Purana Basins of Peninsular India

Proceedings of the Workshop held at Hyderabad
December 29–31, 1984

As part of the Silver Jubilee Celebrations of the Geological Society of India, a Workshop on Purana Basins (Middle to Late Proterozoic) of Peninsular India was organized at Hyderabad between December 29 – 31, 1984. The Workshop was co-sponsored by the Geological Survey of India and the National Geophysical Research Institute.

The wide ranging interest claimed by the Proterozoic Sedimentary Basins is manifest in the modern multi-disciplinary approach adopted by several geoscientists in unraveling the exogenous and endogenous processes that gave rise to these basins. In a bid to achieve refinement in inter- and intra-basinal correlation and in order to identify new target areas for mineral search, advantage is taken increasingly of diverse modern tools like remote sensing and photogeological techniques, geochemical and geophysical (ground and airborne) surveys, palaeomagnetic studies, and isotope geology. Emergence of new concepts and progressive coverage of more areas have generated a large volume of data. The objective of the Workshop was to synthesize this data by providing a common platform to all the geoscientists engaged in the study of these basins. The deliberations of the Workshop helped, as expected, in assessing the state of the art on the subject and in identifying future lines of study.

INAUGURAL SESSION

The Inaugural Session was held on the forenoon of December 29, 1984. Shri N. G. K. Murthy, Geological Survey of India, welcomed the delegates and invitees to the Workshop.

Shri D. P. Dhoundial, Sr. Deputy Director General, Geological Survey of India, Calcutta inaugurated the Workshop.

Tracing the origin of the term ‘Purana’ in geological parlance and defining its original connotation, Shri Dhoundial, in his Inaugural Address, recounted the extensive field work carried out by the Geological Survey of India on Purana Basins, and stressed the need for building up of sedimentary models and for more effective use of stromatolites, microbiota, spores etc., and geochronological data, for correlation of the Mid-Late Proterozoic Basins. Discussing the evolutionary trends of the Proterozoic Basins, he opined, that with progressive sedimentation, the depositional centres shifted away from the heart of the Peninsula towards the less deformed peripheral zones of the axial rises of earlier complex basins. He conjectured that the girdle of shifting Proterozoic Basins around the Bundelkhand nucleus had strong connections on the northern side with the proto-Tethys. Recalling the known mineral potential of the Proterozoic Basins, he observed that the shoreline facies and volcanogenic environments had a great role to play in the genesis and concentration of important non-ferrous minerals and diamonds. He drew the attention of the delegates to the concerted efforts of GSI in locating new mineral resources through multi-disciplinary surveys supported by matching laboratory inputs.

Dr. Kurien Jacob, Addressing the delegates, reminisced with nostalgic memories the historical development of the Geological Society, since its inception in 1958.
and observed that the Journal of Geological Society of India ranks to-day as one among the top Earth Science journals in the world.

Dr. Hari Narain, in his Presidential Address discussed the geophysical work done on the Proterozoic Basins in general, and Cuddapah and Vindhyan Basins in particular, including the studies on the Godavari Rift. He discussed at length the available models of evolution of these sedimentary basins. According to his preferred model, the Proterozoic Basins and the mobile belts of Satpura and Eastern Ghats are closely associated and genetically linked, since the margins of the basins in contact with the mobile belts are deformed. In support of his model, he presented geophysical parameters like gravity, DSS and magnetic data. He observed that there are still many unresolved problems in our understanding of the evolutionary processes of these large intra-cratonic basins and stressed that only detailed and sustained studies can generate the data necessary to resolve these problems as also to locate new ore deposits and hydrocarbon prospects.

TECHNICAL SESSIONS

Stratigraphy, Structure, Sedimentation and Glaciation

Shri M. N. Sehgal, GSI, Nagpur and Prof. K. V. Subba Rao, IIT, Bombay, conducted the Proceedings of this session.

Twenty papers were presented dealing with the stratigraphy and sedimentation of the Cuddapah, Kurnool, Vindhyan, Kaladgi-Badami, Bhima, Pakhal-Sullavai, Chattisgarh, Indravati, Gwalior and Abujhmar Basins.

The salient points that emerged from the papers on ‘Stratigraphy and sedimentation’ are:

1. (a) The Purana Basins reflect the transitional-environmental conditions between the permobile Archaean and the platformal geosynclinal regime during the evolution of the Earth’s crust. (b) The spatial disposition of these basins suggests that they all formed parts of a major sedimentary basin.

2. (a) In Peninsular India the Proterozoic sedimentation started around 3000 m.y. and ended with the Delhi orogeny around 500–550 m.y. (b) The Peninsular Proterozoic is divisible into three major Groups, namely, the Khondalite - Dharwar (3000–2000 m.y.), Bijawar - Sausar (2000–1500 m.y.) and Cuddapah (1700 m.y.).

3. (a) The Cuddapah Basin evolved in stages mainly due to NNW-SSE, ENE-WSW and NE-SW trending lineaments which were periodically reactivated. (b) The Kurnool/Palnad sub-basins were developed as half-grabens with tectonic contacts on the eastern side and transgressive contacts on the western side. (c) The Basin experienced at least six periods of igneous activity manifested in the form of basic, acidic and barium-rich phases.

4. (a) The Vindhyan sedimentation had been initiated as a consequence of the Eastern Ghat and Aravalli Orogeny (1600 m.y.). (b) Radiometric dating by K-Ar method indicates an age of 1400 m.y. for the Semri Group and 910±30 m.y. for the Kaimurs. (c) The Vindhyans were laid down in marine-fluvial-marine environments, the major bulk of the sediments representing shallow marine, tidal flat and lagoonal environments.

5. (a) The Kaladgi (4500 m) is divisible into a lower Bagalkot Group and an Upper Badami Group, with a definite angular unconformity in between.
(b) Stromatolites and microbiota from the Bagalkot Group indicate a Middle Riphean age (1260-1000 m.y.), thus suggesting that the Bagalkot is correlatable with the Tadpatri Formation of the Lower Cuddapah. (c) The Bagalkot Group of sedimentaries were first folded along WNW-ESE axis and later along N-S axis; the Badamis were folded into a series of doubly plunging anticlines and synclines along N-S and E-W axes. (d) The Kaladgi-Badami sequence was deposited in a shallow marine (tidal to beach) environment. The alternating clastic and chemical sediments reflect deposition in transgressive-regressive phases.

6. (a) The Bhima Basin comprises 90 to 270 m thick undeformed sediments dominated by limestone. The sedimentary sequence is divisible into five Formations which can be classified into two Sub-groups. (b) The limestone (cement grade) potential of the Bhima Basin is placed at 15,400 million tonnes of which 20% falls in the 'measured' reserve category.

7. Reconstruction of the palaeo-strandlines of the Kaladgi, Badami and Bhima Groups indicates that these sediments were deposited in one single continuous basin and that the present spatial disposition of the sediments was the result of later tectonic processes.

8. (a) The Pakhal Basin of the Godavari Valley includes, broadly, four major sub-divisions, namely, the Pakhal, Albaka, Penganga and Sullavai of a cumulative thickness of 6000 m, (b) The Pakhal is correlatable with Papagini-Chitravati-Nallamalai sequence of the Cuddapah. The Penganga and Albaka are inferred to have been laid down synchronously in two discrete basins. Lithologically, the Penganga resembles the Kurnool and the Albaka the Srisailam Quartzite of the Cuddapah. The Sullavai Sandstone is correlatable with the Maihar Sandstone of the Vindhyan, (c) The Pakhal was subjected to two periods of folding, the first one giving rise to northeasterly to northwesterly plunging folds and the second one to domes and basins and (d) The dominantly depositional nature of the Archaean-Proterozoic contact of the southwestern belt, the post-depositional age of faulting of the Archaean-Pakhal fault-contact of the northeastern belt and the enormous thickness of the basin negate rift-valley origin for these sediments. The basin was initiated along pre-existing zones of weakness in the sialic crust.

9. The structural and paragenetic studies of the rock units of the 'Shernavala Outlier' of the Pakhal in Khammam district, AP, support that the Pakhal can be assigned Middle Proterozoic age and correlated with the Cuddapah.

10. (a) The Chhattisgarh Supergroup (2000 m) consists of a lower Chandarpur Group (arenaceous) and an Upper Raipur Group (argillaceous and calcareous) with an intervening unconformity and (b) The sediments were deposited in a combination of shallow marine, tidal flat, beach and stable shelf tectonic set-up.

11. (a) The Indravati Group (510 m) of sedimentaries in Madhya Pradesh and Orissa are divisible into two Subgroups, namely the Tiratgarh Subgroup and the Jagadalpur Subgroup. Chitrakot Sandstone (70 m) overlain by Cherakur Formation (40 m) constitute the Tiratgarh, and Kanger Limestone (150 m) overlain by the Kalah Formation (250 m) the Jagadalpur, (b) The Basin was dissected by two transverse faults both with down-throw to the north, (c) The Basin represents an erosional remnant of a sedimentary prism deposited in an Upper Proterozoic transgressive epicontinental sea over the Archaean basement, (d) The Indravati sedimentaries
were deposited in beach, nearshore (backshore to foreshore) and tidal flat environments and (e) The Indravati Group is reckoned to be about 700 – 750 m.y. old.

12. The Abujhmar Group of sedimentaries in Bastar district, MP, overlain by basaltic flows and intruded by sills and dykes of gabbroic composition, are older than the adjoining Indravati Group and correlatable with the Cuddapah Supergroup.

13. The Gwalior Group of rocks of the type area around Gwalior, MP, comprising a lower Par Formation and an Upper Morar Formation are correlatable with the lower Bijawar rocks of the type area near Chhatarpur and with similar rocks exposed around Jabalpur, Sleemanabad and Dhar forest area.

14. (a) The Proterozoic rocks sandwiched between the Noamundi and Gangpur Groups in Rourkela-Bonai area of Sundergarh, Orissa, have been accorded the status of Group and designated as ‘Darjing Group’. (b) The Darjing Group comprises, from the base upward, the Birtola, Kumakela and Jalsa Formations.

Prof. Basant K. Sahu delivered an invited lecture on ‘Statistical Approach in Sedimentological Analysis of Purana Basins’. He observed that textural studies of Purana sediments through thin-sections would be more precise than conventional loose-grain studies because of diagenesis and lithification. He stressed the role of statistical approach in this type of study and added that cumulative curves provide graphical statistics as well as parameters of each component which would be helpful in identifying depositional processes and environments. Highlighting the importance of size, axial ratio, roundness and axial ratio-cum-roundness statistics, he contended that multigroup linear discriminant functions are much better than two-group linear discriminant functions. He explained as to how the confidence of interpretation of size statistics would be best in cases where diagenetic/lithification barriers are removed. The confidence of inference from axial ratio and other shape statistics would be the next best. He cautioned that roundness of grains is prone to change quickly under processes of diagenesis and lithification and that it reflects only later depositional environments.

Speaking on ‘Glaciation in the Purana Basins of Peninsular India’, Shri S. M. Mathur, observed that positive proof of glaciation during the Purana period exists only in the Bijawar Group. He opined that the basal rudite in the Arangi Formation of the Semri Group (Vindhyan), considered by some as a tillite, is a non-glacial diamicrite. He drew attention to the presence of sedimentary structures like ice-crystal markings, V-shaped structures etc., in the Vindhyan which were suggestive of sub-arctic cold climate.

Prof. D. P. Rao presented the latest geological map of the Cuddapah Basin and explained the revisions effected by him and his colleagues on the basis of photo-geological interpretation, followed by field checks and up-to-date geophysical and absolute age data.

Geophysics and Geochemistry

Shri R. N. Bose, Geological Survey of India, Calcutta and Dr. S. M. Naqvi, NGRI, Hyderabad, conducted the proceedings of this section.
Ten papers were presented in this Session dealing with geophysical aspects, Bouger gravity map and aeromagnetic data on Cuddapah Basin and palaeomagnetic and magneto-stratigraphic studies. Only two papers were presented on geochemistry – one on the black slates from the Pakhal Basin and the other on Palnad Limestones of Cuddapah Basin.

The significant points made out were:

1. (a) The estimated thickness of sediments in the Proterozoic Basins ranges from 2 km in the Bhima Basin to 8 km in the Cuddapah Basin; (b) The Cuddapah, Pakkal, Chhattisgarh and Vindhyan Basins are associated with steep gravity linears representing deep crustal fractures. Only the Kaladgi and Bhima Basins appear as simple troughs with no deep seated significance; (c) The gravity features are distorted by deep seated materials in the Cuddapah, Chattisgarh and Vindhyan Basins, and by younger Gondwana sediments in the Pakhal Basin; (d) The Vindhyan Basin, with its low density sediments, does not appear as a gravity low in the gravity map of India, possibly due to basement upwarp.

2. The continental shelf along the east coast should be a good location for prospecting for oil.

3. It is possible, that a meteoritic impact, about 1700 m.y. ago, acted as a precursor to the initiation of the Cuddapah Basin.

4. Aeromagnetic data from Markapur area, Andhra Pradesh, indicate a down-thrown block in the south, with thick sedimentary pile, whereas in the rest of the area the sedimentary cover is thin and the basement shallow.

5. One of the dolerite dykes (1440 ± 60 m.y.), adjacent to kimberlite pipes at Wajrakarur area, provides a reliable palaeo-magnetic pole in the Precambrian period.

6. The high content of Pb (135 ppm) in the Raghunathpalle black shales (Pakhal) suggests that these shales could be the source for lead sulphide mineralization in the associated lithologic types.

7. The uniformly high content of Sr in all the analysed samples of Palnad Limestone is inferred to indicate deposition of the limestone under marine conditions.

Speaking on the DSS profiles and other geophysical studies on Cuddapah Basin, Dr. K. L. Kaila, in an invited lecture, observed that the Cuddapah Basin was initiated through block down-faulting in the western part. Small scale down-faulting in the east, west and north gave rise to the Kurnool and Palnad sub-basins. The eastern margin of the Cuddapah Basin is a thrust-fault with the Dharwars thrust over the Upper Cuddapah. Down-faulting of the coastal block during the Mesozoic led to the formation of Mesozoic and Tertiary sedimentary basins in this area both on land and in the Bay of Bengal. The Moho depth contour map showed a general down dip from NW to SE.

Speaking on the possible extension of the Vindhyan Basin, Dr. Kaila considered that the Vindhyan sediments were deposited north of the Narmada lineament beneath the Indo-Gangetic alluvium right up to the Himalaya. Horst-and-graben tectonics and basement faults played an active role in Vindhyan sedimentation. The thickness of the sediments ranged from 0.4 km in the north of the Narmada to 4.5 km in the Mirganj graben.
In his invited lecture on the palaeomagnetic studies in Cuddapah Basin, Dr. C. V. R. K. Prasad, informed that the palaeomagnetic data indicate an age span of 1700 to 1250 m.y. for the Cuddapah Basin. He surmized that collision of a continent from the east could be responsible for the crescent shape of the Cuddapah Basin.

Palaeobiology

Shri C. Tripathi, Sr. Deputy Director General, GSI, Lucknow and Dr. B. S. Venkatachala, ONGC, Dehradun, conducted the proceedings. Four papers were presented dealing with the stromatolites and microfossils from the Proterozoic Basins of Karnataka. The salient points that emerged during this Session are:

1. (a) The Vempalle and Tadpatri Formations of the Cuddapah Basin are characterized by wide-spread occurrence of morphologically distinct columnar stromatolites which include Conophyton, fms., Kussiella, fms., Collenia symmetrica, fms., close to Baicalia etc. (b) These stromatolite assemblages are of great use for intra- and inter-basinal correlation.

2. The acritarch assemblage indicates a pre-Riphean (1600 m.y.) age for the Papaghni Group, Riphean-Cambrian (1600-500 m.y.) age for the Chitravati Group and Cambrian-Ordovician (500-430 m.y.) age for the Nallamalai Group of the Cuddapah Basin.

3. The study of microfossils suggests Lower Riphean (1600-1350 m.y.) to Middle-Upper Cambrian (540-500 m.y.) age for the Kaladgi, Late Precambrian to Early Cambrian (1200-600 m.y.) age for the Bhima, and Ordovician (500-430 m.y.) age for the Badami Groups of rocks in Karnataka.

INVITED LECTURE

Delivering an invited lecture on Precambrian-Cambrian biota, Dr. B. S. Venkatachala, observed that symbiont species of bacteria and blue green algae recorded from Richat (Mauritania) Formation are important in the evolutionary history of life. Tracing the evolution from procaryots to eucaryote organisms, he stressed the role of bacteria in the formation of metallic deposits. Reviewing the biota from Sargur, Dharwar and Purana sedimentaries, he considered that some of the recorded fossils are not authentic. He also negated the Precambrian origin of vascular plants.

Basin Tectonics and Magmatism

The session was conducted by Dr. S. V. P. Iyengar and Shri N. G. K. Murthy, GSI. Six papers covering all the Purana Basins in general, and Cuddapah and Vindhyan Basins in particular, were presented.

The deliberations generated a wealth of interesting information which is summarised below:

1. (a) The initial igneous activity in the Purana Basins consisted of basalt and rhyolite (Cuddapah), and andesite, basalt and rhyolite (Vindhyan and Chattisgarh). (b) At the close of Cuddapah sedimentation and Kaimur sedimentation in Vindhyan Basin, lamprophyres (Cuddapah) and Kimberlite plugs (Cuddapah and Vindhyan) were emplaced as a result of tapping of mantle material by deep fractures. (c) Purana magmatism has played an important role in the development of deposits of tungsten,
tin and fluorite (Rajasthan), diamond (Cuddapah and Vindhyan), baryte-
(Rajasthan and Cuddapah), iron ore, pyrite, copper and cobalt
(Rajasthan).

2. (a) The Bijawar, Jungel and Vindhyan Basins in UP appear to represent
intra-cratonic basins developed as a result of platformal rifting super-
posed on Satpura orogenic fold belt. (b) The process of taphrogenesis
succeeded orogenesis around 1700 m.y. ago as a sequel to regional arching
and thinning of the crust. (c) Interactions between crust-mantle material
and alkaline magmatism were synchronous with basin evolution.

3. (a) The alignment of dyke swarms with the southwestern margin of the
Cuddapah Basin suggests that these dykes could have originated as fillings
of fractures caused by a powerful meteoritic impact at the beginning of
the Eparchaean interval (1700 m.y. ago). (b) The meteoritic impact
could be a precursor to the initiation of Cuddapah sedimentation during
the later part of the Eparchaean interval.

4. (a) The western part of the Cuddapah Basin is believed to represent an
early stage rift developed in the proto-crust due to local tensions in the
subducted Indian Plate. (b) The igneous activity was fed through fissures
from a common underlying magma and resulted in cone sheets. (c) Further opening up of the Cuddapah Basin on the eastern side resulted in the Cuddapah orogeny.

5. (a) The Basantgarh-Ambaji area (southern Rajasthan and northern Gujarat)
of Delhi geosyncline witnessed three phases of deformation and four
phases of major igneous activity represented by sub-marine tholeiitic
basalts (syn-sedimentational), gabbro and granodiorite-granite (related
to F1), gabbro-diorite (related to F2) and dolerite dykes (related to F3). (b) Hydrothermal brine related to a volcanic-exhalative source, precipitated Cu, Pb and Zn with decreasing temperature and pressure but with increasing Eh and pH/brine dilution.

INVITED LECTURES

Speaking on the ‘Tectonics of the Vindhyan Basin, Central India’, Dr. V. D.
Choubey focussed attention on the increased structural disturbance of the Vindhyans
where they abut against the older massifs. He believed that the Narmada-Son
lineament represented a major orogenic front in the Precambrian Peninsular Shield.
Concluding his talk he stated that the basement rocks underwent major thrusting
whereas the overlying Vindhyans were deformed in the marginal zones independently
presumably above the decollement horizon.

Ore genesis and ground water

Shri N. K. Mukherjee, GSI, Calcutta, Shri T. V. Chowdary, A. P. Mining
Corporation, Hyderabad, conducted the proceedings. Six papers dealing with base
metal, diamond and phosphorite potential in Purana Basins were presented, followed
by an invited lecture on the ‘Ground Water Potential of the Cuddapah Basin’ by
Shri K. C. B. Raju, Central Ground Water Board, Hyderabad.

The highlights of the discussions held in this session are:

1. The sulphide deposits in the Cuddapah Basin are both strata-bound and
stratiform.
2. (a) In the Cumbum Formation of Cuddapah Basin, lead-zinc and copper deposits occur in strikingly similar marine volcanogenic sedimentary sequences. (b) The products of magmatism, explosive volcanism and accompanying exhalative phases, close to deep seated structural loci, provided source material for the sulphide deposits.

3. Anaerobic micro-organisms, inhabiting isolated shallow marine sub-basins, might also be responsible in the production of sulphides (e.g., Zangamrajupalli-Varikunta belt). The sulphide mineralization was syndepositional.

4. (a) The sediments hosting Zawar lead-zinc deposit (Rajasthan) were deposited in an unstable reducing environment under fairly high evaporitic condition and those of Agnigundala deposit (Cuddapah Basin, AP) in a comparatively quiet and stable environment of relatively higher Eh conditions. (b) Both the deposits are of strata-bound syngenetic type; the degree of remobilization is minor in both cases.

5. (a) The Banganapalle Conglomerate (Kurnool Group) is of two types – one ferruginous and the other siliceous. The ferruginous conglomerate is richer in diamonds than the siliceous one. (b) The palaeo-current data indicates that the source of diamonds could be from the northwest. (c) Larger diamonds are associated with conglomerates of bigger mean pebble size.

6. Two palaeochannels, containing 3-5 m thick virgin gravel zones, which are diamondiferous, are located in the Partiala-Chandralapadu area along the Krishna River, Andhra Pradesh.

7. (a) Reconnaissance surveys indicated a number of phosphorite occurrences in Cuddapah and Bhima Basins and indications of phosphorite mineralization in the Kurnool and Pakhal Basins. (b) In the Cuddapah Basin, phosphorite occurs in Tadpatri, Cumbum and Srisailam Formations and in the Bhima Basin in Halkal Shale.

Speaking on the 'Groundwater Potential of the Cuddapah Basin', Shri K. C. B. Raju, explained that the occurrence and movement of groundwater in the rock formations of the Cuddapah Basin are controlled mainly by fracture systems and buried solution channels. He added that the fracture and lineaments are oriented dominantly inENE-WSW and NNW-SSE directions. He further informed that boreholes drilled down to about 90 m depth at favourable locations have given yields ranging from 200 to 1500 lpm. He presented the status of groundwater potential in different districts of Andhra Pradesh falling with in the Cuddapah Basin, and outlined the scope for future development.

CONCLUDING SESSION

Shri Y. M. K. Chandra Chowdary, GSI, Hyderabad and convenor of the workshop chaired the Concluding Session held on the 31st December, 1984. Appreciating the valuable contributions made by the delegates, Shri Chandra Chowdary stressed the need for a more sustained pursuit of the unresolved problems with a view to gaining a clearer understanding of the intra- and inter-basinal correlational problems, depositional environments, mineralization controls etc.

The Chairman of each Technical Session then summarized the salient points that emerged from the deliberations of each of the Sessions, identified the gaps in knowledge and suggested future lines of study. Dr. Kurien Jacob wound
up the discussions with an excellent summary of the entire technical proceedings and suggestions for future study.

Dr. K. S. Rao presented the Vote of Thanks, on behalf of the Organizing Committee, to all the delegates and invitees. He acknowledged his grateful thanks to Shri D. P. Dhoundial, Sr. Deputy Director General, GSI, Calcutta for inaugurating the Workshop, Dr. Hari Narain, Chief Project Co-ordinator, UNDP, NGRI, Hyderabad for his Presidential Address and Dr. S. V. P. Iyengar, Dy. Director General (Retd.) and Messrs. N. K. Mukherjee, C. Tripathi, M. N. Sehgal and R. N. Bose, Sr. Deputy Directors General, GSI for chairing the Technical Sessions. He also thanked the Co-Chairmen and rapporteurs. He expressed his deep sense of gratitude to Dr. Vinod K. Gaur, Director, NGRI, Hyderabad and his colleagues for providing all the necessary facilities for conducting the Workshop and Exhibition.

Geological Survey of India
Hyderabad

Y. M. K. CHANDRA CHOWDARY
K. S. RAO