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ON THE STRATIGRAPHIC POSITION OF THE TAL FORMATION, GARHWAL SYNFORM, GARHWAL AND TEHRI GARHWAL DISTRICTS, UTTAR PRADESH.

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GEOLOGICAL SURVEY OF INDIA,[1] LUCKNOW

ABSTRACT

The detailed lithostratigraphic mapping in the southwestern part of the Garhwal Synform has shown the presence of two horizons of shell limestone in the stratigraphic sequence of the Lansdowne (Bijni and Amri), Binj, Blaini, Krol and Tal Formations in ascending order. One of these horizons, associated with the Binj Formation, consists of grey, veined limestone, occasionally pisolitic with fossiliferous bands containing fragmentary shell of bivalves, bryozoa etc. It overlies the Bijni quartzite and Amri phyllite with an unconformity marked by local development of conglomerate and is overlain by the Middle to Upper Carboniferous bryozoan horizon of the Blaini Formation in Dogadda area. The other horizon of shell limestone, the Tal *sensu-stricto*, referred to as the Manikot Shell Limestone containing fragmentary bivalves gastropods, bryozoa etc., and which successively overlaps the older formations of the southwestern part of the Synform, on preliminary identification of fauna, has indicated Cretaceous-Paleocene age. It is unconformably overlain by the Subathu Formation.

INTRODUCTION

The Tal Formation, which was considered to be an important fossiliferous horizon of Jurassic-Cretaceous age of the Lesser Himalaya in the Garhwal and Mussoorie Synforms since the time of Middlemiss (1885), attracted the attention when Valdiya (1975) reassessed its age and considered it to be Permian. This also lowered the age of the underlying sequence of the Krol and Blaini Formations, and thus, naturally became the subject of discussions and controversies particularly because the Blaini was considered to be a marker horizon in the unfossiliferous sequence of Lesser Himalaya correlative with the Permo-carboniferous Talchir Boulder Bed of Peninsular India. To resolve this controversy, the authors carried out detailed lithostratigraphical mapping on scale 1 : 63,360/1 : 50,000 in the western and southwestern part of the Garhwal Synform bounded by latitudes 29°45' and 30°14'N and longitudes 78°14' and 78°43'E, which not only established the existence of another (older) horizon of fossiliferous limestone but necessitated reinterpretation of the stratigraphy and structure of this part of the Himalaya. In the present paper, the authors discuss the Tal Formation and its age in light of the field data collected by them.

PREVIOUS WORK

Subsequent to the work of Medlicott (1864) who first recorded the fossiliferous horizon from the Tal Valley, a tributary to the Binj Nadi, in the south-western part of the Garhwal Synform, Middlemiss (1885) assigned this horizon to Cretaceous, while Auden (1934, 1937) classified the Tal Formtaion into Lower and Upper in the adjoining Mussoorie Synform and included this horizon in the Upper Tal. He assigned Jurassic to Cretaceous age to the Tal Formation. This classification and age remained acceptable to all the subsequent workers, viz., Tewari and Kumar (1967) who recorded Lower Cretaceous alga and bryozoan fauna, and Shankar (1972) who studied the sedimentological aspects of the Tal Formation of the Mussoorie Synform. It was in 1975, Valdiya considering the faunal and floral assemblages from various horizons in widely apart areas, viz., molluscan fauna of late Triassic to Middle Jurassic by Maithani (1972), Middle to Upper Carboniferous fenestillids recorded by Ganesan (1971, 1972), Upper Westphalian brachiopods, bryozoans, bivalves and crinoid stems fauna discovered by Shankar, Dhaundiyal and Kapoor (1973), Lower Callovian bivalvia from the Lower Tal by Shrivastava (1972) from the Mussoorie Synform, Upper Permian fusulinids of Kalia (1972) and algae (Kalia, 1976), to belong to a single horizon—the Tal Formation and assigned its age to Permian. He classified the Tal Formation into Lower—the Jogira Member, Middle—the Maskhet Member, and Upper—the Bansi Member. Dhaundhiyal and Kumar (1976), reviewing the geology of the western part of the Garhwal Synform, however, recorded another horizon of the shell limestone of middle to upper Palaeozoic age conformably overlain by the Blaini. They correlated it with the uppermost member of the Lower Bijni Unit (Shankar and Ganesan, 1972) of the Dogadda area in the southern part of the Garhwal Synform from which Tewari (1975) recorded Devonian

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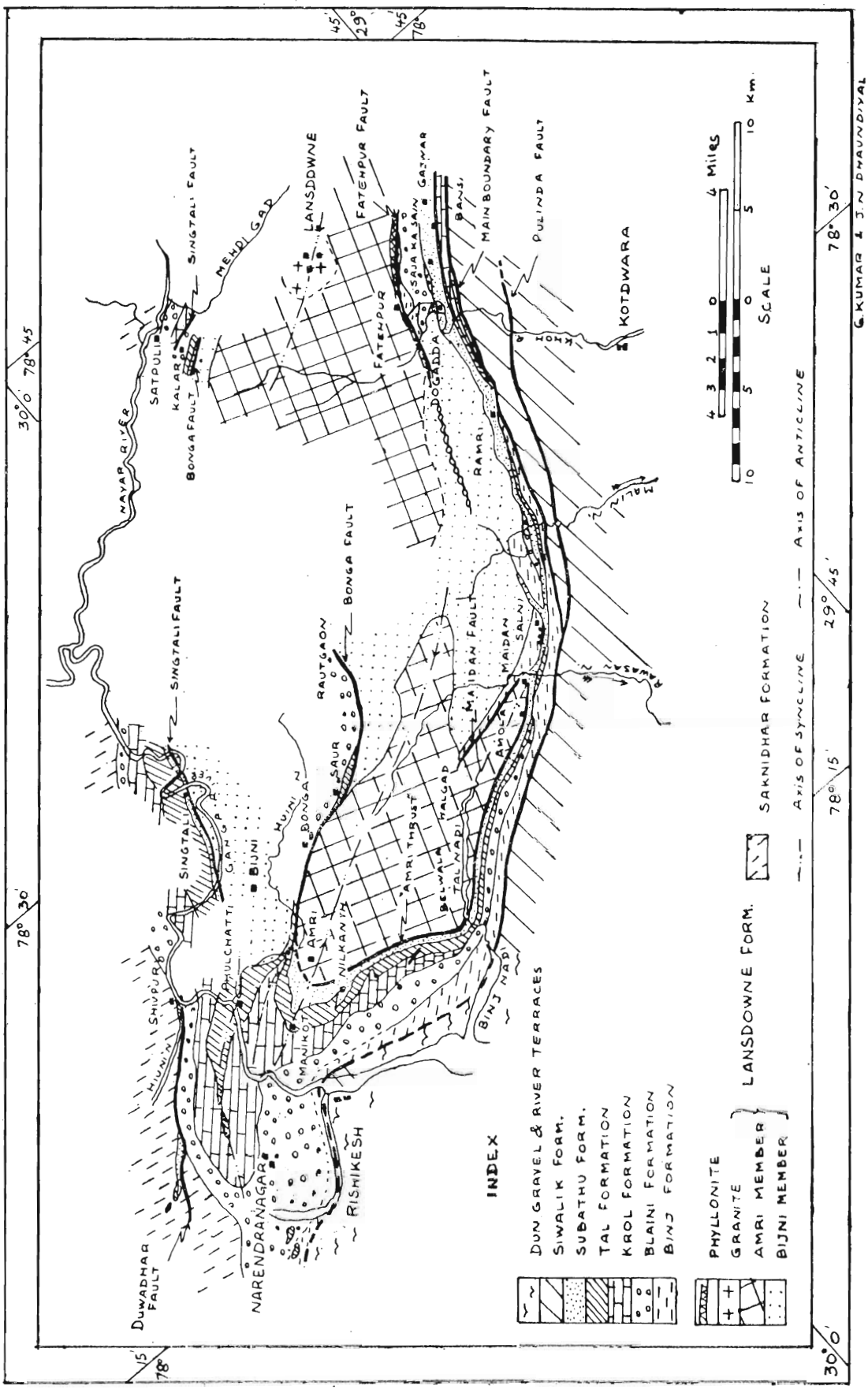

Fig. 1. Geological map of part of the Garhwal Synform, Garhwal and Tehri Garhwal districts, Uttar Pradesh.

scolecodonts. According to them the Tal Formation (Middlemiss, 1887 ; Auden, 1934, 1937 ; Shankar and Ganesan, 1972) belongs to Mesozoic. Mehrotra *et al.*, (1976), however, recorded Permian algae from the Tal shell limestone (their Singtali Formation) in the northern part of the Garhwal Synform.

GEOLOGICAL SETTING

As a result of mapping carried out by the authors (Fig. 1) the stratigraphy worked out is given in Table 1.

Table 1—Stratigraphy of the Garhwal Synform (modified after Dhaundhiyal and Kumar, 1976)

Age	Formation
Pliestocene to Recent	River terraces and Dun Gravel
	——Unconformity——
Middle Miocene to Pliocene	Siwalik
	——Unconformity——
Eocene	Subathu (Nummulitic)
	——Unconformity——
Jurassic to Cretaceous (or to ? Paleocene)	Tal { Upper Tal Member / Lower Tal Member
	——local diastem or unconformity——
Permian to Jurassic	Krol { Upper Krol (C+D) Member / Middle Krol (B) Member / Lower Krol (A) Member
Permocarboniferous	Blaini
Middle to Upper Palaeozoic	Binj
	——Unconformity——
Pre-cambrian	Lansdowne { Amri Member / Bijni Member } = Saknidhar Formation

LANSDOWNE FORMATION

Maithani (1976) proposed the Lansdowne Formation to include the low grade metasediments of the 'Garhwal Nappe' of Auden (1937). The Lansdowne Formation is divisible into a lower—the Bijni and an upper, theAmri Members corresponding to the Bijni Quartzite and Amri Phyllite of Auden. The Bijni Member consists predomiuantly of purple to greenish grey, white quartz arenite and argillite grading upwards into predominantly argillite with subordinate bands of flaggy to schistose quartzarenite constituting the Amri Member. Development of garnet inthe latter member around the granite intrusive of Landsdowne and also in the region of Kandakhal is noticed.

Auden (1937), and Shankar and Ganesan (1972) considered the contact between the Bijni and the Amri Members to be the thrust plane—the Amri Thrust. The authors mapping has revealed that there is no structural discordance between the Bijni and Amri Members and the contact between the two is a normal sedimentary one.

BINJ FORMATION

Dhaundhiyal and Kumar (1976) discovered this fossiliferous horizon confor mably overlain by the Blaini on one hand and limited on the other side by the Main Boundary Fault in the type section in the Binj Nadi (Fig. 3A). The lithostratigraphy in the type section and its variation in the Rawasan is given in Table 2.

Table 2—Lithostratigraphy of the Binj Formation and its variation

Binj Nadi section (After Dhaundiyal and Kumar, 1976)	Rawasan Nadi (upstream of Maidan)
Blaini Formation	Subathu Formation
	————Unformity————
Limestone, light grey, sandy, occasionally oolitic with bands of shell limestone and greyish white to white quartzite.	Shale, dark grey with calcareous nodules, thin quartzite, purple shale
Quartzite, white to greyish white, dark grey quartzite with thin bands of purple shale.	Shale, dark grey, nodulous with partings of quartzite.
Shale, dark grey to black, splintary coated with iron oxide	Shell Limestone, grey, siliceous. Quartzite, greyish white
Limestone, grey sandy, occasionally oolitic with bands of shell limestone with abundant calcite veins.	Shell limestone with calcite veins
Shale, dark grey to black with large polished boulders of grey to dark grey quartzite and lenses of dark grey siliceous limestone coated with iron oxide, occ. fossiliferous	Quartzite, white to grey with lensoid shell limestone, gritty towards top.
	Shale, dark grey to black with thin bands of quartzite.
	Quartzite, white with glauconite
	Shell limestone (1m)
	Conglomerate (locally developed)
Base not exposed	————Unconformity———— Bijni Member

The Binj Formation rests unconformably over the Bijni quartz-arenite and the Amri phyllite of the Lansdowne Formation along the southern limb of the Amri Syncline (Auden, 1937) from Halgad, in the west, to the confluence of the Chaundolisot with the Malin river where it is overlapped by the Blaini diamictite (Fig. 3C). Further in the east, it appears to be concealed due to the overlap of the Subathu Formation, but crops out again north of Dogadda. The limestone of the formation is, in general, characterised by abundant secondary veins of calcite, occasional oolitic nature with bands rich in fragmentary bivales and bryozoa. Development of lenticular bodies of conglomerate with pebbles resembling

[1]Dhaundiyal and Kumar have referred it as the Shankarpur Formation. Since some confusion has come up with the name Shankarpur, it is changed to Binj Formation after the Binj Nadi which exposes its type section.

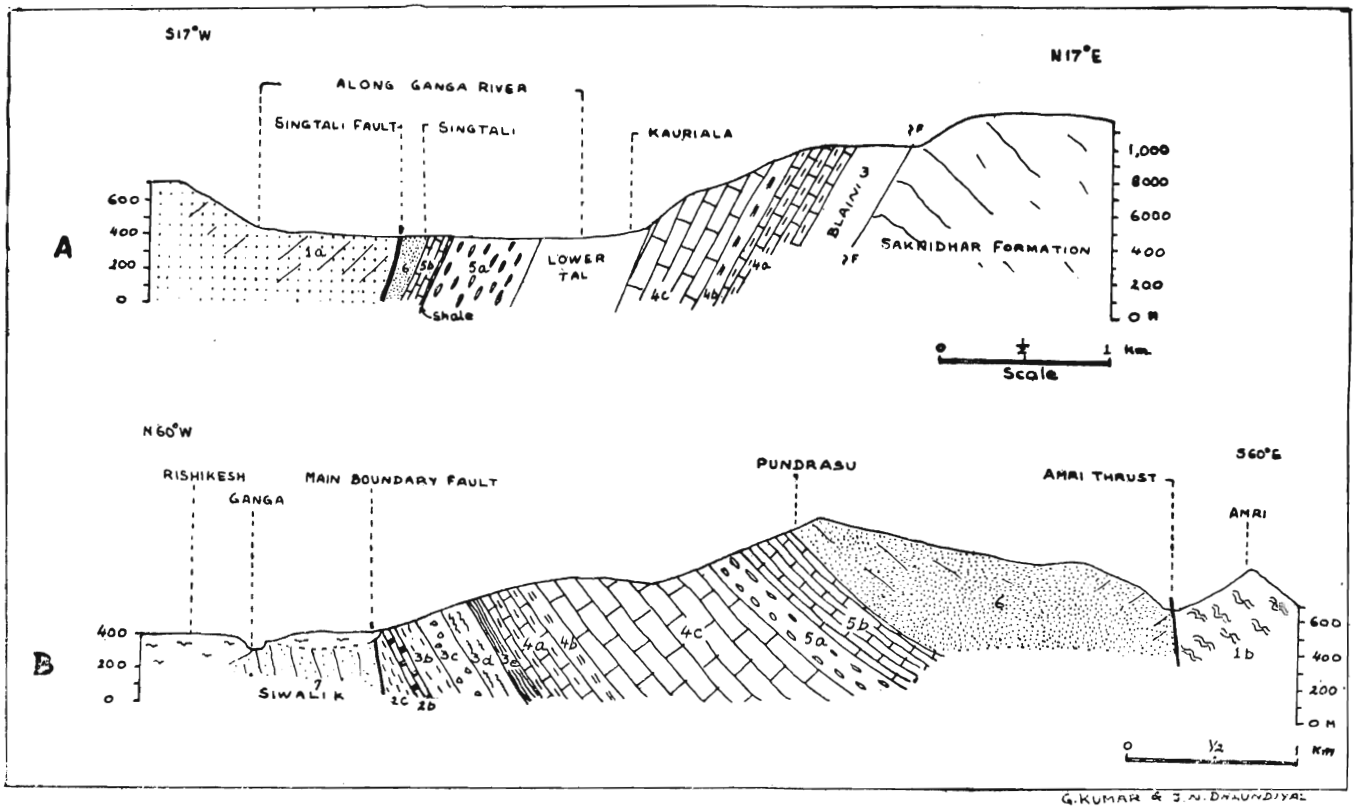

Fig. 2A. The Singtali section showing the position of the Singtali Fault (Garhwal Thrust of Auden) and the Manikot Shell Limestone.
2B. The Rishikesh-Amri section showing the structural and lithostratigraphical setting of Palaeozoic, Mesozoic and Tertiary sequences.

the Bijni quartz-arenite, have been noticed at Halgad, Rawasan Nadi north of Maidan and in the Malin river section just upstream of its confluence with the Chaundolisot. In the eastern part, south of Lansdowne in the Sila Gad section, it outcrops as a narrow band south of Fatehpur in the overturned limb of the Jogira Syncline (Fig. 3E) Here, it is overlain by the sandstone and diamictite of the Boulder Slate Member of the Blaini Formation (in field the succession is inverted), and is limited in north by the Fatehpur Fault which brings the Amri Member of the Lansdowne Formation in its contact. An outcrop of this shell limestone is also seen in the southern limb of the Syncline north-west of Saja ka Sain where it is overlapped by the Subathu in south and overlain by the sandstone of the Boulder Slate Member of the Blaini. It is from this shell limestone, Tewari (1975) recorded Devonian Scolecodonts south of Fatehpur and suggested the possibility of an inverted sequence, which has been confirmed by the present mapping.

Dhaundhiyal and Kumar (1976) have already shown that what Valdiya (1975) considered to be the Jogira Member (Lower Tal) in the Binj Nadi section, in fact belong to this formation. Similarly, the Tj and Tm Members in the Rawasan Nadi, down stream of Maidan, also do not form part of the Tal Formation, but are the continuation of the Binj Formation of the Binj Nadi section.

BLAINI FORMATION

Dhaundhiyal and Kumar (1976) have worked out the detailed lithostratigraphy of the Blaini Formation of the Garhwal Synform. According to them, the formation gets considerably reduced in thickness from about 1,500 metres in the area south of Narendranagar to about 460 metres in the Binj Nadi section where it is represented by Member C consisting of variegated purple and greenish shale and siltstone. Valdiya (1975) took it partly to constitute the Maskhet Member of the Tal Formation while part of it was included in the Subathu. Rupke (1974) also did not recognise the Blaini in this section. Continuing eastwards, the Blaini, represented by Member C, are mapped up to west of Amola where it is overlapped by the Subathu (Fig. 1). It crops out again in the Khoh river section, south of Dogadda, where it is represented by Member C of Dhaundhiyal and Kumar (1976) conformably overlain by the Lower Krol.

In the Khoh river section and Sila Gad, north of Dogadda, it is represented in the Jogira Syncline by the glauconitic sandstone, purple to brown, greenish and white in colour and is intertounged with diamictite enclosing thin beds of conglomerate and tuff in the Golikhet-

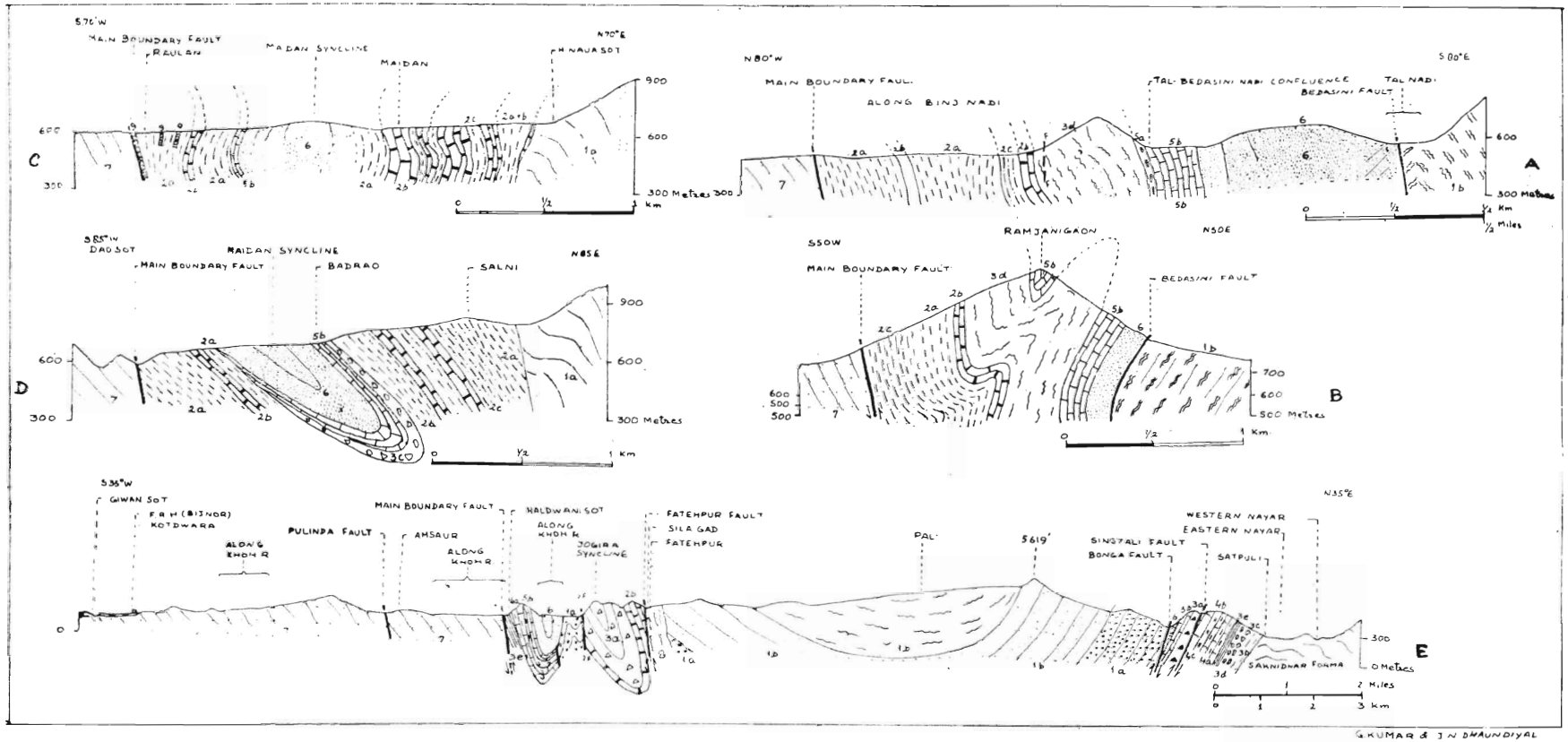

Fig. 3A. The Binj Nadi Section, (right bank). The Krol has pinched out and the Upper Tal Manikot Shell Limestone rests unconformably over the Blaini.

3B. The cross-section through Ramjanigaon outlier of the Manikot Shell Limestone showing overturned nature of the formations and the south dipping plane of the 'Amri Thrust'.

3C. The section along the Rawasan Nadi upstream of Raulan. Note the fan-type nature of the Maidan Syncline.

3D. The cross section near Salni showing overturned nature of the Maidan Syncline.

3E. The generalised cross section between Kotdwara and Satpuli showing structural setting of Precambrian, Palaeozoic, Mesozoic and Tertiary Formations.

1a—Bijni, 1b—Amri Members of the Lansdowne Formation ; 2a—Dark grey shale, 2b—Shell limestone, 2C—Quartzite of Binj Formation ;3a—Boulder Slate Member, 3b—Dark grey shale and quartzite, 3c—Diamictite, 3d—Purple and greenish shale, siltstone, 3e—Bleaching shale of Blaini Formation ; 4a—Lower Krol, 4b—Middle Krol, 4c—Upper Krol, 5a—Phulchatti Quartzite, 5b—Manikot shell Limestone of Upper Tal ; 6—Subathu Formation ; 7—Siwalik ; 8—Phyllonite ; 9—Basic intrusive.

Jogira road section. It corresponds to the Boulder Slate Member of the Lower Bijni Unit of Shankar and Ganesan (1973), Kophara of Rupke (1974). It is from the shale of this formation that Ganesan (1971, 1972) recorded fenestellid fauna. The diamictite is found to contain pebbles of granite besides the clasts of quartzite, limestone, slate/shale etc.

In the northern part of the Amri Syncline, this horizon of the Boulder Slate has been mapped from Bonga to Rautgaon. Shankar and Ganesan (1973) considered it to belong to the Tal Formation, and so did Rupke (1974) and Valdiya (1975). Maithani (1976), however, rightly correlated it with the Boulder Slate sequence of the Dogadda area. It has again been mapped in the Gumkhal-Satpuli section near Kalar (Shankar and Ganesan, 1973) where it is overlapped in south by the Manikot Shell Limestone and quartzite of Upper Tal, and comes in contact with the Upper Krol towards north due to the Singtali Fault (Garhwal Thrust of Auden, 1937; Shankar and Ganesan, 1973), (Fig. 3E).

The presence of the Fenestella Shale and the tuffaceous rocks in the Boulder Slate Member suggests its correlation with the Fenestella Shale and Agglomeratic Slate (Middle to Upper Carboniferous) of the Kashmir. The recent mapping of the Blaini Formation, carried out by the second author in the Nainital Synform has indicated the presence of a diamictite horizon containing pebbles of granite similar to that noticed in the Boulder Slate Member. This probably establishes the eastward continuity of Middle to Upper Carboniferous formations.

KROL FORMATION

The Krol Formation is divisible into Lower, Middle and Upper Members (Dhaundiyal and Kumar, 1976). It is well developed in the western and northern part of the Garhwal Synform, but gets attenuated in the south-western part of the Synform probably due to erosion and subsequent deposition of the Upper Tal Manikot Shell Limestone in area between the Tal Nadi and west of Khoh river. In the Khoh river section (Fig. 3E), the Krol is represented by the Lower Krol only, and attains its full development in area further to east.

TAL FORMATION

Dhaundiyal and Kumar (1976) worked out the detailed lithostratigraphy of the Tal Formation of the Garhwal Synform which is given in Table 3. It is based on the classification of the Tal Formation of the Mussoorie Synform given by Shankar (1971).

LOWER TAL

The four subdivisions of the Lower Tal of the Mussoorie Synform given by Shankar, namely the chert, argillaceous, arenaceous and calcareous units, holds good

Table 3—Lithostratigraphy of the Tal Formation (after Dhaundiyal and Kumar, 1976)

Member	Lithology
Upper Tal	Manikot Shell Limestone-Grey, oolitic, sandy, current-bedded fossiliferous limestone containing fragmentary bivalves, gastropod, and quartzite.
	————locally unconformable————
	Phulchatti Quartzite-White to purplish, felspathic, fine-grained to gritty, current bedded, locally conglomeratic.
Lower Tal	Calcareous Unit-Ferruginous, sandy limestone or calcareous quartzite (locally developed)
	Arenaceous Unit-Siltstone, micaceous, grey to dark grey.
	Argillaceous Unit-Shale, micaceous, grey to dark grey, locally carbonaceous with calcareous pyritous nodules.
	Chert Unit-Chert black with intercalatios of black shale, phosphate beds and nodules (locally developed).

in this Synform as well, though developed in lesser magnitude and restricted to the western part of the Synform in either limbs of the Narendranagar Syncline. It is well developed in the northern limb of the syncline near Kodiyala in the Ganga river section. In the southern limb of the Narendranagar Syncline, the Lower Tal appears to pinch out south of Gular Chatti. The basal Chert Unit is represented by a few cm. thick zone of chert and phosphate beds as is seen on the left bank of the Ganga river at about one km. southeast of Brahmpuri. In sections where the Chert Unit is not developed, the overlying Argillaceous Unit rests directly over the Krol. Development of the Lower Tal in the southern and south-western part of the Garhwal Synform has not taken place, and the formations mapped as Lower Tal by Rupke (1974) actually belong to Upper Tal and those described by Valdiya (1975) have been grouped in the Binj Formation by the authors.

UPPER TAL

The Upper Tal is further subdivided into lower arenaceous sequence of orthoquartzite/arkosic sandstone and an upper calcarenite containing abundant fragmentary shells of bivalve, gastropod, bryozoa etc. Earlier the authors (in Dhaundiyal and Kumar, 1976) grouped a shally horizon, named by them as the Pundrasu Shale, within the Upper Tal, but the subsequent work and examination of the fauna contained, it appears to have closer similarity with the Subathu Shale, and hence, has been excluded from the Tal Formation.

The Phulchatti Quartzite attains its maximum development in the western half of the Garhwal Synform (Fig. 1 & 2). It thins out gradually eastwards, both

in the southern and northern parts of the Synform with the result that in the southern and northern parts the uppermost Manikot Shell Limestone rests directly over the older rocks. In the southern part of the Synform, the shell limestone rests unconformably over the Blaini in the Binj Nadi section due to pinching/erosion of the Krol, and comes in contact with the Binj Formation in the Rawasan Nadi where the Blaini are also not exposed. An outcrop of shell limestone is seen along the left bank of the Binj Nadi unconformably overlying the Binj Formation and tectonically overlain by the Blaini. This could possibly be an outlier of the Manikot Shell Limestone. An outlier of the shell limestone is seen around Ramjanigaon resting over the Blaini. It is due to the folding of the rocks into an overturned anticline and syncline (Fig. 3B). In the northern overturned limb of the Maidan syncline ,south of Salni (Fig. 3D), it rests over the Blaini diamictite (in field sequence inverted). Further in the east, the shell limestone occurs as a narrow linear zone between the underlying Binj Formation and the overlying Subathu Formation up to about two km west of Ramri where it gets concealed due to overlap by the latter formation. The Manikot Shell Limestone, however, reappears south of Dhura and gain prominence eastwards, first overlying the Blaini, then Lower Krol in the Khoh river section west of Dogadda, Middle Krol south of Dogadda and overlies the Upper Krol south of Gajwar.

In the northern part of the Synform, the complete succession of the Tal Formation has been mapped continuously from Seramala in the west to Singtali underlying the Subathu and overlying the Upper Krol. Further to the east, it is gradually reduced in thickness and gets cut-off by the Singtali Fault with the result that the Upper Krol comes in direct contact with the Blaini outcrop at Kalar in the Gumkhal-Satpuli section (Fig. 3E). However, in this section Manikot Shell Limestone and quartzite overlap the Kalar outcrop of the Blaini and occurs as a narrow band. It is overlain by shales resembling the Subathu. In the region of Kathur "half Window" (Maithani, 1976), the Boulder Slate Member of the Blaini Formation is seen to be overlain by a lenticular band of shell limestone physically resembling the Manikot Shell Limestone and has been tentatively grouped with the Upper Tal.

Isolated outcrops of the Upper Tal Phulchatti quartzite and or Manikot Shell Limestone have been mapped on the south-western and eastern slopes of Shankarpur Hill in the Chandrabhaga valley, west of Narendranagar, resting unconformably over the Blaini and or Binj Formation, south of Duwadhar over the quartzite of the Saknidhar Formation (Kumar *et al.*, 1974) and overlain by the Subathu Shale and in the Hunil Nadi upstream of Shivpuri bridge.

SUBATHU FORMATION

The Subathu Formation unconformably overlies the Manikot Shell Limestone in almost all the sections excepting in limited areas in the southwestern part of the Garhwal Synform where it overlaps the Tal completely and comes in contact with the Blaini and or Binj Formations. Lithologically, it resembles with the Lower Eocene Beragua and Kalakot Formations of the Subathu Group (Singh, 1972) of the Jammu region.

DISCUSSION

Medlicott (1864) described a fossiliferous shell limestone from the Tal Nadi in the southwestern part of the Garhwal Synform. This was subsequently studied in detail by Middlemiss (1885, 1887) who classified it into Lower and Upper Tal, and considered it to be Mesozoic. He included the sandstone, quartzite, quartzose conglomerate, black carbonaceous shale in the Lower Tal while the fossiliferous shell limestone was grouped in the Upper Tal. Auden (1934, 1937), however, reclassified the Tal Formation grouping the argillaceous rocks in the Lower Tal while the quartzite and sandstone were classified in the Upper Tal with the shell limestone. He considered the Tal Formation to be of Jurassic-Cretaceous age. This classification was followed by Shankar (1971) in the adjoining Mussoorie Synform where he further subdivided the Lower Tal into Chert, Argillaceous, Arenaceous and Calcareous Members and the Upper Tal into quartzite and Limestone Members. Maithani (1972) recorded some fossil pelecypods and gastropods from "Tal" from north of Gajwar and south of Dogadda assigning late Triassic to early Jurassic/Cretaceous age. He (in Table 2) describes Lower Tal from the southern part of the Synform. The work carried out by authors has revealed that there is no development of Lower Tal in the southern and south-western part of the Synform. In absence of any accompanying geological map with the work of Maithani, it is not possible to compare precisely with that of the authors map. It is probable that Maithani either considered the Blaini grey Shale of the Haldwani Sot south of Dogadda or included the dark grey shale of the authors' Binj Formation in the Malin and Rawasan Nadi, in his Lower Tal. Moreover, he included the Bijni quartzite of Auden (1937) also in the Upper Tal. The Bijni quartzite, in fact, is quite different being much more indurated and recrystallised mosaic of quartz grains as compared to the felspathic sandstone or quartzite of the Upper Tal. The units 'f' and 'g' of Maithani (1972, Table 2) appear to belong to the Subathu rather than the Upper Tal. No such rock types have been mapped by the authors' or mentioned in the work of Auden, and Shankar from the Upper Tal. The fossil fauna recorded by Maithani, on preliminary examination, has been found to resemble very much with that associated

with the Subathu containing *Nummulite* spp. besides pelecypods and gastropods. Therefore, the classification and age given by Maithani is not acceptable.

Valdiya (1975) described the three members—the Jogira, Maskhet and Bansi, to constitute his Tal Formation from the Binj Nadi outcroping between the Main Boundary Fault and the Subathu. Dhaundiyal and Kumar (1976) have already shown that Valdiya's Jogira and Maskhet Members, in fact, belong to the Binj Formation and the Blaini Formation respectively. Similarly, in Rawasan Valley, downstream of Maidan, the Jogira and Maskhet Members (Valdiya, 1975, fig. 3B) do not belong to Tal but constitute the Binj Formation overlapped by the Manikot Shell Limestone. It is the Bansi Member of Valdiya which constitutes the Tal in the Binj Nadi and Rawasan Nadi down stream of Maidan. Upstream to Maidan, all the three Members of Valdiya's Tal Formation, belong to the Binj Formation. This is confirmed by the presence of Blaini diamicite and Manikot Shell Limestone found overlying the Binj Formation southwest of Salni. The contact with the underlying Bijni is not a tectonic plane as visualised by Valdiya, but marks an unconformity. Coming to the Khoh Valley in the east, immediately north of the Main Boundary Fault are purple shale and siltstone, and bleaching shales of the Blaini corresponding to the Member F and G of Dhaundiyal and Kumar (1976) followed by the Lower Krol, Upper Tal quartzite and Shell Limestone and Subathu in ascending order. There is no development of Lower Tal. It is possibly the Blaini and the Lower Krol which are considered to be the Jogira Member by Valdiya. Further to the east, in the Bansi Quarry-Golikhet-Sila gad section, no T_j and T_m members of Tal Formation of Valdiya are developed. Here, the Lower Krol comes in direct contact with the Siwalik due to the Main Boundary Fault. It is successively overlain by the Middle Krol, Upper Krol, Manikot Shell Limestone and Subathu in the southern part. In the northern part of the section, the Subathu overlaps the folded sequence of the Binj Formaiton (represented by the quartzite and shell limestone) and the Boulder Slate Member of the Blaini Formation consisting of sandstone, diamictite, conglomerate, quartzite, shale containing fenestellids and brachiopod fauna of Upper Carboniferous to Permian age. It is limited in north by the Fatehpur Fault which brings the Amri Member of the Lansdowne Formation in juxtaposition with the Binj and or Blaini Formations. It is from the Manikot Shell Limestone near Bansi, Kalia (1972, 1976) recorded fusulinids and algae of Permian age. Dhaundiyal and Kumar (1976) have already pointed out that what Kalia considered to be fusulinids appear to be distorted oolites and other bryozoa, and the algae present therein according to Nakazawa (in Dhaundiyal and Kumar, 1976) may be of Cretaceous age. Most of the forms considered to be algae by Kalia (1976) are bryozoa which according to Prof. S. B. Bhatia of Panjab University, Chandigarh belong to Upper Cretaceous to Paleocene (personal communication). Tewari and Kumar (1967), however, recorded Lower Cretaceous alga and bryozoa from the Manikot Shell Limestone at Nilkanth. Tewari (1975) recorded Devonian scolecodonts from the shell limestone belonging to the Binj Formation of the authors' at Fatehpur in the Sila Gad. Valdiya had considered this shell limestone to be his Bansi Member of the Upper Tal. The Jogira and Maskhet Members of Valdiya also do not belong to the Tal but form the Palaeozoic sequence of the Blaini Formation.

In the northern part of the Garhwal Synform, at Singtali, a complete succession from Blaini to the Subathu Formation is exposed. It is limited in north by the Saknidhar Formation and in south the Singtali Fault (Garhwal Thrust of Auden, 1937) brings the Bijni arenite and argillite in juxtaposition with the Subathu. Mehrotra *et al.*, (1976) considering the Shell Limestone to be of Permian age, shifted the position of Auden's Garhwal Thrust to the base of the Manikot Shell Limestone (their Singtali Formation). The shale bed occurring between the shell limestone and the Phulchatti quartzite was considered by them to belong to the Subathu Formation. The authors work has shown that there is no tectonic plane at the position visualised by Mehrotra *et al.*, and the outcrop of the Subathu actually overlies the shell limestone (fig. 2A). The bryozoa and the gastropods in the shell limestone are the same as found elsewhere in the Manikot Shell Limestone, and therefore, are of the same age. The position of the Garhwal Thrust (authors' Singtali Fault) remains where it was originally marked by Auden (1937) and followed by subsequent workers.

CONCLUSION

From the foregoing discussions it is quite clear that there are two horizons of shell limestone in the normal stratigraphic sequnce of the Binj, Blaini, Krol and Tal Formations besides the Subathu in the Garhwal Synform. One of these horizons belong to the Binj Formation from which Tewari (1975) recorded Devonian scolecodonts. It is overlain by the Blaini Formation containing Middle to Upper Carboniferous fenestillids (Ganesan, 1971, 1972), and molluscan and bryozoan fauna of upper Westphalian to Lower Permian (Shankar, Dhaundiyal and Kapoor, 1973) in its Boulder Slate Member. The Binj Formation therefore, may range in age from Devonian to Lower Carboniferous, and is correlative with the Syringothyris Limestone of Kashmir. It represents a shallow marine deposit of a transgressive sea.

The other horizon of the shell limestone constitutes

the topmost unit of the Upper Tal Member of the Tal Formation and represents another marine transgression during Upper Cretaceous. It contains Cretaceous algae and bryozoa besides fragmentary bivales and gastropods. According to Tewari and Kumar (1967) the fauna and flora indicates Lower Cretaceous age, but Prof. Bhatia has suggested Upper Cretaceous to Paleocene age to the Bryozoa contained in it. Jurassic fauna and flora was recorded by Shrivastava (1972) from the Lower Tal Member. Therefore, the age of the Tal Formation could be taken from Jurassic to Cretaceous (maximum up to Paleocene).

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