation PK Baruah, based on the stratigraphic studies of the Eocene-Oligocene sediments of Patkai hills of Assam-Arakan Fold belt of NE India contended that the Disang group sediments have poor hydrocarbon generation potentiality while the Barail group have comparatively better reservoir characteristics A K Bhaumik explained how gas inputs were accumulated in the Blake Ridge Plateau in N W Atlantic He opined that adequate pressure, high organic carbon, high porosity in the sediments and high bacterial content are the important causes for the accumulation of gas hydrates in the Ridge A Anuradha made an attempt to understand the nature of waxes through the study of carbon distribution pattern Her studies have shown that oils in some areas have been generated from predominantly terrestrial source

Anil Bhandari studied different sedimentary basins of India and observed that the major source rocks occur mainly between Late Paleocene and Pliocene Dewakar made a detailed survey of 5 distinct petroleum systems in upper Assam basins to upgrade the knowledge He concluded that a major commercial discovery was made in the Sylhet/Tura Formations N Pendkar brought out the influence of palaeoclimatic signatures of Cretaceous sediments of K-G basin He opined that the Albian-Aptian times of Cretaceous age are favourable for deposition of suitable source rock facies in the basin D K Singh observed that the absorbed gases in Kutch-Saurashtra offshore basin are catagenetic in origin and petroliferous in nature These hydrocarbons are cogentic and have not been influenced by secondary alteration effects during their upward migration While Kalpana studied the adsorbed gas and fluorescent fingerprinting techniques in surface geochemical exploration of hydrocarbons in general, Vyas discussed the influence of adsorbed gas studies in exploration of hydrocarbons with special reference to KG and Cauvery basin The importance of microbial prospecting as a tool to detect the presence of methane, ethane, propane and butane was discussed by Rasheed The basic assumption in microbial prospecting according to the author is that light hydrocarbons from oil and gas fields escape to the earth's surface and contribute to the development of bacteria which feed on these hydrocarbon gases Mangotra, who made detailed geochemical studies in Ramnad sub-basin indicated localized generation and migration of hydrocarbons in the area Rakesh Sharma mentioned that geochemical heterogeneities can act as a tool for chemostratigraphic studies using immobile elements Integrated studies of both remote sensing information and GIS data were effectively

used for hydrocarbon prospecting from Saurashtra basin by Vishnu Vardhan while palaeomagnetic studies to identify the occurrence of hydrocarbons from Vindhyan basin were discussed by Poornachandra Rao Devleena Mani brought out the role of soil salts, particularly iodine, in hydrocarbon exploration

Coal and Coal Bed Methane (CBM)

Although the abstracts received under this theme were many, only five papers were presented Das Gupta of GSI, who delivered the keynote address gave an overview of Coal Bed Methane (CBM) studies in general with various basic attributes like temperature, pressure and permeability He opined that the CBM activity in India is confined to sinking of exploratory wells in Damodar valley and Sohagpur coalfields He contended that GSI has to play a vital role in CBM exploration and evaluation Shankar opined that potentiality for CBM depends mostly on the rank, composition, and permeability of coal based on his studies from Ramkola-Tatapani coalfield His analysis of coal facies indicated that levels of bio-chemical degradation influence the petrographic composition of the seams Datta went further and opined that microleat analysis along with petrographic characteristics play a significant role in CBM evaluation from his studies on Bokaro and Rajmahal coalfields His investigations have shown that East Bokaro coals are richer in vitrinite and are much higher in coal rank compared to those of Rajmahal coal fields thereby implying generation of more methane in the former Studies on the Raigarh coalfield, Chattisgarh have revealed higher concentrations of arsenic and mercury Ray cautioned that this may pose some environmental problem during mining and storage of coal He recommended that the level of trace element concentration in fly ash and stack emission need to be monitored periodically if the coal is used for power production Finally, M V Subba Rao suggested that fly ash should be used in a big way as road metal, cement industry and in making bricks and ceramic tiles to avoid any environmental hazards following his studies at Vijayawada Thermal Power Station in Andhra Pradesh

Marine Resources Including Gas Hydrates

Pranaya Sangvai of the Reliance Industries Limited highlighted the growing importance of geochemistry in hydrocarbon exploration He discussed about the International Coring Programme and the Reliance Coring Programme and suggested future research programmes for exploring marine resources and gas hydrates Jayaprakash opined that geochemical study of gravity core samples depicts changes in sedimentological as well as geochemical

cycle from his investigations around Kavaratti island of Lakshadweep. His studies indicated variation in carbonate content and other trace element characteristics. All these may imply an increasing order of destruction of the coral reefs in the area. Statistical analysis of all geochemical data of marine sediments from Cannanore-Quilandi shelves of Kerala by Unnikrishnan has established five major groups of sediments, each representing a particular sedimentary environment. Their lateral and vertical extension throws light on the palaeogeomorphology of the coast. Martin Deva Prasath who made a detailed investigations of the variations in heavy metal concentrations in pre and post Tsunami time in Nagapattinam and Tharangampadi coasts of southeast coast of India observed significant variations in the heavy metal concentrations after the tsunami in both the areas. Trace elemental studies in Upper Ganga River in Himalayas by Chakrapani have brought out the dominance of carbonate rock weathering source similar to the major role played by carbonate rock weathering in water chemistry. Drolia mentioned that a methodology has been established for the estimation of trace elements and dissolved methane using ICP-MS and gas chromatography. Using this technique he suggested a probable hydrothermal activity from his studies on Central Indian Ridge and Carlsberg Ridge.

Ferrous and Non-ferrous Metals

V.V. Rao gave an overview of the mineral resources of our country in his keynote address. According to him, India has surplus reserves of Fe, Mn, Al and Mn, is sufficient in Nb-Ta, Ti and REE and is deficient in Au, Ag, and U. He stressed the need for discovery of concealed ore deposits and recommended systematic geochemical surveys for locating new mineral deposits, particularly precious metals and base metals. Dinesh used the Mn/Mg ratio in ilmenite from different rock types as a tool in deciphering the provenance. Nambiar who studied the distribution and pathways of metals in surficial sediments in territorial waters of parts of Konkan coast concluded that the total metal concentrations are of little value in assessing the carriers and pathways of elements in marine sediments. The Siwana Ring Complex of Rajasthan was studied by Vallinayagam with particular reference to evaluation of georesources. He contended that the volcanoplutonic characters of the complex are favourable for continuous supply of fresh water throughout the year to the region.

Gold, PGE and Diamonds

V. Balaram in his keynote address projected the worldwide scenario of PGE in general and India in particular. He mentioned that the concentration of PGE is exceptionally

low in natural rocks. He opined that the most favourable host rocks are mafic and ultramafic rocks and the concentrations of PGE in these rocks serve as important tracers of mantle process. Olivine, chrome-spinel/chromite and the sulphides are the most favourable candidates for PGE enrichment. He stressed on the need for an integrated approach covering geology, geochemistry, geophysics and remote sensing for targeting new areas. The geology, wall rock alteration like silicification, chloritization, carbonitization, etc. of Buddini gold deposit in the Huttimaski greenstone belt were discussed by Sangurmah. He concluded that silica-rich solutions were responsible for leaching of gold and these solutions along with gold migrated to low pressure sites forming new veins and lenses. Saleem Khan described the detailed geology, petrography and geochemistry of the Hanumalapur area of Shimoga schist belt with special reference to the PGE and recommended test drilling of the entire northern stretch of the belt for an overall estimation of the grade and reserves. Vidyadharan is of the view that the mafic-ultramafic complexes of the entire south Indian shield are potential targets for PGE mineralization. Abhijeet Mukherjee highlighted the multi-disciplinary studies carried out by NMDC for diamond exploration in kimberlites using remote sensing and stream sediment sampling together with geological, geochemical and geophysical studies. Burra Subrahmanyam gave a conceptual model for kimberlite exploration in Andhra Pradesh and suggested three potential areas for kimberlite search. Siva Kumar brought out the geo-engineering properties of rocks and their role in mineral exploration programmes. He explained the correlation between physicochemical properties of rock and their geochemical characteristics *vis-a-vis* gold mineralization at KGF and coal at Kothagudem. C.R.M. Rao felt an urgent need for geochemical mapping of the entire country from various angles like mineral exploration, environment, agriculture etc. using new analytical techniques and collaboration among different organizations in India to estimate the overall crustal abundances of various elements.

Radioactive and other Strategic Minerals

P. Krishnamurthy in his keynote address gave a bird's eye-view of the concepts, causes and problems in dealing with giant uranium deposits. These concepts are evaluated in terms of the existing genetic models but he felt that the challenges are in a better understanding of the ore controls and genesis. He argued that the exploration strategy should include a concentrated and integrated geological, geochemical and geophysical approach. He emphasized that there is a great need to discover giant uranium deposits in

India to overcome the present deficiency. Ravi discussed the global distribution of strategic and associated economic mineral deposits in both onshore and offshore regions and presented an alternative rapid and precise technique using wavelength dispersive XRF spectrometry (WDXRFS). Safi who studied the phosphate ores and their beneficiation from Syria mentioned that the beneficiated phosphate can be effectively used for production of phosphoric acid. Parthasarathy's findings from the Killari borehole samples indicated that moganite is preserved in rocks younger than 130 Ma where the geological formation is unaffected by surface weathering. Dhana Raju compared the geochemical characteristics of the Peninsular Gneiss and Closepet granite around Lakkireddipalli in Andhra Pradesh and their implications on the age differences between the two in the western and eastern Dharwar cratons. Tarun C. Khanna studied the felsic volcanics of the Gadwal greenstone belt and identified two types of volcanics - rhyolites and adakites with distinct chemical characteristics. He opined that the adakites are formed by partial melting at subduction zone tectonic setting. D.V. Subba Rao, based on his studies of tholeiite intrusions in Chattisgarh Basin demonstrated that the dykes inside the basin have a different mantle source compared to those of outside the basin. Gnaneshwar Rao attempted to estimate REE in geological reference rock samples ranging from felsic to ultramafic by ICP-MS and found that multi-element solution as calibration standard is best suited for estimation of REE in general.

Water Resources

One of the most important societal necessities is water and exploration and utilization of water, therefore, is of paramount importance. Sapna Sedri of ONGC who delivered the keynote address dealt with the geochemical characters of waters in the oil fields of Assam as water is associated with every process right from the beginning of deposition of organic matter to its generation, migration and accumulation of hydrocarbons. According to her, most of these waters are of bicarbonate sodium type indicating continental conditions of deposition. She observed significant variation in the Na/Cl ratio in

Tipam sandstones compared to Barail, Geleki and Lakwa sandstones indicating the existence of hydrodynamic conditions. She advocated that waters in each formation and field show hydrogeochemically different and distinct signatures. Sambasiva Rao who evaluated the chemical quality of groundwater in Andhra Pradesh observed significant variations in chemistry from different regions, some of the parameter being above drinking water standards. He suggested that some of these waters can be used for

irrigation purpose. In continuation, Singh observed high fluoride content in the granites and gneisses of Nalgonda district and suggested mixing of groundwater with low fluoride content from nearby areas for drinking purposes. Mittal lamented that the depleted water resources around Ladnum area of Rajasthan were due to excessive drilling of tube wells for irrigation purposes and suggested methods like optimum depth for tube wells, desalination and defluoridation and rain water harvesting for sustained development of groundwater resources. Arun Vyas also suggested similar remedial methods for the high fluoride groundwaters of Nagpur district. Khanday while studying the hydrogeochemistry of Dal lake of Kashmir valley observed two chemical facies reflecting the meteoric character of the lake water and the role of water-rock interaction in the catchment area.

Environmental Pollution

Mrs. K. V. Ramani of the Andhra Pradesh Pollution Control Board addressed the issue of environmental pollution due to vehicular traffic in her keynote address. Her studies show an increased level of SPM which is estimated to be 1400 tonnes/day. Epidemiological studies revealed an increase in respiratory problems. The strategies adapted by the A.P. Government to curb vehicular pollution was presented. Das Sharma inferred from his carbon and oxygen isotopic studies of waters from Kolleru Lake, A.P. that indiscriminate anthropogenic activity around the lake is responsible for the poor quality of water in the lake. P.N. Rao made a detailed study of the groundwater quality in Vijayawada Urban agglomeration and observed that nitrate, phosphate and sulphate are at a higher concentration than standard norms in certain areas indicating anthropogenic pollution while in certain other areas bacteriological pollution is the dominant. The managerial strategies to circumvent these hazards were outlined by him. Heavy metal concentration studies in the surface waters of Katedan industrial area around Hyderabad by N.N. Murthy revealed higher concentrations of As, Cd, Cr, Cu, Ni, Pb, V and Zn during pre-monsoon season compared to post-monsoon period although the latter values are also above the permissible limits. The post-monsoon scenario was explained to be due to inflow of rain water. These high concentrations of heavy metals were attributed to anthropogenic activity. Some of the remedial strategies were discussed by the author. A.G.S. Reddy suggested that the high fluoride concentrations in the groundwater of Nalgonda district could be due to water-rock interaction during the process of percolation, recharge and flow. Dasaratha Ram attributed the heavy metal concentration like Cr and Fe in

the waters from Pattanchern area of A P to indiscriminate disposal of industrial effluents and improper storage of solid wastes Naresh Jadhav also opines that the heavy metal concentration in Boduppall Cheru around Hyderabad is due to indiscriminate dumping of wastes by nearby industries thereby disturbing the ecological balance Sumitha observed that the polluted groundwater at Kottur industrial area is the result of indiscriminate release of the nearby textile industries She also discussed the impact of this contaminated water on the health aspect and suggested a few remedial

measures Madhuri carried out physico-chemical studies of groundwaters from Nacharam industrial area around Hyderabad and observed that the polluted and deteriorating quality of groundwater is mainly due to the toxic effluents released by the industries in the vicinity

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SOME VIEWS ON NEOGENE STRATIGRAPHY OF THE ASSAM PLATFORM

1.1 The author's observations of the Neogene formations from the electrical logs of Brahmaputra valley and their correlations with their exposures in the Schuppen Belt of Assam and their extension into the Surma-Barak valley region of Cachar called for a certain rethinking and need for a revised classification of those formations Certain comparisons/contrasts with the Neogene stratigraphy of the northwestern India also seemed relevant These ideas are elaborated for a wider consideration by geoscientists

1.2 Neogene stratigraphy in northwest India starts with the Himalayan flysch - the Murree sediments, magnificently exposed in the Poonch-Rajouri belt of Jammu area and the Dagshai-Kasauli beds (collectively Dharmasalas) west of the Yamuna They do not continue east of the Yamuna where the pre-Cambriams (phyllite, schist and quartzite) are thrust over the Siwaliks Lithologically the Murree- Dagshai-Kasauli are deep brown, well stratified sandstones with minor well stratified brown sandstones The southern boundary has been referred to as the Great Boundary Fault To their north lie the Subathus (Eocene) rocks, not observed east beyond Nainital The Murree-Dharmasalas occupy Aquitanian-Burdigalian range with possible extension into Lower Siwalik (Kamlial-Helvetian stage) Only HM (Heavy Mineral) and palynological studies established their identity Dharmasalas have been observed in the Janauri well drilled by the ONGC Thus it may be inferred that the Flysch basin terminated west of the Yamuna, yielding a profound Oligocene unconformity, to be also observed in the northeast (Assam) In general, Oligocene was a period of non-sedimentation, possibly exposed land area over-thrust by the Eocene (Subathu) and pre-Eocene rocks

2.1 The Neogene sequence following the Flysch is the Molasse Siwalik foreland basin commencing from Helvetian (Kamlial) and building up to Boulder Conglomerate

(Cromarian) litho-chrono stratigraphic levels Its sub-montane contact with the Gangetic plain marks the final phase of the Himalayan orogeny These dip homoclinally under the Siwalik hills and are underlain by the Krols/Vindhyaans

3.2 S N Talukdar is the living authority on Siwalik stratigraphy V Rai Verman another ONGC geologist proposed eight-fold En-Seq (energy sequence) classification of the Siwaliks

4.1 We now shift to the northeast Assam - Cachar and Tripura regions AOC geologists Percy Evans, WB Metre and A B Das Gupta classified the Paleogene and Neogene sedimentary formations of this region - a classification so far unchanged Tectonically this region comprises Assam platform, a miogeosynclinal basin and the Schuppen Belt accommodating an imbricate homoclinally dipping sedimentary formation extending from the Disang (Paleogene) sediments to Dekiajuli-Dihing (Quaternary) systems Successively upwards these are

Assam Platform	Schuppen Belt	Standard Time Scale
Dekiajuli Dihing (silts)	Not observed	Quaternary
Tipam Girujan clay (massive sandstone with minor clay beds)	Tipam (sandstone)	Mio Pliocene
Barail (Sandstone clay with coal beds)	Barail (sandstone and clay with massive coal beds)	Oligocene (Aquitanian)
Jaintia/Kopili (Sandstone)	Disang Limestone (indurated)	Eocene
Slyhet Limestone	Dirang	Eocene
Chenna/Tenighat Sandstone) oil bearing with Borhalla Chungmai goan beds	Not observed	Pre Tertiary to Cretaceous