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STRATIGRAPHY OF THE BHIMA GROUP

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ABSTRACT

Detailed geological mapping of the Late Proterozoic Bhima Group (of northern Karnataka and Western Andhra Pradesh) was undertaken with the aid of Remote Sensing techniques. These studies re-emphasised the undisturbed nature of these shallow marine sediments, except in the close vicinity of various fault zones.

Observations of vertical and lateral facies variations in these sediments in parts of this basin, were followed up by studying the altitudes of exposures of the different lithological contacts (above m.s.l. datum) throughout the basin. This study unveiled serious descrepancies in the established lithostratigraphy of these sediments. The exposures of the so-called "Upper Bhimas/Andola Subgroup" occur at almost the same, or at places at lower altitudes than the adjoining exposures of the "Middle-Lower Bhimas/Sedam Subgroup". In light of the uneven, undulatory nature of the Archaean crystalline Basement, and the predominantly horizontal disposition of the Bhima sediments, it is pointed out that the Andola Subgroup represents only a lateral (facies variant) extension of the Sedam Subgroup and not a vertically superposed sequence.

The Bhima Group therefore can be divided into utmost two Formations, representing broadly co-eval sedimentological facies, namely the near shore clastic facies (= Rabanpalli Clastics Formation) and the relatively distal, tidal flat carbonate facies (= Shahabad Limestone Formation). The sedimentation in this basin is not a cyclic one, but the result of a solitary transgressive episode.

INTRODUCTION

Exposed in area of just over 5000 sq.km., as an en-echelon array of narrow strips, across a maximum linear extent of 160 km, in parts of northern Karnataka and western Andhra Pradesh, the Bhima basin is perhaps the smallest of the independently recognised 'Purana basins of Peninsular India' (c.f.: *Mem. Geol. Soc. India*, no: 6, 1987). Most authors are unanimous (eg: Mishra *et al.* 1987) in the conclusion that these are Late Proterozoic sediments deposited on a basement of Archaean age. The importance of this small basin, present on the northeastern edge of the Dharwar craton (of Naqvi and Rogers, 1987) lies in the extensive, commercially exploited cement-grade limestone deposits occuring in it.

The Department of Geology, University of Poona had undertaken detailed investigations of this basin under an I.S.R.O. — sponsored research project (1978 to 1982), with the aid of various remote sensing techniques (Peshwa et al., 1982). The results and interpretations presented here are based on the mapping and data collected during this project, along with subsequent follow-up studies.

It was realised that the existing (litho-) stratigraphic classifications of these sediments suffer from significant shortcomings, particularly in the context of: (a) the established principles of lithostratigraphic classification (G.S.I., 1971; I.S.S.C., 1976; Brenner and McHargue, 1988); and (b) the order of superposition of the component lithologies from the Bhima Group.

PREVIOUS WORK

The occurrence of unmetamorphosed and undisturbed sediments, resting upon the Archaean crystallines and capped by the Deccan Traps in this region, were first described by Newbold (1842-1845: c.f.: Foote, 1876). King (1872) named this sequence as the "Bhima Series". Foote (1876) classified them into the "Lower Bhima Series" and "Upper Bhima Series" comprising conglomerates-sandstones-shales and cyclic limestones-shales, respectively. This classification was revised by Mahadevan (1947) who divided this "Series" into three units, namely the Lower (conglomerate-shale-sandstone), Middle (limestone) and Upper (shale-limestone) Bhimas. While naming this as the Bhima Group, Janardhana Rao *et al* (1975) advocated lithostratigraphic nomenclature, because their classification was based purely on lithological discrimination. They diagnosed three separate "For-

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mations" from Mahadevan's "Upper Bhimas", but retained his "Middle" and "Lower Bhimas" as independent Formations.

Mathur (1977) suggested minor nomenclatural changes in the preceeding 5-fold classification. Mudholkar and Kale (1982) recognised the presence of four formal subdivions ("Members") of the Rabanpalli Shale Formation, throughout the Bhima basin. Mishra *et al* (1987) retained the five Formations of the Bnima Group, reassigning them to two sub-groups separated by a "para-unconformity". They have recognised as many as thirteen "members" (5 + 5 + 3) from the lower three Formations.

The classifications of the Bhima Group by the above-mentioned previous workers are summarised in Table 1, for comparisons. It is necessary to emphasise here that all these are essentially based on purely lithological considerations, and therefore lithostratigraphic, though several authors using these classifications have implied otherwise. In the following description (except in the conclusions, and wherever mentioned otherwise), the nomenclature of Mishra *et al* (1987) has been followed.

ALTITUDES OF CONTACTS OF THE BHIMA GROUP

Detailed geological maps were prepared during the ISRO — sponsored project, through the interpretations of LANDSAT MSS imageries on regional scales (1 : 250,00 and 1 : 100,000) and aerial photographs on local scales (1 : 60,000), followed by exhaustive field verification of various lithological contacts and structures. Fig. 1 is a compilation from these maps, depicting the entire Bhima basin.

The geological maps were draped over the Survey

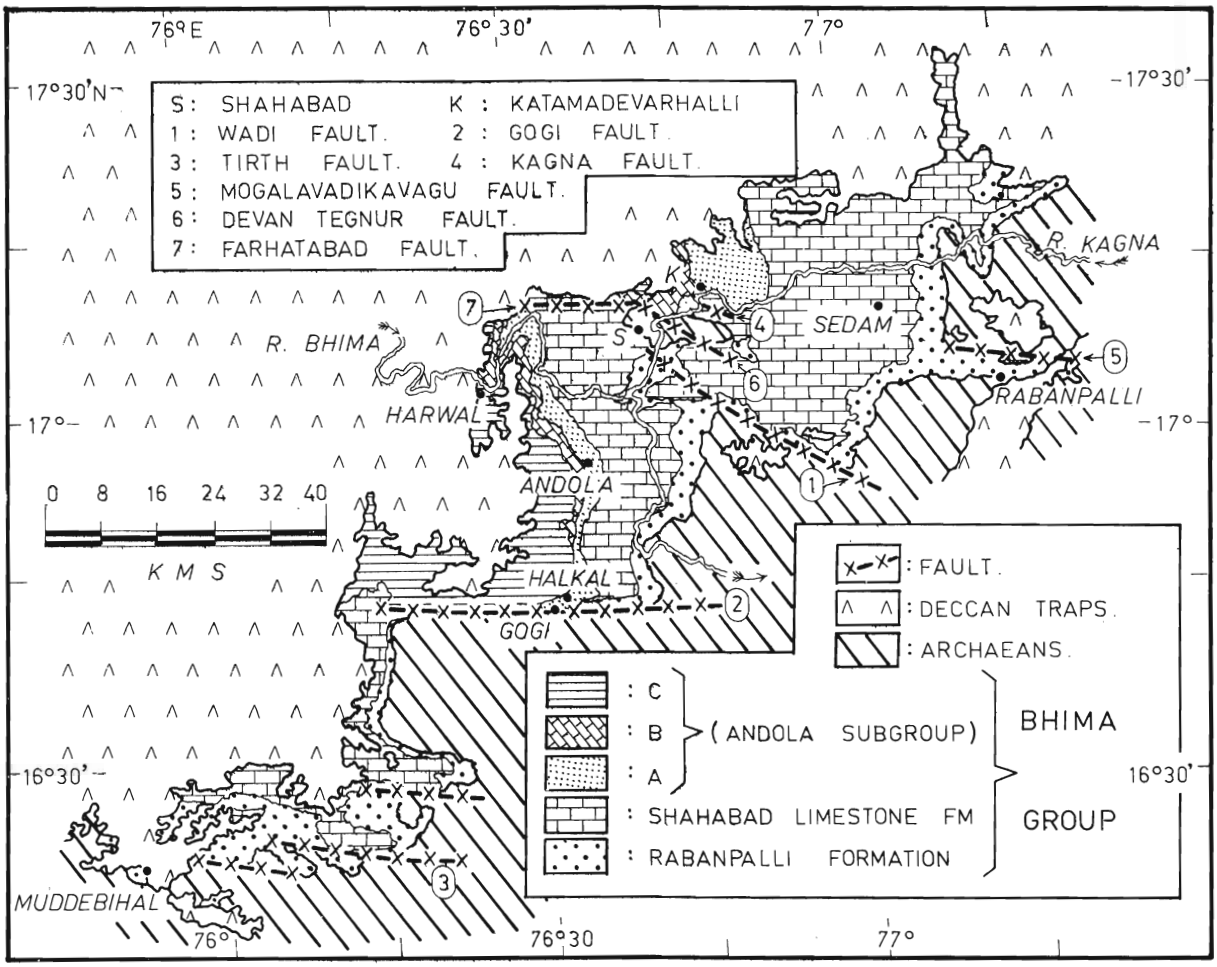

Fig. 1. Geological map of the Bhima basin: modified from Peshwa *et al.*(1982). [A = Halkal Fm.; B = Katamadevarhalli F.; C = Harwal-Gogi Fm.: of Mishra *et al.*(1987)].

of India topo-sheets (1 : 50,000 scale), to establish the altitudes (above m.s.l. datum) of exposures of the various lithological contacts. Three such overlay maps of parts of the Bhima Basin (wherever the "Andola Subgroup" is exposed) are presented here as examples (Figs. 2, 3 and 4).

BHIMA — BASEMENT CONTACT

Almost all the earlier workers (Foote, 1876; Janardhana Rao *et al*, 1975; Akhtar, 1977; Mishra *et al*, 1987; etc.) concur that the Archaean Basement is overlain by the Late Proterozoic Bhima Group with a distinctly erosional and angular unconformity, representing a significant hiatus. Peshwa and Chitrao (1983) have pointed out that the Bhima sediments display unconformable relationships with the basement along the N-S to NNE-SSW trending rectilinear eastern margins, where as the E-W to WNW-ESE trending rectilinear southern boundaries are all of faulted nature (see Fig. 1).

The elevations of exposures of the unconformity between the basement and the Bhimas, at locations where the overlying Bhima sediments repose horizontally (implying their undisturbed character) have been listed in Table 2. The uneven, undulating nature of the basement, evident at numerous locations (including those mentioned in Table 2) is best highlighted by the exposures in the easternmost, Rabanpalli - Damancherla - Mitta Baspalli region of this basin (see Fig. 5 and 6). The point to be noted in this context is that, the Bhima - basement conformity occurs at elevations ranging between 545 m and 370 m above m.s.1. This range of variation (~ 175 m) is equivalent to more than $^3/_5$ of the computed aggregate stratigraphic thickness of the Bhima Group (= 273 m by Mishra *et al*, 1987).

This unconformity is exposed at the highest elevations in the western (around Rabanpalli) and eastern (around Muddebihal) flanks of the basin, while its lowest elevations of exposures are encountered in

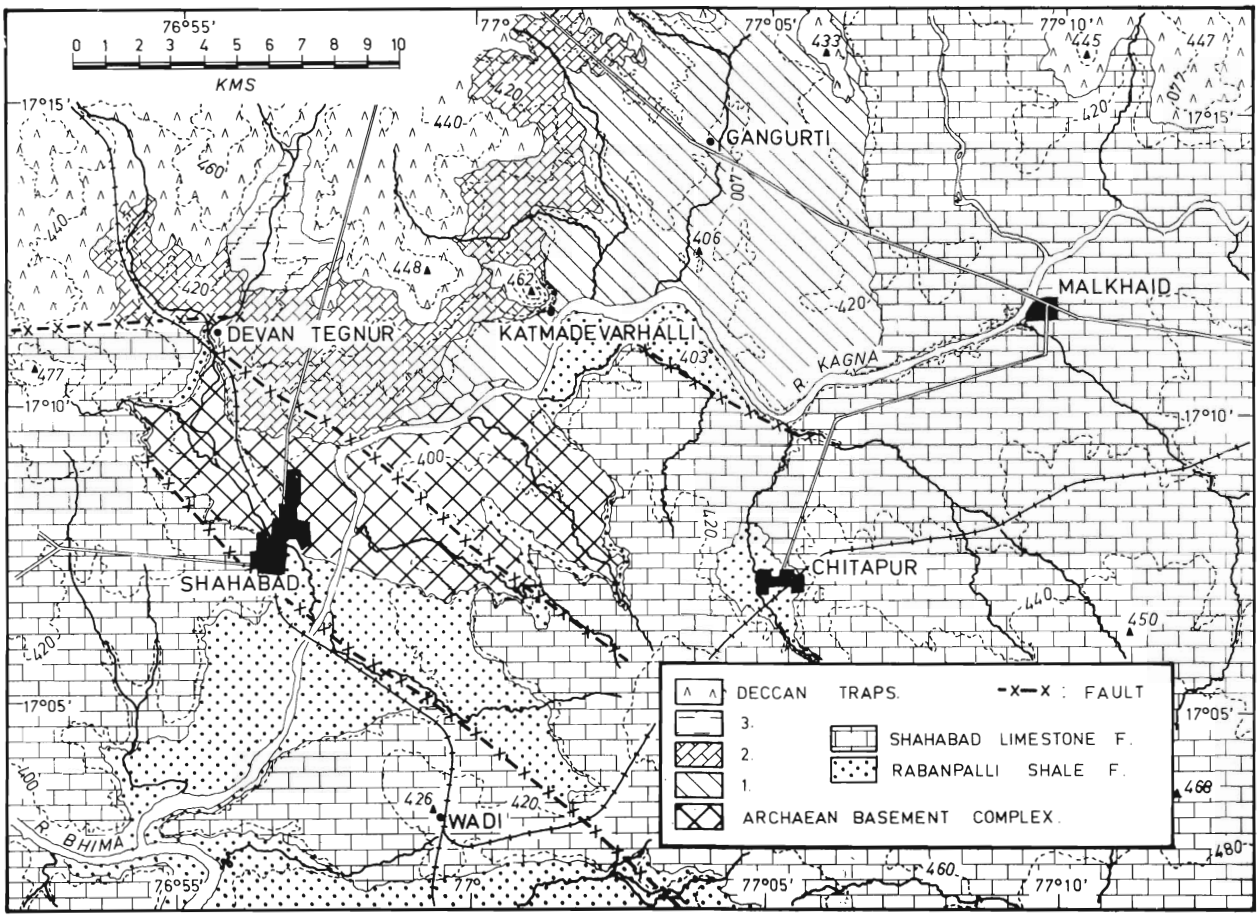

Fig. 2. Geological map of the Shahabad Sector draped over the topographic contours. All elevations are in m above mean sea level. [1 = Halkal Fm.; 2 = Katamadevarhall Fm.; 3 = Harwal-Gogi Fm. of Mishra *et al* (1987)].

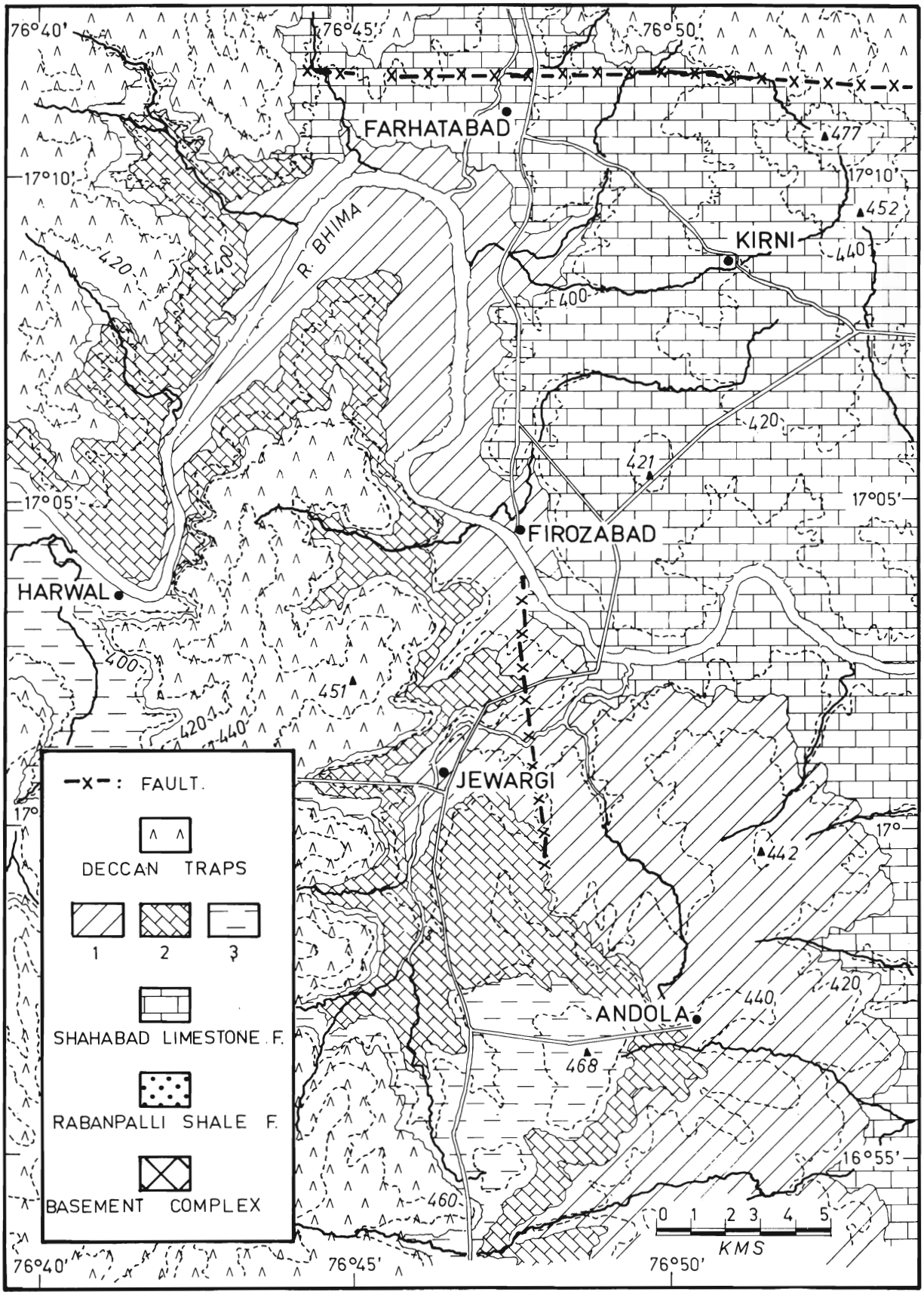

Fig. 3. Geological map of the Andola Sector draped over the topographic contours. All elevations are in m above mean sea level. (1, 2 and 3 are the same as in Fig. 2).

the central parts of the basin between Doranhalli and the Bhima River bed, southwest of Wadi. This indicates that the deepest parts of the basin were in the central sector, while the eastern and western flanks were relatively shallower. The Deccan Traps mask the northward extension of the Bhima Basin.

ANDOLA SUBGROUP — SEDAM SUBGROUP INTERRELATIONS

The Andola Subgroup (= Upper Bhimas) has been mapped only in two sectors of the Bhima Basin. These exposures (Figs. 1 to 4) of shales and limestones occur north of Shahabad (around Katamadevarhalli - Dewan Tegnur) and between Farhatabad - Harwal and Halkal - Gogi (west and south of the Bhima River) according to the previous authors (Mahadevan, 1947; Janardhana Rao *et al*, 1987).

SHAHABAD SECTOR

Horizontal exposures of limestones (mapped by earlier workers as Shahabad Limestone) occur upto elevations of more than 480 m in the eastern parts of this sector and upto 477 m altitude in the western part. They rest on the fine clastics (from the Rabanpalli Formation) which occur below the 400 m contour, wherever undisturbed.

The shales and limestones exposed north of the Kagna River, have been recognised previously as the Andola Subgroup equivalents, "separated from the Shahabad Limestone by a para-unconformity" (Mishra *et al*, 1987). Fig. 2 depicts the elevations of their exposures.

A traverse along the Malkhaid - Gangurti road is very significant. Westwards from Malkhaid, horizontal, flaggy limestones are exposed upto the N-S trending ridgelet (marked by the 420 m contour). The N-S trending gradational contact between these (Shahabad) limestones and the calcareous fissile shales is exposed across the ridgelet. The horizontal shales persist through Gangurti (below elevations of 400 m) westward till they are (again) capped by flaggy, siliceous limestones (at altitudes of 405-410 m). Existing classifications maintain that, the eastern (Shahabad) limestones are "overlain" by the (Halkal) shales exposed around Gangurti at elevations between about 390 m to just over 415 m, which in turn are capped by the western (Katamadevarhalli) limestones above 400 m contour. This "vertical stacking" of the horizontally exposed sedimentary sequence, implied by the existing classification, is exposed across a distance of less than 15 km. The western (Katamadevarhalli) limestones, with a maximum vertical thickness of 40 m, capping the shales at the 400m contour are in no way petrologically different from the eastern (Shahabad) limestones, whose contact with the shales occurs at 415-420 m altitude. The inherent contradiction is obvious, and is re-emphasised in the adjoining sectors.

ANDOLA SECTOR

This sector, adjoining the Shahabad sector in the west and southwest, is the only sector which - atleast in parts - displays a vertical sequence of limestone - shale - limestone - shale (in that order of superposition), consistant with the previously established stratigraphy of the Bhima Group. Such a sequence can be observed along any east-west traverse in this sector, south of 17° N latitude. These sediments are exposed subhorizontally, with local northward dips of less than 5°. Krishna Rao *et al*, (1984) have mapped a number of "plunging folds" between Jewargi and Gogi. However, field studies indicated that most of them were penecontemporaneous deformational features, having extremely restricted aerial extent.

The northward continuations towards Jewargi - Farhatabad of the shale - limestone - shale suite (= Andola Subgroup) discloses contradicting elevational characters (Fig. 3). The (Halkal) shales (which rest atop the Shahabad Limestone east of Andola) are subhorizontally exposed below the 400 m contour in the Bhima River bed between Farhatabad and Firozabad. The limestones capping them, west of the 'inverted-V'-bend of the Bhima River and within the concave portion of the V-bend, are recognised by earlier workers as the equivalents of the Katamadevarhalli Limestone, whereas those limestones east of the river (which are horizontally exposed upto 477 m altitude around Kirni) are termed as the Shahabad Limestone. The justification for this discrimination by previous workers can only be presumed to be the southward extension of the former (Katamadevarhalli) limestones around Andola, because there are no significant petrological variations between the two limestone exposures. It follows, therefore, that the super-position of these shale-limestone horizons (of Andola Subgroup) above the Shahabad Limestone does not hold in many exposures.

The (Harwal - Gogi) shales exposed around Harwal can be traced laterally, at the same elevations across the Bhima river, to grade into the (Katamadevarhalli) limestones. The superposition of this "youngest" shale horizon from the Bhima Group does not thus stand scrutiny in its "type exposure".

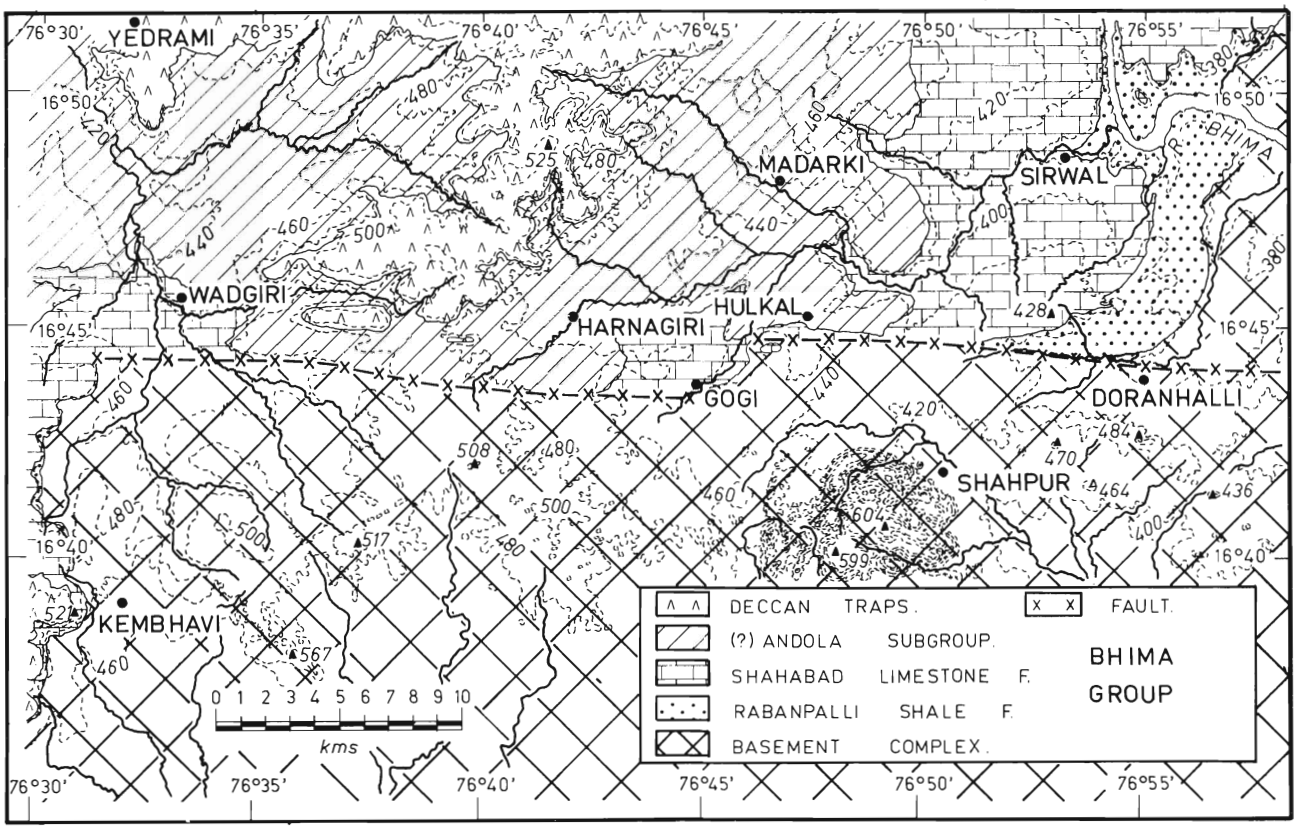

Fig. 4. Geological map of the Gogi Sector draped over the topographic contours. All elevations are in m above mean sea level.

Comparable shales are no doubt exposed overlying the limestones west of Andola and west of Farhatabad, above elevations of 430-455 m and 400-410 m, respectively. But is this sufficient evidence for placing these shales at the top of the Bhima Group and that too as an independent formation?

GOGI SECTOR

In Fig. 4, all the horizons from the Andola Subgroup are shown together, because, the "Katamadevarhalli Limestone" is not exposed in this sector as it pinches out south of Andola (see Fig. 1). Consequently this Subgroup is entirely represented by calcareous and ferrugenous fissile shales, along with minor sandstones and conglomerates exposed locally around Halkal. In the northwestern quarter of this sector, around Wadgiri, the Shahabad Limestone is exposed at higher elevations than the subhorizontal (Harwal-Godi) shales, which continue northwards below the Deccan Traps. Here again therefore, the superposition of these (Harwal-Gogi) shales as the topmost Bhima horizon is untenable, particularly in context of the undisturbed nature of the limestone and shales.

The exposures adjoining the Gogi-Doranhalli fault are significantly deformed. However, the intensity of deformation reduces very swiftly away from the fault zone, and within a distance of 1.5 to 2.0 km north of the fault, practically undisturbed, very gently (about 5° or less) northward dipping sediments are encountered (eg. at Harnagiri, north of Hulkal, etc.) The fault itself dies out southwest of Wadgiri and continuous, undeformed, subhorizontal to horizontal exposures of the limestones and underlying clastics are exposed along the western edge of this sector (west of Kembhavi) unconformably overlying the Archaean basement.

The isolated exposure of coarse sandstones and thin conglomerates resting atop (Shahabad) limestones, in a hill east of Hulkal, has been cited as, "the only" exposures displaying the vertical superposition of these clastics (= Halkal Formation) above the Shahabad Limestone (Janardhana Rao *et al*, 1975, p.: 182; Mishra *et al.* 1987, p:233). Apparently, therefore, disregarding the sedimentological attributes and the previously described contradictions, one would be tempted to reemphasis the validity of the order of

superposition and classification of the Bhima Group elucidated by the earlier workers.

RABANPALLI AREA

This "type-area" for the basal clastic sediments from the Bhima Group (Janardhana Rao *et al.*,1975; Mathur, 1977; Mudholkar and Kale, 1982; Mishra *et al.* 1987) provides a specific clue for resolving the above discussed contradictions, within an area of less than 18 km x 20 km. The lithologs of different horizontal exposures of the Bhima sediments in this area were prepared (Mudholkar, 1988) and are presented here as Fig. 5. A schematic cross-section across the Bhutgira-Adki hills is given as Fig. 6.

Except the section 'F' in Fig. 5, no other section has been vertically or laterally dislocated relative to any other section by any fault or shear zone. Yet, the differences in altitudes of exposures of the various lithological contacts within the Bhima Group are significant. The study in this area (Mudholkar, 1988) has highlighted the following points:

a) The basement on which the Bhima sediments rest was greatly uneven, with a regional westward slope.
b) Consequently, different lithologies representing varying (broadly: carbonate v/s clastic) sedimentological facies were concurrently deposited; but may occur at different elevations of repose, in response to progressive changes in the transgressing sea.
c) The conglomerates - sandstones - siltstones - shales suite of the Rabanpalli Formation grades vertically as well as laterally into the limestones of the Shahabad Formation.

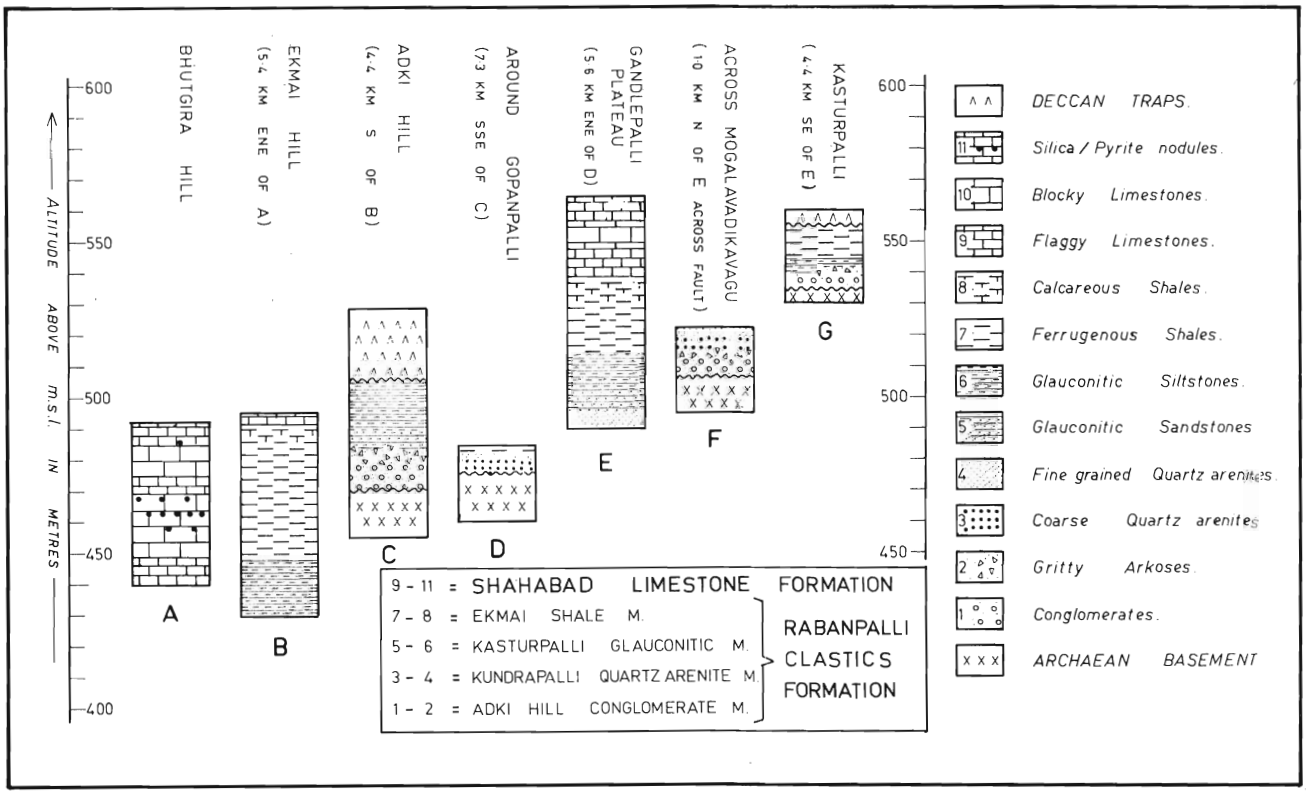

Fig. 5. Lithologs of selected sections from the Rabanpalli area: adapted from Mudholkar (1988). Section "F" is upthrown by about 20 m. with respect to Section "E". All other Sections are of undisturbed, horizontal exposures.

These observations clearly indicate the diachronous nature of not only the Bhima-basement unconformity, but also of any of the lithological contacts within the Bhima Group. The diachronity could provide an explanation for the extreme variations in the altitudes of exposures of the different lithological contacts. None of the previous authors have assigned any of the exposures of the Bhima sediments in this area (occuring in the altitudes ranging from less than 430 m to 570 m) to the Andola Subgroup.

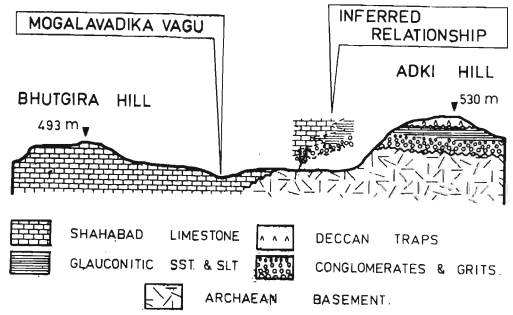

Fig. 6: Schematic cross-section (approximately 8 km long) between the Bhutgira and Adki Hills, illustrating the possible lateral associations between the clastic and carbonate facies. (Adapted from Mudholkar, 1988).

DISCUSSION

SEDIMENTATION MODEL

Geophysical studies have shown that the Bhima sediments accumulated in a very shallow, epicontinental/supracrustal depression (Ramakrishna and Chayanulu, 1988). Sedimentological studies of these sediments (eg: Dutt, 1975; Deshpande and Sukhtankar, 1976; Akhtar, 1977; Venkoba Rao, 1977; Sukhtankar and Parashar, 1980; Joshi, 1986; Jayaprakash, 1986; Mudholkar, 1988) unequivocally conclude that the Bhima sediments represent platform deposits of shallow marine, near shore environments. The coarser clastics (conglomerates and sandstones) represent shoreline to beach deposits, while the siltstones and shales represent deposits of relatively deeper, subtidal to intertidal, clastic tidal flat environments. Progressively deeper facies are represented by the carbonate tidal flat limestone deposits.

Broadly, passive, undisturbed conditions prevailed during the deposition of these sediments, occassionally punctuated by episodes of penecontemporaneous deformation (eg: slum folding, intraformational limestone breccias, and other features described by Akhtar, 1977; Venkoba Rao, 1977; Peshwa *et al*, 1982; Joshi, 1986; Mudholkar, 1988). These sporadic events are attributed to localised, episodic movements along the various faults which transect this basin (eg: Mudholkar and Peshwa, 1988; Kale and Peshwa, 1989) but have very limited lateral spatial extensions.

The presence of glauconite (Mathur, 1979) has been attributed to localised development of anaerobic environments in (temporally and spatially) isolated pools within this basin (Mudholkar and Kale, 1982) and the diagenetic growth of glauconite at the expense of clayey admixtures from the silt-stones (Joshi and Peshwa, 1986). Studies using XRF and SEM have indicated (Mudholkar, 1988) that, diagenetic chlorite accounts for a major proportion of the 'green' minerals from the Kasturpalli Glauconitic Member, whereas glauconite is present only in minor proportions.

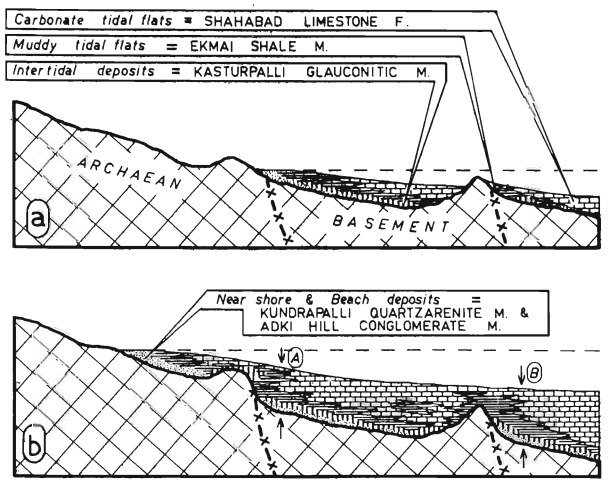

Fig. 7: Schematic cartoons illustrating the inferred depositional history of the Bhima Group and the mutual interrelationships between the various component lithostratigraphic units. (a) depicts the early phases while (b) depicts the peak of the transgression onto the Archaean crystalline basement. For explanations of "A" and "B" refer text.

Based on all these characters, the generalised depositional history of the Bhima Group is interpreted as being a product of a Late Proterozoic transgression onto an undulating Archaean basement. Fig. 7(a) depicts the early stages of the marine transgression, which was followed by a progressive rise in the sea-level, resulting in the submergence of larger areas, attended by episodic penecontemporaneous faulting (Fig. 7(b)).

STRATIGRAPHIC IMPLICATIONS

In the preceeding descriptions, the contradictions which arise out of the existing 5-fold classifications have been highlighted, implying that this lithostratigraphy of the Bhima Group suffers from serious shortcomings. The most incontrovertible character of the Bhima sediments is their horizontal, undisturbed disposition, except in the vicinity of fault-zones (and even along them with severaly limited lateral extensions). Krishna Rao *et al*, (1984) have recognised a number of 'folds' and disturbances

within the Bhima sediments. However, detailed structural analysis of these features and the deformation along practically all the fault zones indicates that almost all these "deformations" are synsedimentational in nature. There exist very few "structural elements" in this basin which can be treated as being strictly post-deposition, post-lithification, superimposed structural elements (Kale and Peshwa, 1988, 1989). None of these structural features significantly alter the later or vertical juxtapositions of the various component horizons of the Bhima Group.

No lithostratigraphic classification of any sedimentary sequence can be independent of the history and environments of sedimentation (Krumbein and Sloss, 1963; Brenner and McHargue, 1988). Though most of the earlier workers have discussed the depositional history of the Bhima sediments, almost all of them appear to have interpreted it as a sequeal to their classifications. The limestone-shale-limestone-shale sequence exposed around Andola was treated as 'type exposures' (without formally saying so), in dividing the suite into four separate 'Formations' resting one above the other. This was followed by inference of the two contributing 'cycles' of sedimentation of the Bhima Group. Their exposed thicknesses (even at or around Andola) and their lateral continuations, taken together reveal very obviously that these beds represent nothing else, but intertounging alternations of shales and lime-stones. The presence of such interrelations between the clastic suite of the Rabanpalli Formation and the carbonate suite of the Shahabad Limestone has been demonstrated (Fig. 6) from the Rabanpalli area by Mudholkar (1988). If one were to extrapolate (based on altitudes of exposures) horizons in this area itself, it would necessitate recognition of the sequence in the Gandlepalli Plateau ('E' in Fig. 5) as equivalents of the Andola Subgroup, in comparison to the sequence in the Bhutgira and Ekmai hills ('A' & 'B' in Fig. 5). But such extrapolations do not have any acceptable justification petrologically or otherwise.

There is, therefore, sufficient reason to believe that the entire sequence recognised as the Andola Subgroup/Upper Bhimas (Mahadeva, 1947; Janardhana Rao, *et al.* 1975; Mathur, 1977; Mishra, *et al.* 1987) represents the exposures of an 'intertounging' between the fine clastics and carbonates (as would be encountered along 'A' or 'B' in Fig. 7(b). The recurrance of some lithologies in a particular section cannot be justification enough for their recognition as separate "formations", unless there is a significant petrological bias (see: I.S.S.C. 1976; Brenner and McHargue, 1988). The Harwal-Gogi Shale and Halkal Shale do not display any significant petrological differences from the constituents of the Rabanpalli Shale Member (of Mudholkar and Kale, 1982). The Katamadevarhalli Limestones and the 'a' and 'e' members of the Shahabad Limestone (of Janardhana Rao *et al*, 1975) are petrologically similar to each other. The independent recognition of either of these three Formations of the Andola Subgroup cannot be justified by any evidence other than the solitary case of the exposures around Andola, which in turn can be treated as an exposure of the interfingering sequence of clastics and carbonates.

Therefore, the Bhima Group can be (lithostratigraphically) divided into not more than two constituent Formations, representing the clastic facies and the carbonates facies respectively. No further 'Formation' level subdivision of the Bhima Group can stand scrutiny.

CONCLUSIONS

A simple bipartite lithostratigraphic classification of the Bhima Group is therefore advocated. The proposed subdivision of the Bhima Group into two Formations, representing the clastic facies and the carbonate facies is given in Table 3. On the basis of their historic preceedance, the locality names of 'Rabanpalli' and 'Shahabad' are retained. In keeping with the nomenclatural system advocated by the Code of Stratigraphic Nomenclature (G.S.I., 1971; ISSC 1976), the clastic and carbonate facies from the Bhima Group are named as the Rabanpalli Clastics Formation and the Shahabad Limestone Formation respectively.

On the basis of observable order of superposition and sequence of occurrence throughout the entire basin, the classification of the clastic suite into four 'Members' comprising the conglomeratic grits, orthoquartzitic sandstones, green siltstones and ferrugenous-calcareous shales, proposed by Mudholkar and Kale (1982) is retained. However their 'Basal Member' is renamed as the 'Adki Hill Conglomerate Member' in keeping with the system of stratigraphic nomenclature. To avoid confusion of names between the Formation and Member, the 'Rabanpalli Sahle Member' of Mudholkar and Kale (1982) is renamed as the 'Ekmai Shale Member'.

The five types of limestones, recognised as informal 'members' of the Shahabad Limestone by Janardhana Rao *et al* (1975) and Mishra *et al* (1987) do not always occur in the same sequence, at all exposures. For example, flaggy argillaceous limes-

Table 1. Previous (Litho-) stratigraphic classifications of the Bhima group [F. = Formation. M. = Member.]

NEWBOLD (1842-1845)	FOOTE (1876)	MAHADEVAN (1947)	JANARDHANA RAO, *et al.* (1975)	MATHUR (1977)	MUDHOLKAR & KALE (1982)	MISHRA, *et al.* (1987)
			5. Harwal Shale	5. Gogi Shale F.		ANDOLA SUBGROUP: 3. Harwal — Gogi F.
		Upper Bhima Series [local sst., shales and lst.]	4. Katamadevarhalli Limestone.	4. Katamadevarhalli Limestone F.		ANDOLA SUBGROUP: 2. Katamdevarhalli F.
	Upper Series [limestone and shales with minor local sst.]		3. Halkar F. [shales with local qtzitic sst. & congl.]	e. Halkal Shale F.		ANDOLA SUBGROUP: 1. Haikal F. [with (c) Fissile shale M. (b) Orthoquartzite M. (a) Chertpebble Congl. M.
		conformable	break	conformable		para unconformity
2. Talikote Limestone		Middle Bhima Series [Limestones]	2. Shahabad Limestone. [with (e) Flaggy argillaceous lst. M. M. (d) Massive lst. M. (c) Variegated, siliceous & cherty lst. M. (b) Slabby/ blocky lst. M. (a) Flaggy / slabby lst. M.]	2. Kurkunta Limestone F		SEDAM SUBGROUP: 2. Shahabad F. [with (e) Flaggy argillaceous lst. M. (d) Massive lst. M. (c) Variegated, siliceous lst. M. (b) Blocky lst. M. (a) Slabby/flaggy lst. M.]
1. Muddebihal Sandstone	Lower Series [congl., sst. and shales]	Lower Bhima Series [basal congl., sst. and shales]	1. Rabanpalli F. [with (e) Purple shale shale M. (d) Green-yellow shale M. (c) Siltstone M. (b) Quartzitic sandstone M. (a) Conglomerate/grit M.]	1. Rabanpalli Shale F.	d) Rabanpalli Shale M. c) Kasturpalli Glauconitic M. b) Kundrapalli Quartz-arenite M. a) Basal M.	SEDAM SUBGROUP: 1. Rabanpalli F. [with (e) Purple shale M. (d) Green /yellow shale M. (c) Siltstone M. (b) Quartzitic sandstone M. (a) Conglomerate/ Grit M.]

Table 2. Elevations [above mean sea-level] of the exposures of the Archaean Basement - Bhima Group Unconformity

No	Location	Altitudes
1.	Around Muddebihal (16°20′N - 76°07′30″E)	530 ± 5 m.
2.	West of Nagarbetta ((16°17′N - 76°16E)	540 ± 5 m.
3.	In the Don River Section:	
	(a) Near Kareka (16°25′30″N - 76°21′E)	490 ± 3 m.
	(b) West of Nagur (16°24′30″N - 76°20′E)	485 ± 5 m.
	(c) Around Bopargi (16°23′N - 76°20′E)	490 ± 10 m.
4.	West of Gulbal (16°26′N - 76°27′E)	460 ± 5 m.
5.	West of Kembhavi ((16°39′N - 76°32′E)	485 ± 15 m.
6.	West of the Bhima River, north of Doranhalli (16°44′N - 76°55′E)	380 ± 10 m.
7.	South of Devan Tegnur (17°11′N - 76°55′30″E) and northeast of Shahabad ((17°11′N - 76°55′30″E)	variable: 390-430 m
8.	North and northwest of Rabanpalli (17°03′N - 77°28′30″E)	<430->535m.
9.	Near Damancherla (17°11′N - 77°27′E)	455 ± 5 m.
10.	South of Mitta Baspalli (17°18′N - 77°30′E))	variable: 425-460 m.

Note: For further details of #5, #7 and #8 above, refer to Fig. Nos 4, 2 and 5 respectively.

The locations are arranged sequentially from West to East.

Table 3. Revised Lithiostratigraphy of the Bhima Group

Formation	Maximum Thickness	Member	Main Lithological Components
2. Shahabad Limestone	< 75 m.		* Grey, argillaceous micritic limestones. * Dark, bluish grery, massive limestones. * Variegated, siliceous, and cherty limestones. * Blue-grey, blocky micritic limestones * Flaggy, [partly impure argillaceous and cherty] limestones
- - - - - - - - gradational and transitional contact - - - - - - - - - - - - - - -			
1. Rabanpalli Clastics	< 70 m.	4. Ekmai Shale Member	Ferrugenous shales, with calcareous shales at top.
		3. Kasturpalli Glauconitic Member.	Green, glauconite bearing fine sandstones and siltstones.
		2. Kundrapalli Quartz-arenite Member.	Quartzitic sandstones [medium to fine grained].
		1. Adki Hill Conglomerate Member	Polymictic conglomerates and arkosic, gritty sandstones.

tones (= 'e' Member) constitute the base of this Formation and is overlain by siliceous limestones at a number of localities. Therefore these five types of limestones are recognised only informally as components of the Shahabad Limestone Formation, and not as formal 'Members'.

The exposures previously attributed to the Harwal-Gogi and Halkal Formations represent lateral interfingered extensions of the clastic facies, i.e. the Rabanpalli Clastics. The Katamadevarhalli Limestone similarly, is nothing but a tongue-like continuation of the Shahabad Limestone. It is therefore concluded that the Bhima Group, constituted of the clastic and carbonate facies sediments is a product of a solitary Late Proterozoic cycle of shallow marine transgression onto an epicontinental depression whose geometry was controlled by faulted margins.

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REFERENCES

AKHTAR, K. 1977 Depositional environment, dispersal pattern and palaeogeography of the clastic sequences in the Bhima basin. *Indian Mineralogist*; **18**: 65-72.

BRENNER, R.L & McHARGUE, T.R. 1988: *Integrative Stratigraphy: Concepts and Applications*. Prentice-Hall, New Jersey; 419 p.

DESHPANDE, G.G. & SUKHTANKAR, R.K. 1976. Depositional environments of the Bhima sandstones from Muddebihal area, Bijapur district, Karnataka. *Bull. Earth Sci.*, **4&5**: 47-62.

DUTT, N.V.B.S. 1975. Bhima Group of Hyderabad district, Andhra Pradesh. *Misc. Publ. Geol. Surv. India*; **23**(1); 185-189.

FOOTE, R.B. 1876. Geological features of the South Mahratta country and adjoining districts. *Mem. Geol. Surv. India.* **12**(2): 70-138.

GEOLOGICAL SURVERY OF INDIA. 1971. Code of stratigraphic nomenclature in India. *Misc. Publ. Geol. Surv. India*; **20** 28 p.

INTERNATIONAL SUBCOMMISSION ON STRATIGRAPHIC CLASSIFICATION 1976. *International Stratigraphic Guide* (*Ed*: H. Hedberg) John Wiley & Sons, N.Y. 199p.

JANARDHANA RAO, L.H.; SRINIVASA RAO, C. & RAMAKRISHNA T.L. 1975. Reclassification of the rocks of Bhima basin, Gulburga district, Mysore state. *Misc. Publ. Geol. Surv. India.* **23**(1); 177-184.

JAYAPRAKASH, A.V. 1896. Stylolites and their relationship with the composition of Shahabad Limestone, Bhima Group. *Rec. Geol. Surv. India.* **115**(5); 5-8.

JOSHI, S.V. 1986. Geology of the area around Shahabad, Karnataka State: A study based on aerial photographs and Landsat imagery interpretation. *Unpubl. Ph.D. Thesis*; Poona Univ. 223 p.

JOSHI, S.V. & PESHWA, V.V. 1986. Occurrence, morphology and probable mode of formation of glauconite from Ladlapur, Shahabad dist., Karnataka state; (in *Ed*: R.A.K. Srivastava): *Glauconite: Form & Function; Current Trends in Geology*; **10**; 197-208. Today & Tommorrow's Printers and Publ.; New Delhi.

KALE, V.S. & PESHWA, V.V. 1988. Mainfestations of the Kurduwadi Lineament based on Remote Sensor data interpretation. *Curr. Sci.* **57**(23); 1293-1295.

KALE, V.S. & PESHWA, V.V. 1989. A Proterozoic "Pull-apart" basin: Interpretations based on Remotely sensed data. *28th Intern. Geol. Cong.*; Washington, DC; U.S.A. **2**: 149-150.

KING, W. 1872. The Kudapah and Karnul formations of Madras Presidency. *Mem. Geol. Surv. India.* **8**(1) 1-346.

KRISHNA RAO, G. GOPALA RAO, K. RAGHAVA RAO, K.V. 1984. Tectonic history of parts of Bhima basin and its influence on groundwater conditions in Gulburga district. *Jour. Geol. Soc. India.* **25**(8); 505-513.

KRUMBEIN, W.C. & SLOSS, L.L. 1963. *Stratigraphy and Sedimentation* (2nd Edn.) W.H. Freeman & Co. Publ., San Fransisco; 660 p.

MAHADEVAN, C. 1947. The Bhima Series and other rocks of Gulburga district. *Jour. Hyderabad Geol. Surv.*; **5(1)**; 102-161.

MATHUR, S.M. 1977. Some aspects of the stratigraphy and limestone resource of the Bhima Group. *Indian Mineralogist* **18**: 59-94.

MATHUR, S.M. 1979. A note on glauconite in the Bhima Group. *Indian Minerals*; **31**(14); 57-58.

MISRA, R.N., JAYAPRAKASH, A.V.; HANS, S.K. & SUNDARAM, V. 1987. Bhima Group of Upper Proterozoic - A stratigraphic Puzzle. (In: *Purana Basins of Peninsular India (Middle to Late Proterozoic)*. *Mem. Geol. Soc. India*; **6**; 227-237.

MUDHOLKAR, A.V. 1988. Geology of the area around Adki, Gulburga district, Karnataka State: A study based on aerial photo and Landsat imagery interpretation. *Unpubl. Ph.D. Thesis*; Poona Univ.; 118p.

MUDHOLKAR, A.V. & KALE, V.S. 1982. Lithostratigraphy of the Rabanpalli Shale Formation, Bhima Group, Rabanpalli area, Karnataka (in *Eds*: R.M. Badve, *et al*). *Proc. X Indian Coll. Micropal. & Strat.*; 97-110; MACS, Pune.

MUDHOLKAR, A.V. & PESHWA, V.V. 1988. Classtic limestone dikes from the Late Proterozoic Bhima Group South India. *Sed. Geol.*, **57** 221-229.

NAQVI, S.M. & ROGERS, J.J.W. 1987. *Precambrian Geology of India*; Clarendon - Oxford Univ. Press; N.Y./Oxford; 223 p.

PESHWA, V.V. & CHITRAO, A.M. 1983. Status of the Metamorphics - Bhima sediments boundary - A study based on Remote Sensing Techniques. *Proc. 4th Asian Conf. Rem. Sens.*; Colombo, Sri Lanka, Q.1.1 - Q.1.11.

PESHWA V.V., DESSAI, A.G. & SUKHTANKAR, R.K. 1982. Geology of the Bhima basin and associated Archaean rocks of Karnataka and Andhra Pradesh. *Unpubl. Project Rep: ISRO Respond Project*; 120 p; Deptt. Geology, Poona Univ.

RAMAKRISHNA, T.S. & CHAYANULU, A.Y.S.R. 1988. A geophysical appraisal of the Purana Basins of India. *Jour. Geol.*

Soc. India; **32**(1): 48-60.

SUKHTANKAR, R.K. & PARASHAR, V.T. 1980. Post depositional changes in the Bhima limestone of Ammapur - Hunusagi area, Gulburga district, Karnataka state. *Curr. Sci.*, **49**; 907.

VENKOBA RAO, V.R. 1977. Limestone in the Bhima basin - An appraisal. *Indian Mineralogist*; **18** 54-58.