II. PREVIOUS WORK

Several workers have made contributions to the Gondwana flora of India and the vast literature is available on it. Following workers have made important contributions on the Indian Gondwana flora. They are Feistmantel (1870, 1889), Zeiller (1902), Arber (1905), Seward and Sahni (1920), Sahni (1931), Surange (1957-1973), Pant (1958), Bharadwaj (1953), Maheshwari (1965), Maithy (1968, 1977), Chandra & Surange (1976-1979), Chandra & Prasad (1979), Pant & Gupta (1968-1971), Prasad and Chandra (1978-1979), Mahabale (1964-1966), Vagyani and Mahabale (1974).

The present investigation deals with only fossil flora of the Kamthi formation, therefore, the previous work includes the contributions made by several workers on the formations upto Upper Permian only.

The Palaeozoic era in India is divided into following stages -

1) Talchir, 2) Karharbari stage, 3) Barakar stage, 4) Barren measure stage, 5) Raniganj stage. These stages show Lower Gondwana flora representing the elements of Glossopteris flora found in different parts of the country.

1) Talchir stage : In this phase the Indian peninsula showed elevation of land surface covered by ice. This situation was present in the beginning of early part of the Talchir deposition. The vegetation developed in the basins. The

climate got changed due to melting of ice, in the later phase. It helped the development of the ferns which later on flourished due to warm temperature and more sunlight.

It is considered as the lower most part of the Lower Gondwana and the flora is not richer than the higher horizons. Feistmantel (1882) described Equisetaceous stem from Goraia and Samaropsis from South Rewa. Surange and Lele (1956) described from South Rewa Gondwana basin following fossil plants Gamgamopteris, cyclopteroides, G. cycl. var. attenuta, G. angustifolia, Noeggerothiopsis hislopi, Samaropsis gorainsis, Cordaicarpus furcata, Paranocladus indica, Arberia umbellata. From Rikba plant stage following plants have been recorded. Gangamopteris cyclopteroides var. acumilata, G.cycl. var. cordifolia, G.major, G. obliqua, G. buriadica, Glossopteris communis, G.indica, V.indica, Cornocarpus, Rotundocarpus. The presence of Gangamopteris in large proportion and absence of Pteridophytes is an important feature of Talchir Stage. By the end of this stage following plants become extinct, Gangamopteris, cyclopteroides, var.attenuta, G.spathulata, Paranocladus indica. Ganguli (1959) described from Chirmiri coal fields Gangamopteris, Glossopteris, Cordaicarpus and Samaropsis. Lele (1966), Swarup and Singh (1968) described Gangamopteris and Noeggerathiopsis from the Singrauli coal field.

Recently Venkatachala (1987) have discussed Lower Gondwana Marine incursions. They further reviewed Palynological

data of the Talchir formation. According to Tiwari (1975) and Tiwari and Tripathi(1988) the index fossils of the Talchir formation are Plicatipollenites Parasaccites, Verrikkipollenites, Callumispora, Quadrisporites. Venkatachala and Rawat (1973) described from Talchir sediments of Chingleput area near Madras Plicatipollenites, Leiosphaeridia, Leiofesa and Dactilofusa. The last three shows acritrch assemblage showing marine incursions.

Bharadwaj, Tiwari and Anandprakash recorded Leiosphareids from Dodhara area of Satpura basin. Rawat and Jain (1985) described the Palynoflora of Talchir sediments found in the Pranhita, Godavari valley and identified a monosaccate dominant assemblage along with Leiosphaeridia. Recently Tiwari et al. (1987) have recorded a Talchir palynoflora in the South West part of Athgarh basin. The flora includes Plicatipollenites and Leiosphaeridia. Banerjii and D. Rozario (1987) described from the Talchir sediments in Rajmahal basin, Monossaccate Pollen rich palynoflora and Leiosphaerides.

2) Karharbari Stage : It is named after Karharbari village of Giridihcoal field in Bihar. Pareek (1969) distinguishes Karharbari for its mature soft, yellowish sandstones alongwith greenish yellow material to that of Talchir having gritty and Pabbly sandstones having pieces of quartz and feldspar. It is also found in the son valley. Feistmantel (1879) described from Giridih coal field several fossil plants. Dasgupta (1928) described Gangamopteris cyclopteroides, Glossopteris indica, Gondwanidium validium, Buridia heterophylla, Cordaites

whittiana, Schizoneura gondwanensis from this stage. Fox (1931) described from Karanpura, Hutar, Daltonganj, Umaria, Pali, Mohapani and Shahpur coal fields several fossil plants. Recently Maithy (1966-b) summarized the fossil flora found at different localities. It includes Gangamopteris clerkeana, G.karharbariense, G.kashmiriense, G.cyclopteroides, Noeggerathiopsis hughesi,N. zeilleri, N.spathulata, N.stoliczkenus, N. lacerata, N.indica, N. gondwanensis, N.densinervis, G. damudica, G. communis, Gondwanidium validum, Vertibraria indica, Buriadia sewardii, Psygmophyllum sp., Euryphyllum whittianum, Rubidgea lanceolata, R.emarginata and Samaropsis ganjrensis.

Recently Manju Banerjii (1987) discussed the bioassemblage of Karharbari sediments. She reviewed the work of Srivastava (1973), Maithy and Mishra(1984), Pant & Gupta (1968), Pant and Singh (1976), Maheshwari & Tiwari (1986). According to Banerjii 31 genera and 100 species of Mega fossils are recorded from Karharbari sediments of different coal fields. Following table gives megafloral assemblage from Karharbari sediments.

Genus	Qualitative Analysis	Relative abundance of occurance
Glossopteris	Mostly fine mesh form and also medium mesh form.	common
Gangamopteris	Diverse	Dominant
Noeggerathiopsis	Diverse	Dominant
Botrychiopsis	Three species	Occur in Karharbari only.
Ottokaria	Three species	Dominant
Buriadia	Diverse	Dominant
Euryphyllum	Two species	Occur in this horizon only.
Rubidgea	Three species	Occur in this horizon only.
Gymnospermic seed	Diverse	Frequent
Vertebraria	Two species	Frequent
Schizoneura & Equisetaceous stem	Diverse	Frequent
Neomeriopteris	Three species	Frequent

Following Palynoassemblages were recorded from Giridih coal field by Maithy (1965), Bharadwaj (1966), Srivastava (1975). Similar assemblages were recorded from number of coal fields by Bharadwaj (1971-1974), Maithy (1969-b). These contributions showed that 67 genera and 200 species are

recorded from Karharbari sediments. The assemblage shows dominance of trilete spores and monosaccate pollengrains. Following important genera are recorded (1) Callumispora, (2) Cyclorgranitisporites, (3) Granulatisporites, (4) Gravitriletes (5) Microbacculispora, (6) Lophotriletes, (7) Microfoveolatispora. These are trilete taxa and (1) Parasaccites, (2) Plicatipollenites, (3) Virrikkipollenites, these are common monosaccate pollen grains. According to Banerjii the floristic pattern of Karharbari stage indicate the members present in Talchir and Barakar and forms a continuation of Lower Gondwana sequence. She further remarked that Karharbari and Talchir show a distinct biostatigraphic zone. It includes megafossils like Gangamopteris, Noeggerathiopsis, Glossopteris megafossils and Parasaccites, Plicatipollenites, Callumispora microfossils.

Recently the fossils from Kashmir and Arunachal Pradesh have been studied. Kapoor (1979), Singh et al. (1982) and Lele and Maithy have described from Nishatbag in Kashmir. The megafossils Gangamopteris, Kashmirensis, Cordaites and Psygmophyllum which is the member of Ginkgoales. Singh(1979) described from Arunachal Pradesh a rich palynoassemblage having Callumispora and other genera from Garu formation in Siang district.

3) Barakar Stage : It is termed as Lower Coal Measures and succeedes Karharbari Stage. In India it is major coal producing strata. Therefore, economically more important than

other Lower Gondwana Stages. It experienced warm temperate climate which helped the growth of better vegetation. The Barakar flora is studied by following workers Maithy (1965-a, 1969, 1971-a, 1971-b, 1974-a), Kulkarni (1971), Surange (1966), Surange and Saxena (1958), Agashe and Chitnvis (1971), Agashe (1977), the following plants were recorded :

Glossopteris indica, Glossopteris intermitens, G.fuses, G. browniana, G.damudica, G.formosa, G.retifera, G.tortuosa, G.stricta, G.karanpurensis, G.barakarensis, Phyllothica indica, P. griesbachii, P.crassa, Trizygia speciosa, Samaropsis hughesi, Cyathia cf. tachihatcheffi, Eretomonia karanpurensis, Dictiopteridium sporiferum, Rhipidopsis gondwanensis, Pseudoctenis balli Walkomiella, indica, Voltzia heterophylla, Gondanidium indicum, Ginkgophyllum kidstonii, G.sahnii, G. hollandii, G.hydenii. Following coniferous woods have been reported - Barakaroxylon jhariense, B. monocanalosum, Prototaxopitys andrewsii, Dadoxylon barakarensis, D.parenchymosum, D. kharkhariense. Lele, Swarup and Singh (1968) have recorded from Singrauli coal fields several species of Gangamopteris Glossopteris, Samaropsis & Cordaicarpus. Lele (1969) described Alatocarpus a new Platy-spermic seed. In Wardha Godavari valley this stage occurs in several coal-fields in Chandrapur district. Feistmantel (1881) described several well preserved specimens of Pterophyllum like fossils from the Barakar group in the Auranga coal field. He further described two species of Rhipidopsis viz. R.ginkgoides, R.densinervis, Seward and Sahni (1920) instituted the genus Barakaria which includes a

a specimen earlier described by Feistmantel (1881) as Cyclopitys dicotoma from the Barakar formation of the Aurunga coal field in Bihar. Recently Srivastava (1987) described Lower Barakar flora of Raniganj coal field and described following plants : Equisetales Lelstotheca robusta, L. stricta, Trizygia speciosa, Phyllotheca indica.

Filicales → Neomeriopteris polymarpha, N.hughesii.

Glossopteridales → Rubidgia obovata, Euryphyllum whittianum, Gangamopteris, Cyclopteroides, G. intermedia, G.major.

Several species of Glossopteris, Palaeovittaria, Kurzii, Gondwanophyllites, Scutum species and Lidgettonia.

Gordaitales Noeggerathiopsis hislopii, N.minor and Cordaites sp.

Seeds → Samaropsis sp, Cordaicarpus sp., Cornocarpus sp. and Arberiella type of sporangia. Recently Tiwari and Tripathi (1988) described palynological zones in the coal bearing Gondwana of Peninsular India. According to them striate and non-striate bisaccate pollens are found in large number. The older assemblage represents Scheringipollenites while younger one dominates Faunipollenites.

4) Barren measures Stage : Barren measures is also described as Ironstone shale formation. It shows comparatively poor fossil flora. It is due to adverse condition which created swampy areas and elevation of land mass. Feistmantel (1881) and Kar (1968) described the following fossil plants

Glossopteris indica, G.communis, G.angustifolia, G. browniana, G. damudica, G.retifera, Gangamopteris cyclopteroides,

Rhabdoptaenia danaeoides, Macrotaeniopteris sp., Cyclodendron leslii, Sphenopteris hughesii. Feistmantel (1881) described from the Ironstone shales of Kulti the impression of Bathrodendron stem, Surange (1966) included it under the genus Cyclodendron.

Bhardwaj (1971) divided Ironstone shale formation into three zones on the basis of different proportions of the genus Densipollenites. The basal zone having 1 to 11 percentage of this genus while the middle zone shows 12-40% and upper zone showing 2-7%. Kar (1966) have also contributed on the palynoflora of Ironstone shale. Bharadwaj (1971) further remarked that palynoflora of Ironstone shale consist of striate bisaccate pollengrains in addition to Densipollenites assemblage.

5) Raniganj Stage : It represents the end of the Lower Gondwana and shows warm moist climate having thick forest developed along the 'river vallies'. The overall situation was quite favourable for plant growth due to plenty of water, bright sunlight, better rainfall and soil covering. As a result of this favourable situation a rich flora developed in the Raniganj stage which shows climax of the Glossopteris flora. Several workers have made contributions on the fossil flora of Raniganj stage they are Pant and Gupta (1968). Maheshwari (1965-a, 1965-b, 1965-c, 1966), Maithy (1971-b, 74-a) and Surange (1966, 1974) have given a detailed review of the megafossils found in this stage. The plants reported by these workers are as follows :

Schizoneura gondwanensis, Phyllotheca indica, P.griesbachii, Raniganjia bengalensis, Trizygia speciosa, Cyclodendron leslii, Dichotomopteris lindleyii, D.major, Pecopteris phlegopteroides, Ptychocarpus srivastavae, Sphenopteris hugheshii, S.polymorpha, S.polymorpha, S.lobifolia, Glossopteris angustifolia, G.arberi, G.communis, G. decipens, G.emarginata, G.indica, G.linearis, G.retusa, G.taeniodes, G.taeniopteroides, G.intermittens, G.waltoni, G.harrisii, G.tennifolia, G.petiolata, G.brongniarti, G.vulgaris, G.varia, G.tenuinervis, G.ghusikensis, G.contracta, G.browniana, G.cordata, G.damudica, G.formosa, G.leptoneura, G.orbicularis, G.retifera, G.sahnii, G.srivastavae, G.tortuosa, G.stricta, G.gondwanensis, G.verticillata, G.eurynura, G.subtilis, Palaeovittaria kurzi, Macrotaeniopteris danceoides, M.feddeni, Gangamopteris cyclopteroides, Noeggerathiopsis hislopii, Glossotheca utkalensis, Eretmonia utkalensis, E.hingirdiensis, Lidgetonia indica, Dictyopteridium sporiferum, Senotheca mahudensis, Scutum sp., Cistella sp. Rhipidopsis densinervis, R.gondwanensis, Pseudoctenis balli, Senia reticulata, Voltzia heterophylla, Samaropsis raniganjense, Stereocarpus emarginatus. Woods : Dadoxylon jamuriense, D.ningahense, D.parbeliense, Kaokoxylon zelesskyi, Trigonomeylon raniganjense, Damudoxylon waltonii, Megaporoxylon krauselii. Recently Chandra and Chandra (1988) have given vegetational changes and their climatic implications in coal bearing Gondwana. The term coal bearing Gondwana here includes all the stages of Lower Gondwana. They have given brief review of Megaflora and Palynoflora of the Raniganj Stage in India. They have noted

the absence of Lycopodes in Raniganj but Pteridophytic remainse are quite common. Equisetalean genera like Phyllotheca, Raniganjia, Schizoneura and Trizygia are present. Fern genera like Neomeriopteris Dictomopteris, Dizeugotheca, Asansolia, Trithecopteris, Damudopteris and Leleopteris. The gymnosperms shows a major portion and Glossopteris attained climax. As many as 40 species of Glossopteris are represented. According Bajpai (1985) Gangamopteris is absent but other leaf genera like Palaeovittaria, Rhabdotaenia and Belemnopteris. Cycadalean genera like Teronelsonia, Pseudopteris and Senia are also present. Several Glossopteridian fructifications have been discovered from Raniganj stage by Chandra and Surange (1976-1977). The male fructifications are Eretmonia and Kendostrobus while female fructifications are Venustostrobus, Jambadostrobus, Plumstadiostrobus and Dictyopteridium. The number of Petrified woods like Dadoxylon, Kaokoxylon and Trigonomyleon have been described.

The palynoflora indicates trilete and monolete spores. Maheshwari (1967), Kar (1970-b) found that Raniganj coal field. Disaccate, striate pollen are dominant Polyplicates are common while triletes are few. Trivedi and Mishra (1970) also described palynoflora of Raniganj from the contribution of above workers. It is found that following genera represent the Raniganj palynoflora. Punctatisporites, Verrucosisporites, Decisporis, Kraeuselisporites, Lundblandispora, Playfordiaspora, Densipollenites, Striomono-saccites, Alisporites, Striatites, Verticipollenites, Lahirites, Lunatisporites, Gondwanipollenites,

Striatopiceites, Sulcatisporites, Labisporites.

6) Kamthi Stage : It is characterised by red and grey sandstones and conglomarates. The colour of sandstones is variable. Kamthi is considered as homotaxial with Raniganj by Prasad & Chandra (1981) and Surange (1966).

However, there is difference of opinion about its age. Vagyani and Mahabale (1974) consider it as Lower Triassic in age. Hence the previous work on the Kamthi formation is separately considered. Kamthi formation overlies the Barakar in the type area. In the Wardha-Godavari valley it is placed between Ironstone shale and Yerapalli formation. In the South it is known as Chintalpudi sandstone and is overlain by the Upper Gondwana of the East Coast.

Bunbury (1861) first time described the fossil plants from the type area. The Glossopteris is represented by G.leptoneura, G.stricta, G.musaefolia, G.damudica, G.angustifolia, G. indica. The equisetales represents Phyllotheca and Schizoneura. The other members are Neomeriopteris which is a fern, Vertibraria which is a fern, Vertibraria which is rhizome and Taeniopteris which is a Cycadophytic leaf. Feistmantel (1880) described from Chandrapur district, Glossopteris indica, G.browniana, G. Cf. musaefolia. Other members described by him are Actinopteris sp. and seeds called as Cycadinocarpus. He also recorded from another locality Phyllotheca indica, Schizoneura, Glossopteris indica

and G. browniana. Oldham (1869) described fossil plants from Kamthi a type area, Polytheca indica, Vertibraria indica, G.communis, G.damudica, G.browniana, G.stricta, G.musaefolia, G.leptoneura, Gangamopteris hughesi, Angiopteridium Cf. madlendii, Macrotaeniopteris danaeoides, M.feddeli and Noeggerathiopsis hislopi. Feistmantel (1887) described from Wardha Godavari valley the following plants -

Macrotaeniopteris danaeoides,M.feddli, Angiopteridium Cf. Amactlendii, G.communis, G.stricta, G.mŭlasfolia, G.indica, G.damudica, G.angustifolia, G.leptoneura, Gangamopteris hughesi, Noeggerothiopsis hislopi, Anthrophyopsis and Rhipidopsis densinervis.

Recently Chandra & Prasad (1981) described two assemblaes from Bazargaon and kanhargaon localities in Chandrapur district of Maharashtra. They described following plants - Neomeriopteris hughesi, Trizygia speciosa, Schizoneura gondwanensis, Glossopteris musaefolia, G. stricta, G.leptoneura, G.mahudensis, G.indica, G.raniganjensis, G.bosi, G.angustifolia, G.lanceolatus, G.tueniofolia, G.densinervis, G.venustus, Vertibraria. The gymnospermous woods described by these authors are Dadoxylon chandrapurensis, D.maharashtraensis, D.parenchymosum, Trigonomeyelon kamthiensis, Kaokoxylon pseudotrimedullaris, Taxopitys indica, T. surangei, Australoxylon kanhargaonse, A.longicellularis, Zalesskeoxylon lepekhini, Z.simplexum, Prototaxoxylon uniseriale, P.maithyi and Bairoxylon multiseriale.

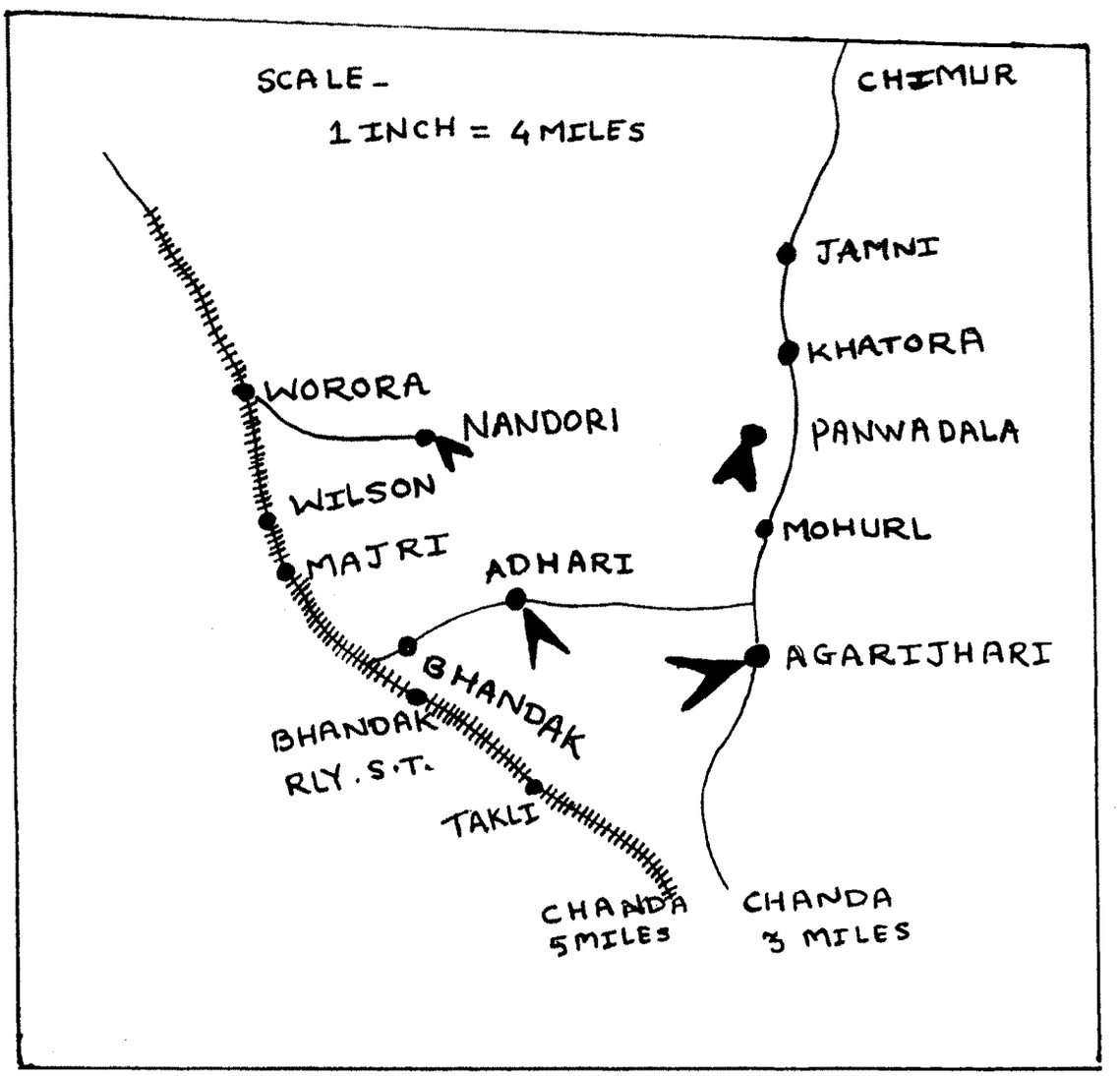
Chandra & Prasad (1981) have reported from Bazargaon Schizoneura gondwanensis, G.musaefolia, G.mahudaensis, Dictiopteridium sporiferum from Kamthi formation in Hingrida Ghati of Dhankenal district in Orissa. Chandra & Rigby (1981; 1983) described several fossil plants they are Cyclodendron leslii, Trizygia speciosa, Phyllotheca indica, Raniganjia bengalensis, R.etheridyes, Schizoneura gondwanensis, Lelstotheca robusta, Sphenophyllum crenulatum, S.churulianum and S.utkalensis, Dizeugotheca phegopteroides, Neomeripteris hughesi, N. polymorpha, N.khanni, Pantopteris gracillus, Damudopteris bengalensis and Asansolia Cf. phegopteroides, Pseudopteris balli, Senia reticulata, Eretmonia utkalensis, E.ovata, Glossotheca utkalensis, G. orissiana, G.immanis, Dictiopteridium sporiferum Indocarpus elongatus, Cistella ovata, Scutum sahnii, S.elongatum, S.indicum, Partha indica, P.spathulata & Utkalia dichotoma. The authors suggests that Kamthi flora is also as diversified as the Ranjganj flora.

Agashe & Gowda (1979, 1982) described Araucarioxylon loharense, A.lathiense, A.surangei, Prototaxylon chandrapurense from Chandrapur district. Biradar & Bonde (1981) described Nandorioxylon saksenae. Varadpande (1977-a) described Dadoxylon satnaoriense. Prasad (1982) revised its name as Parapalaeoxylon satnaoriense, Chitaley (1949) described Dadoxylon chandaensis from Chandrapur district of Maharashtra. Lepekhina (1972-a) revised its name as Zalleskioxylon chandaense. Vagyani and Mahabale (1974) described Planoxylon indicum from Adhari in Chandrapur district. Mahabale & Vagyani

(1980) described Kamthioxylon adhariense from Adhari in Chandrapur district. Vagyani & Raju (1982) described Araucarioxylon nandori from Nandori in Chandrapur district. Vagyani & Jamane (1989) described Agathioxylon maheshwarii from Nandori in Chandrapur district. From this account it appears that several gymnospermous woods genera have been reported from Kamthi formation. Some genera from Kamthi formation shows their presence in the Raniganj but some are only present in the Kamthi stage. Genus Australoxylon is reported from India in the Kamthi stage only Genera like Kamthioxylon and Nandorioxylon are newly instituted showing the distinct characters. Hence they represent highlights of the flora. Again occurance of Planoxylon in India is from Kamthi stage only. These facts suggests distinct Xylotapho flora of Kamthi formation which differs from Raniganj in many aspects.

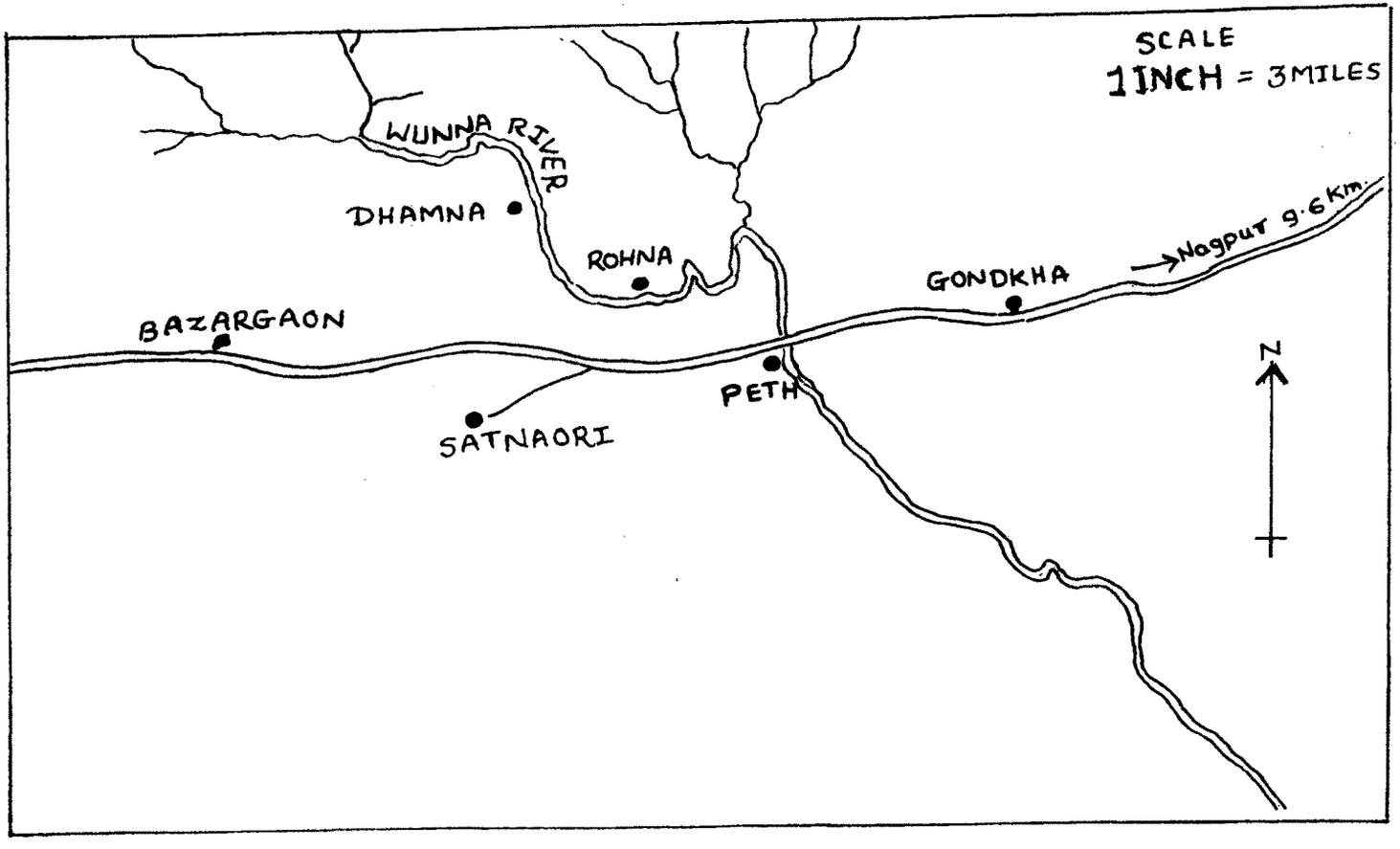
Srivastava & Jha (1987) described palyno flora of Kamthi formation in Godavari valley. They have recognized five assemblages based on morphological characters and also quantitative data. They show presence of Faunipollenites, Striatopodocarpites, Scheuringipollenites, Verticipollenites, Lahirites, Hindipollenites, Crescentipollenites, Distriatites, Lunatisporites, Hamiapollenites, Corisaccites, Lueckiosporites, Alisporites, Falcisporites, Vitreisporites, Chordasporites, Horriditriletes, Brevitriletes, Verrucosisporites, Gondisporites, Vesicaspora, Strisulcites, Polypodiidites, Osmundacidites, Parasaccites, Densipollenites, Guttulapollenites, Weylandites.

MAP-I



SHOWING THE FOSSILIFEROUS LOCALITIES IN CHANDRAPUR DISTRICT

MAP-II



SHOWING THE FOSSILIFEROUS LOCALITIES
IN NAGPUR DISTRICT