

architecture and the biocontrol potential of assassin bugs. Selective insecticides, which are safer to non-target beneficials should be identified. Possibilities of weeds in biological control, use of introduced parasitoids, *Encarsia haitiensis*, and *E. quadeloupae* for the management of spiralling whitefly *Aleurodicus disperses* on guava were also discussed.

Neem products, viz. Neem Guard, Nimbicidin, NeemGold and Rakshak reduced the pod borers, *Apion ampulum* and *Gydia ptychora* of green gram as comparable to fenvalerate. Two bio-agents, namely, *Metarhizium anisopliae* and *Bacillus thuringiensis* were equally effective in reducing the weevil population. Spraying of NeemAzal, *Hyptis suaveolens* leaf extract and the combination of *H. suaveolens* and *Melochia corchorifolia* leaf extract on groundnut reduced the population of *Spodoptera litura*, *Protaetia modicella* and *Aphis craccivora*. They were found to possess significant ovicidal and larvicidal activity against *Helicoverpa armigera*.

The importance of accurate identification of the pest species was discussed for successful pest management programme and the following are the key criteria: (a) identifying the pests to be managed in the crop production system, (b) defining the management unit, (c) developing pest management strategy, (d) developing reliable monitoring techniques, (e) estab-

lishing economic thresholds and (f) evolving descriptive and predictive models. Pheromones (sex pheromones, aggregation pheromones, etc.), NPV, and some of the parasitoids are highly host-specific and proper identification including the biotype is essential. Success of insect-resistant varieties of crops depends entirely on the accurate identification of the pests and their biotypes.

A new synthetic pyrethroid Lambda cyhalothrin applied at 20 ppm effectively controlled shoot and capsule borer, *Canoglyphus punctiferalis* in cardamom and a new insecticide Proflinophos reduced the damage caused by tea mosquito bug, *Helopeltis antonii* on cashew. Imidacloprid and quinalphos were most effective in controlling the mealy bug, *Maconellicoccus hirsutus*.

The IPM package of mulberry leaf webber, *Diaphania pulverulentalis* consists of releasing natural enemies, namely, egg parasitoid, *Trichogramma chilonis* at one lakh/acre and pupal parasitoid *Tetrastichus howardi* at 1 lakh/acre coupled with spray of 0.076% DDVP followed by neem pesticide for effective management.

The symposium discussions centered around identification of newer components of IPM, adoptability, accessibility, economic feasibility and suitability for large-scale implementation. A thrust was given for developing newer IPM models

incorporating various components for the management of insect pests in different agro ecosystems.

The panel discussion at the end of the symposium highlighted the following: efforts should enhance studies on biosystematics, biodiversity conservation and enhancement, change in pest scenario in different states, collection of quantitative data on the impact of various agronomical and IPM practices, development of IPM models, field demonstrations and dissemination and working out economics of IPM for different cropping systems. Surveys and collections of native isolates of *Bt* and studies on bioecology of entomophages on *Bt* transgenics are required for insect pest management. Sub-lethal effects of pesticides and botanicals on beneficial fauna are needed to create awareness for the use of pesticidal plants. HRD programmes and networkings are required for extension functionaries, industries personnel, pesticide dealers, NGOs, IPM workers and farmers for better coordination and utilization of IPM modules and exchange of materials for sustainable IPM.

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Vindhyan vagaries*

Vindhyan ranges in central India are the abode of two revered Hindu deities – Vindhyavasani Devi and Sharda Devi. The Kanderia Mahadev-Khajuraho Temple, a World Heritage Monument made up of Ken Sandstone, which constitutes a part of Vindhyan terrain, is also situated in this chain of hillocks. These hillocks have traditionally attracted and inspired saints, philosophers, poets, and writers. The Ashoka Pillar of Sarnath, the lion cap of which now constitutes the national emblem of the Government of India, was carved out of Vindhyan sandstone. Not only have the Stone Age men left indeli-

ble marks in these hills in the form of cave paintings but also some of the impregnable fortresses like those at Rohtas and Kalinjer are in this chain. The region has been explored for precious diamonds and minerals. The same Vindhyan ranges are now being explored by investigating geoscientists to find answers to some of the important questions pertaining to the limit and extension of the basin and steps in the evolution of early life based on reports of advanced (triploblastic) animal traces in Chorhat Sandstone, Small Shelly Fossils in Rohtas Limestone, etc.

The Palaeontological Society of India and Geology Department of the Lucknow University organized an International

Field Workshop on Vindhyan Basin from 3 to 11 December 2002. Thirty-four participants from universities, institutions and academia from various parts of the world assembled at Varanasi – the oldest living city of the world. S. Kumar, the organizing secretary, introduced the problems of Vindhyan, aims and objectives of the workshop and the weeklong itinerary (Figure 1).

On the first day, the team covered Kaimur and Semri groups of rocks exposed in Varanasi–Robertsganj–Ghurma, Dala–Chohan Road and Dala–Billi Road sections. Excellent outcrops of Kaimur Group were seen near Adalhat about 24 km from Varanasi and close to south of Arhaura (36 km from Varanasi). Team

*Based on an International Field Workshop on Vindhyan Basins, Central India.

members were not unanimous on the environment of deposition of the Dhandraul Quartzite. It transpired that models proposed earlier needed revision in the light of new information and facies analysis carried out in the Vindhyan basin. Dhandraul Quartzite and Scarp Sandstone are exposed in the Robertsganj-Ghurma Ghat Section, which is an ideal location for the study of Upper Kaimurs. At the base of the Scarp Sandstone, a poorly developed thin horizon of Bijargarh Shales is exposed. In the abandoned Ghurma Mine Section, excellent exposures of Rohtas Limestone – the topmost horizon of the Semri Group – are seen and it is here that a contact between the Semri and the Kaimur is also noted. There are some bands of black shales containing pyrite within the Rohtas Limestone. Some participants collected samples for palaeoenvironmental studies. Poorly preserved carbonaceous megafossils and material for sulphur isotope studies were collected from the Ghurma Mine Section. Exposures of Porcellanite Formation are easily accessible and seen in the Dala-Chopan Road Section. The nature of enigmatic features on the surface as well as the sole of the porcellanites with the well-marked colour bandings was a subject of argument. Most participants opined that the features were abiogenic and formed either by degassing or dropping of large chunks of

bomb-like pieces. A faulted contact between the Basal Conglomerate and Bijawar Phyllites was seen half a km from Dala Township towards Billi. It helped one to understand the Vindhyan succession in correct perspective.

The team members got another opportunity to see the Bijawar Phyllites (Mahakoshal Group), some 3 km from Dala Township. The Phyllites are highly folded and well-exposed on either side of the road. On the next stop in the Dala Mines, the participants saw the best-exposed lower and middle parts of the Kajrahat Limestone. In this section limestones are high dipping with intercalations of varied colour shales that show low angle discordances. A gradational contact between Basal Conglomerate and Kajrahat Limestone was seen on the way to mine from Dala Factory. A dolerite dyke piercing the Kajrahat Limestone was also noticed. In view of recent data, the participants felt that these dykes may be dated again to constrain the age of the Semri Group. The next stop was at the Salkhan Hill Section, exposing the Fawn Limestone. It constitutes one of the best-preserved *Conophyton* localities in the world. There was wide-ranging exchange of views and information between the experts, media, local administration and the people of surrounding villages. The forest department and local administration have erected a barbed wire fencing

to preserve this locality for future generations. The participants appreciated the concern for preservation and safety of the stromatolites and felt that similar attempts could be replicated to preserve the geological heritage at other places. In this section overlying glauconitic sandstones of Semri Group was also noticed. Engaging times on Salkhan Hill restricted the visit to nearby Pataudh Hill, which incidentally marks the change in Limestone facies to bluish grey. The only section of Olive Shales Formation underlying the Fawn Limestone is exposed on either side of the Lift Canal Pumping station in Sonbhadra district. The low water levels enabled the participants to make a good collection of samples. Delegates of the Oil and Natural Gas Corporation Limited were specifically interested in the Olive Shales to know the Total Organic Carbon (TOC) of the shales for comparison with drill core data. In the Dala Mines, participants saw the lower and middle part of the Kajrahat Limestone, whereas the uppermost horizon of the Kajrahat Limestone is seen near Bari in the hillock, which was mined for dolomite. Various types of stromatolites are noted in the dolomite beds of the hillock in another abandoned mine of Bari. The columnar stromatolites of both Salkhan and Bari show NE inclinations that have probably something to do with the earth's inclination towards the sun at the time of formation of these stromatolites. This aspect needs to be examined in detail.

While shifting the camp from Renukoot to Rewa, the participants saw exposures of Rewa Group in Drummandganj Ghat section, Mirzapur district. The complete section of Rewa Group was studied along the road of Drummandganj Ghat section. The Panna Shale Formation is exposed at the base of the hillock. It is followed by Lower Rewa Sandstone, Jhiri Shales and Upper Rewa Sandstone formations. Carbonaceous fossils are known from the Jhiri Shales but once again participants could not obtain proper lithology to find any remains of *Chuarina* and *Tawuia*.

Most participants were eager to see Seilacher *et al.*'s locality¹ for finding some traces of triploblastic remains. The team then packed for Rewa-Chorhat section. Rewa city itself is spread over the Bhandar Limestone. Rocks of Rewa Group are encountered east of Govindgarh, some 20 km from Rewa. Here Up-

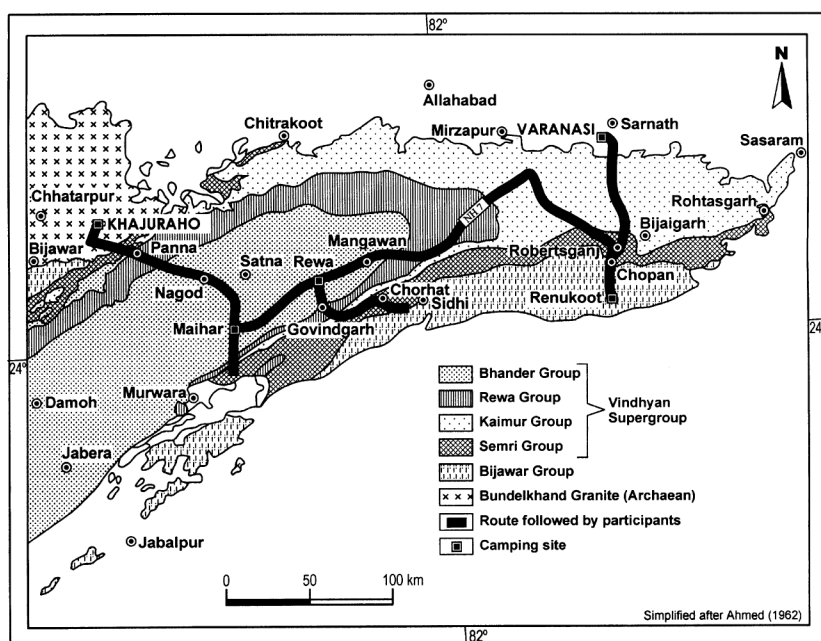


Figure 1. Simplified geological map of the area covered and route followed by the participants during field workshop.

per Rewa Sandstone overlies the Jhiri Shales and the Lower Rewa Sandstone. But on the ridge it was difficult to demarcate Lower Rewa Sandstone from Kaimur Sandstone. Here even the different lithological formations and members of Kaimur Group are not properly established. It is considered a lithostratigraphic problem yet to be resolved. Similarly, the depositional models of the eighties need to be refined in the light of new sedimentological inputs of the last two decades. On the lower reaches of the ridge, Bhagwar Shales are well exposed. From the equivalent beds in Rohtas locality in Bihar, Azmi had reported shelly fossils that made all the participants interested in collection of the samples of Bhagwar Shales. Hinauti Limestone, in which *Colonnella columnaris* type of stromatolites is noted in some of the roadside blocks, underlies Bhagwar Shales. If described and documented systematically it is possibly the first record of stromatolites from the Rohtas Limestone equivalent rocks. At Chorhat, beautifully preserved sedimentary structures are present, similar to those described in textbooks. Profuse development of ripple marks, both current and wave ripples, mud cracks, synaeresis cracks, sole marks, flute casts, drag marks, etc. are present for kilometers by the side of the road that follows the strike of the Chorhat Sandstone horizon. The participants searched for biological remains, trace fossils or impressions, in vain. Several putative structures were discussed but none could be considered as unequivocal biogenic structure. With that, the hopes for considering the Seilacher *et al.*'s specimens¹ as biogenic became remote. In the absence of precise locality details, participants were unable to pinpoint the controversial spot of collection but all were sure that any biogenic activity could not be confined to a meter square section. If present, it had to exist at adjoining places too. The participants felt that in the age of GPS, Seilacher *et al.*¹, should have been precise in furnishing data about their locality with longitude and latitude or should have accompanied the team, especially when their report was going to alter the evolutionary clock. The participants collected porcellanite samples in the Son Valley Section south of the Chorhat Township. It is another exposure of porcellanite similar to that in Dala–Chopan road section in Sonbhadra district. Sampling was

possible because water level was low during that period of the year.

The porcellanite problem of Vindhyan Supergroup is many-faceted. Earlier the Porcellanite Formation of Semri Group was considered to be the only occurrence of volcanics in the entire Vindhya. Subsequent studies have shown the presence of volcanics at the base of Kaimur Group and at different levels within the Rewa Group in central India. Presence of volcanics in the Upper Vindhyan sequences questions the widely held belief that Upper Vindhya are free from any volcanic episodes and represent a quiescent tectono-sedimentary history. Recording the timing of these episodes can help constrain the age of various groups of the basin.

The participants then moved towards SW on National Highway 7 to their next destination in Maihar. On the way to Maihar the Tamas River Section exposes good outcrops of the Bhandar Limestone. At Emliya, profuse development of various stromatolites was noticed. In this section too, the stromatolites are inclined in NE direction. Extensive black-bedded chert full of oolites is found in the locality. We missed visiting the important section from where sponge spicules-like forms and microstromatolites have been reported in similar cherts². The outcrop in Pathera *Nala* Section is being badly damaged due to sundry usage. This is a unique section where a thin limestone in Sirbu Shales Formation contains exceptionally large domal stromatolites. Some of the participants felt these domal stromatolites may be part of carbonate mounds that may be of even younger age. We climbed the typical Vindhyan Scarp in the Maihar–Rampura section in which the youngest horizon of the Vindhyan Supergroup – the Maihar Sandstone is exposed. It shows very good sedimentary features and algal mat textures. Such textures are supposed to have been death traps for early animals. The algal mat texture makes the Maihar Sandstone a potential site for search of animal remains. Sirbu Shales is also exposed in the same section, from which samples were collected. *Chuarina* and *Tawuia* have been recorded from this section³ but good specimens could not be collected on the trip.

The participants then visited the Bhagwar Shales exposed in Badanpur–Sarlanagar Section. Shelly fossils have been reported earlier from this lithology. Samples were collected for maceration to

check the report of shelly fossils. The Kaimur Sandstone followed by Jhiri Shales and Upper Rewa Sandstone formation of Rewa Group overlies Bhagwar Shales. Exposures in the mines of Maihar Cement Factory are good for studies of Rohtas Limestone, the upper horizons of which are represented by calcareous shales. Some silicified shales (the Bhagwar Shales) are also exposed in the locality. The contact between the Rohtas Limestone and the Kaimur Sandstone is also seen in the section. Some of the participants could collect minute *Chuarina* from the uppermost part of the Rohtas and a few found slabs with cast of *Grypania*-like remains. These remains are larger in size and relief (thickness) than the type specimen of *Grypania*. The Kajrahat Limestone is well exposed in the beds of Chhoti Mahanadi River. Of the three members of this Limestone, the middle part, which is biohermal, is well exposed on either side of the Chhoti Mahanadi. In this section, several cycles of varied types of stromatolites are noted. These include *Conophyton*, *Colonnella*, *Calypso*, *Thyassageles* and *Jacutophyton*. The columnar stromatolites here too show NE inclination, indicating the strong possibility of heliotrophism. The good preservation, varied types and cyclic nature of the stromatolite growth and easy access to the area made the overseas participants suggest that this locality can, with a little effort, be made a tourist spot. There was concern that the area would be lost for study after the completion of Ban-Sagar Dam by the year 2005. Preservation and curation of Salkhan Hill stromatolites by locals, administration and forest department sets a good example for the Madhya Pradesh Directorate of Geology and Mining and Tourism Department to develop the site and preserve stromatolites.

On the last day of the workshop, the participants moved the base to Khajuraho. On the way we saw National Mineral Development Corporation's Panna Diamond open cast mine where the Kimberlite pipe intruding the Kaimur Sandstone is seen. The Kimberlite is being mined for diamond for the last 40 years; the yield is 10 carats/100 tonnes. Participants were shown the diamonds mined the previous day. On the way to Khajuraho good exposures of the Bundelkhand Granites, on which the Vindhyan basin rests are seen on either side of the road.

One of the interesting features of the field workshop was the post-dinner formal/informal deliberation by experts. Jokhan Ram (ONGC) presented new geophysical data for resolving the litho-stratigraphic problems of the Vindhyan. The data show that there is clear angular unconformity between the Semri and Kaimur groups at certain places whereas at other spots the same succession seems to be concordant. Report of gravity low over Bundelkhand Granite Complex (BGC) near Jhansi was new information that has been interpreted in terms of thrusting of BGC over Semri sediments. In recent years, ONGC drilled three different wells in Vindhyan basin namely Jabera-1, Damoh-I and Kharkhari (in progress). Occurrence of hydrocarbons was established in Jabera-1. However, commercial oil/gas has not been struck so far. Bruce Runnegar of the University of California, Los Angeles talked about *Grypania* and its antiquity in the world record. Hans Hofmann (McGill University, Montreal) talked on pseudofossils, dubiofossils and true fossils on the scale of 5 that was enlightening. He showed transparencies of various sedimentary features including some features on volcanic rocks that could easily be mistaken for fossils. Publication of such objects as

true fossils confuses the Precambrian palaeobiologists. B. Prasad (ONGC) showed some interesting acritarchs, including *Tapania plana* in the subsurface Vindhyan equivalent sediments and in the sediments of recently drilled boreholes. His findings suggested that Semri Group is Mesoproterozoic in age while the younger formations belonging to Kaimur, Rewa and Bhandar groups are Neoproterozoic in age. Vindhyan basin sediments, therefore, do not transgress into Cambrian and their sedimentation terminates well below the Terminal Proterozoic. Azmi (Wadia Institute of Himalayan Geology, Dehradun) reported occurrence of Small Shelly Fauna (SSF) in the Semri Group sediments based on a new set of samples. Objects shown in slide and samples looked interesting and akin to SSF, but could not convince all the participants. Discussions during the workshop brought forward the new line of investigations to be pursued in future.

Some of the salient recommendations based on participants' views are: (a) Generation of reliable radiometric data for the Vindhyan sediments for solving many of the inherent problems of this basin. (b) The available palaeontological data should be scrutinized and search be made for additional fossil-bearing hori-

zons, especially in the Upper Vindhyan. (c) To assist others in duplicating fossil reports, it should be made mandatory to give GPS values for publication of any palaeontological record. (d) There is an urgent need to establish high-resolution sequence stratigraphy and chronostratigraphy. (e) Similarly, environment of deposition of different litho-stratigraphic units is to be established with a modern approach. (f) International collaborations are required in many fields of Vindhyan studies. (g) Many geologically important sites of Vindhyan, e.g. Salkan (UP) and Chhoti Mahanadi (MP) should be developed as tourist spots, and declared as National Geological Heritage by enactment of law.

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