Pakistan Journal of Hydrocarbon Research
Vol.3, No.1(January 1991), P.35-45, 10 Figs.

On the Chorgali Formation at the Type Locality

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ABSTRACT

The type locality of the Chorgali Formation is the Chorgali Pass, located in the Khair-e-Murat Range, Potwar Plateau. The age of the formation is Early Eocene. It is suggested to use the term Chorgali Formation to refer to a sequence of grey, bedded to thin bedded dolomite with intercalated shale, about 80-90m thick. The overlaying greenish shale, about 70m thick, should be included within the (overlaying) Kuldana Formation.

The contact with the underlaying Sakesar/Margala Hill Limestone and the overlaying Kuldana Formation is conformable. Both contacts are well exposed at the type locality.

The Chorgali Formation was deposited in intertidal to supratidal environments during an overall regression of the Early Eocene sea.

Most of the Bhadrar beds in the Salt Range are fully marine deposits, and are therefore considered as a member of the Sakesar Limestone, not as a homolog of the Chorgali Formation.

The Lora formation of the Hazara mountains is also a fully marine deposit, and therefore should be excluded from the Chorgali Formation.

INTRODUCTION

Chorgali Pass is the type locality of the Chorgali Formation. It is located in the Potwar Plateau, Khair-e-Murat Range, lat. 33° 26′ 30″ N, long. 72° 41′ E. According to the definition, the Chorgali Formation consists of dolomitic limestone and shale in the lower part, while the upper part is composed predominantly of shale (Shah, 1977:77). The thickness of the formation is recorded by Shah as 150m. The author of the name of this formation is E.H. Pascoe (1920), who introduced the term "Chorgali beds". This term was later on changed into "Chorgali Formation" (fide Shah, 1977). The age of the formation is Early Eocene.

After Pascoe the type locality seems to have been studied again only by N.A. Wells (1984).

Wells (1984:335) measured 138.2m of thickness at the type locality, mentioning that the basal 15m may represent Margala Hill Limestone.

Wells distinguished 5 main facies, which are, from top to bottom:

- 3m marl,
- 2.2m miliolid-ostracodal micrites,
- 60m shale,
- 58m essentially unfossiliferous marly to dolomitic siltstones with possible algal beds,
- 15m shallow water and upward shoaling nummulitic limestone.

Frame of this study

Observations on the Chorgali Formation at the type locality were carried out in 1988 in the frame of a technical cooperation project between HDIP and BGR (Hannover, Germany), in the context of a study on Eocene sedimentary rocks in the Salt Range and Potwar Plateau (H. Jurgan, G. Abbas and M. Mujtaba, 1988). The section was revisited in 1990 by H. Jurgan and G. Abbas.

LITHOLOGY OF THE CHORGALI FORMATION AND ITS UNDERLAYING AND OVERLAYING FORMATIONS

Field Observations and thin section analysis

At the Chorgali Pass, the type locality, the complete sequence of the Chorgali Formation is exposed in the northern limb of an anticline, whose axis plunges to the WSW.

Measurement of the section started at the lowest accessible beds in the core of this anticline, and extended upwards to the unconformity which separates this sequence from the basal conglomerate of the Murree Formation. This conglomerate is known as the Fatehjang member of the Murree Formation.

The Chorgali Formation is conformably underlain by beds of the Sakesar, or Margala Hill Limestone. The upper contact with the Kuldana Formation is likewise

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conformable. Sediments of the Kuldana Formation are in erosional contact with a calclithic conglomerate of the Fatehjang member of the Murree Formation.

The thickness of the measured sequence is 158m (Figure 1). 45 samples were collected and analyzed (Figures 2a, 2b).

Sakesar/Margala Hill Limestone

According to microfacies analyses, the basal 7m are regarded to represent Sakesar or Margala Hill Limestone. The limestone is a benthonic foraminiferal debris packstone. The biodebris is mixed with common *Assilina, Nummulites,* alveolinids, soritids, sparse small miliolids, ostracods, and rare planktonic forams; there are few bivalve and echinid and sparse small coral remains.

In the upper beds, euhedral, medium-size crystals of dolomite occurring in clusters are common. Pervasive dolomitization was observed too; the third bed measured in the section is a 0.8m thick dark brownish-grey medium-grained crystalline dolomite containing abundant benthonic forams, especially *Assilina sp.* The softness of the rock is caused by a high degree of microporosity due to leaching of the calcitic matrix.

These rock types were observed frequently at different locations in the Sakesar Formation in the Salt Range, and likewise in well cores from the Potwar Plateau (Jurgan et al, 1988). While the colour of the limestone in outcrops varies between creamy white and light grey, it is dark grey in well samples.

So far, a comparative study between the Sakesar and the Margala Hill Limestone is lacking. Field observations and thin section studies carried out on samples of the Margala Hill Limestone indicate, that both rock units are fully marine deposits, very similar in composition, and of the same age. They are possibly sediments of the same environment, deposited in different areas of the same sea.

Chorgali Formation

The lithology of the Chorgali Formation is very different from that of the Sakesar, or Margala Hill Limestone (Figure 1). The rock is frequently very thin bedded to laminated, mostly finely to very finely crystalline dolomite. This dolomitic sequence has a total thickness of about 80-90m, including 30m of shaly marl at the top. The dolomitic beds, 54m thick, contain hardly any fossils except for tiny miliolids and ostracods, which are more common only locally, and scarce echinid remains. The rocks consist dominantly of thin bedded and laminated finely crystalline dolomite with some beds displaying a mottled or a nodular-flaser texture (Figure 3), or abundant burrow features (Figure 4).

There are two kinds of laminations:

Inorganic sedimentary lamination.— Laminae have a thickness in the order of 0.1-3mm and consist of alternating dark bluish-grey and light buff layers. Horizontal burrow tubes, always filled with bluish-grey mudstone, cutting through the light buff layers are a common feature.

Biogenic sedimentary lamination.— These are irregular wavy laminae ranging in thickness between 0.1-1mm, interrupted by desiccation cracks and vertical burrow features or rootlets. A bed of about 1 to 2m of irregular, wavily laminated dolomite (Figure 5), about 30m above the top of the Sakesar Formation, is very conspicuous (Figure 1).

This irregularly laminated rock is a stromatolite (Figure 6), generated by mats of blue green algae which formed one on top of the other. It is interpreted to have formed in upper intertidal to supratidal environments (Shinn, 1983).

Two grain types were frequently observed in the finely crystalline dolomite:

-round to subrounded intraclasts, and
-clusters of "peloids" (Figure 7).

These grains are evidently derived from larger, irregularly shaped accumulations of loosely packed "peloids", frequently set in a sparitic cement. Sometimes the intergranular space is occupied by matrix or incompletely filled with cement, leaving room for open pore space. The loose packing of the peloids indicates rapid cementation of these clusters. The peloid clusters are generally arranged in small nodules, which adopted a flaser to nodular texture during pressure solution (Figure 3).

Upwards, over a short vertical distance the nodules become smaller and vanish, but single peloids or parts of these peloid clusters (intraclasts) are very persistent in the rock (Figure 8). Actually these particles are so characteristic that they can be used to determine whether a sample belongs to the Chorgali Formation or not, as checked on core samples from the Potwar Plateau (Jurgan et al, 1988).

The genesis of these clusters is unknown. Their position in the lithologic column (Figure 1) is labelled as "partially reworked blue green algae mats?", but they might have been generated as fecal pellets, or possibly represent bacterial products - a quite unsatisfactory state of interpretation.

Almost at the top of the dolomitic sequence, there is a buff to tan bed only 0.2m thick, which is a sedimentary breccia (Figure 9). The clasts are of sand to pebble size, angular to rounded. They are synsedimentary clasts of intraformational origin and consist of dolomite as well as shale flakes. The presence of soft, angular clay debris indicates very short transport distances between the place of origin and the site of deposition. The rock is a product of the supratidal environment.

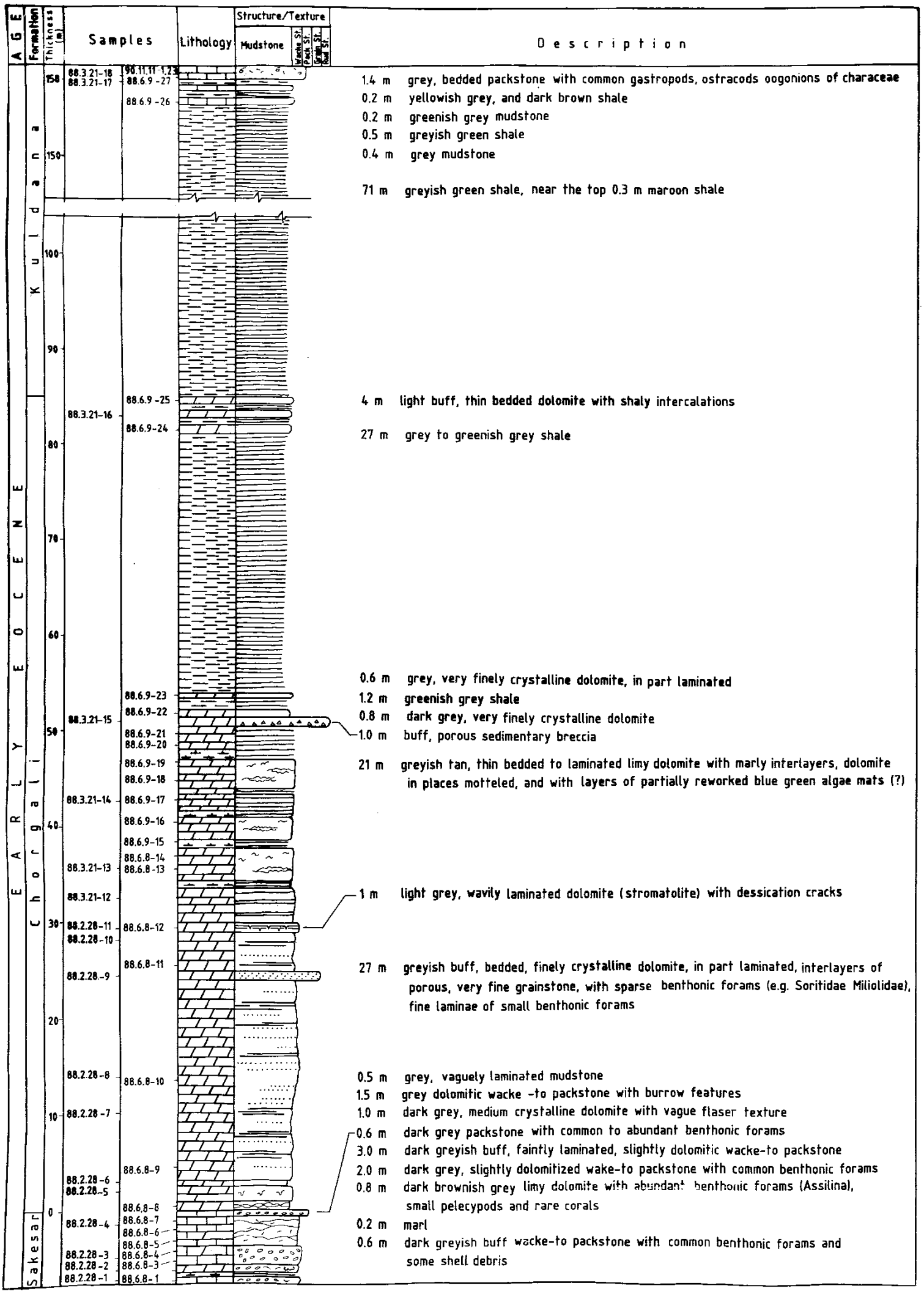

Figure 1— Lithosection of the Chorgali Formation at the type locality.

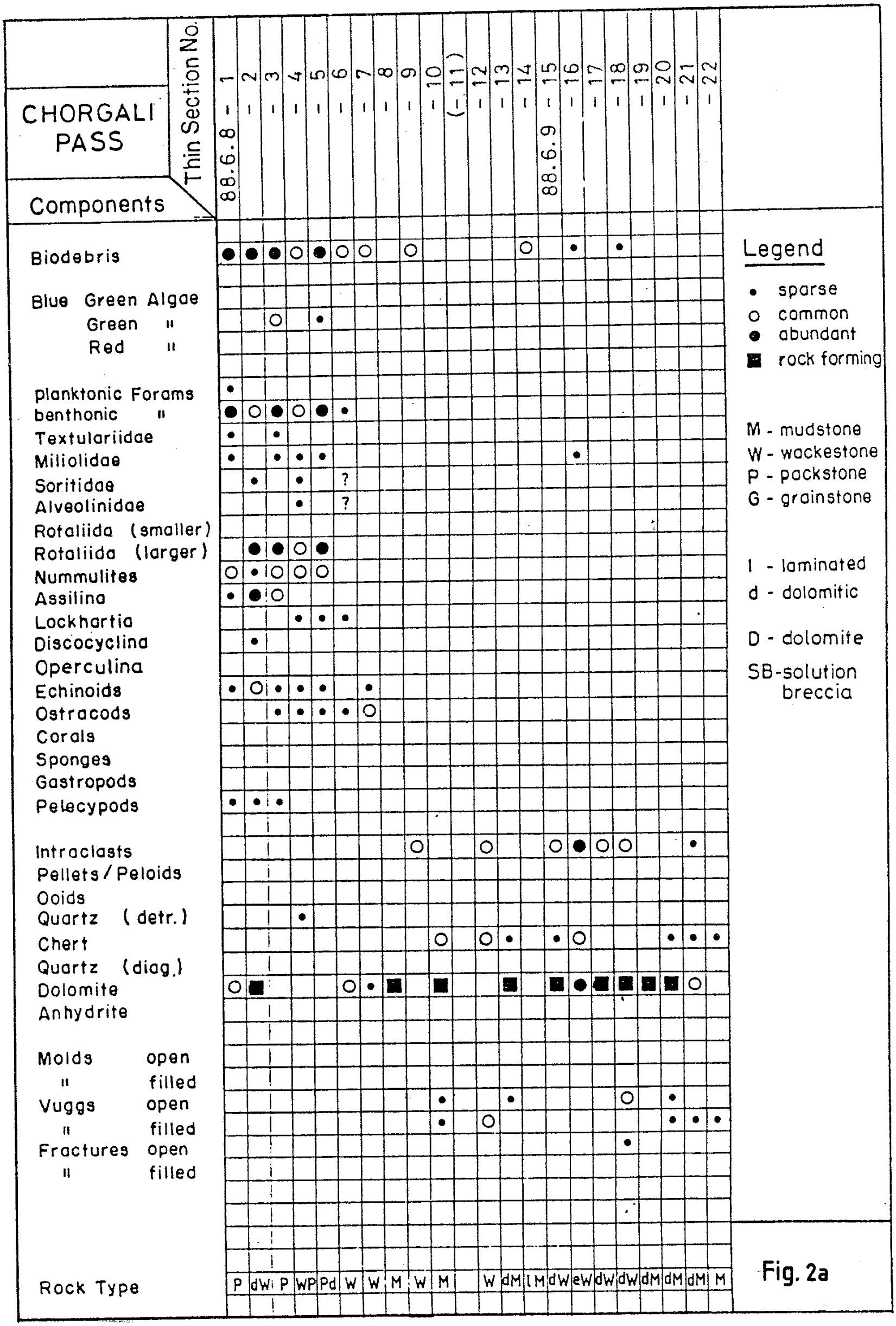

Figure 2a— Thin section analysis chart of the Chorgali Formation.

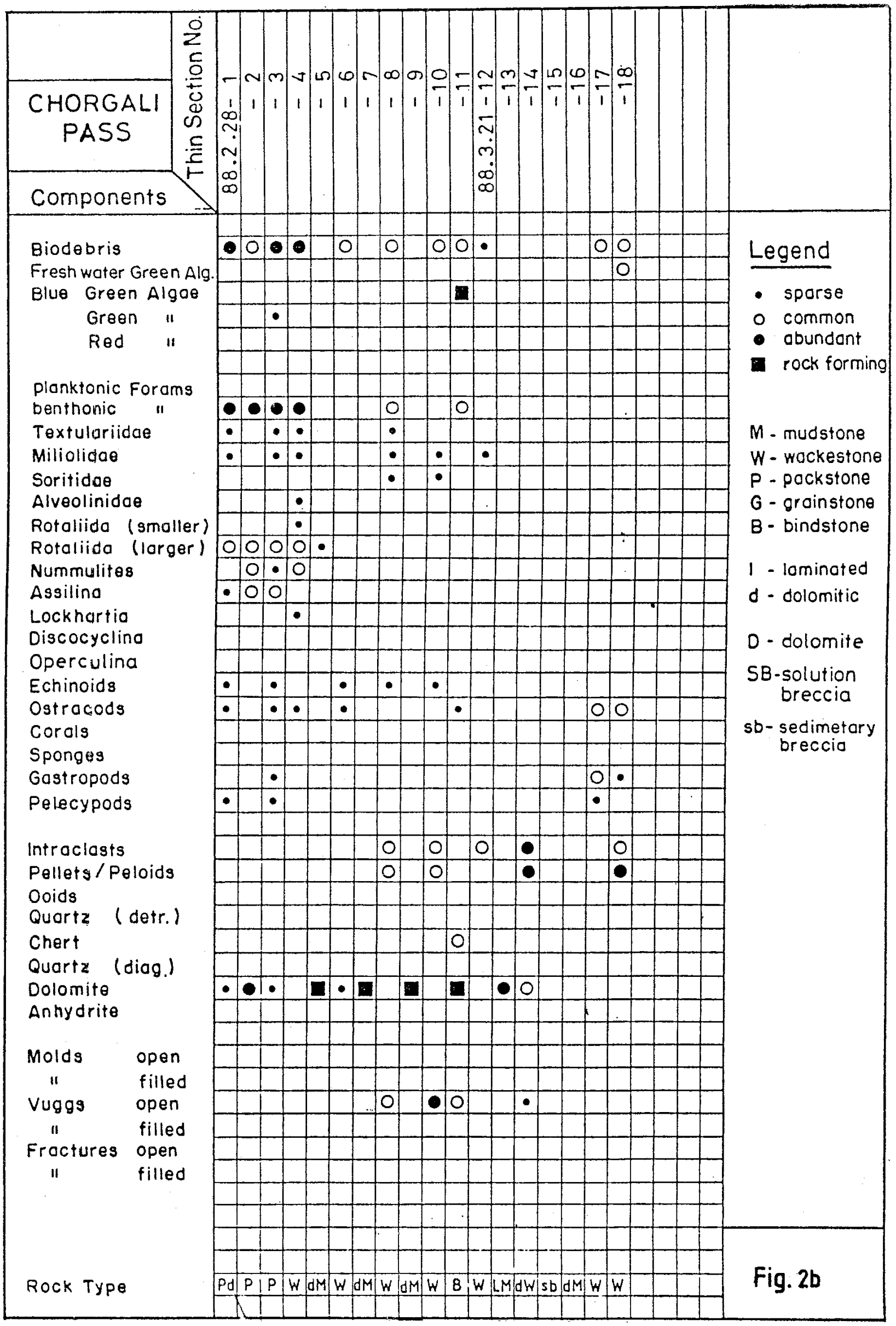

Figure 2b— Thin section analysis chart of the Chorgali Formation.

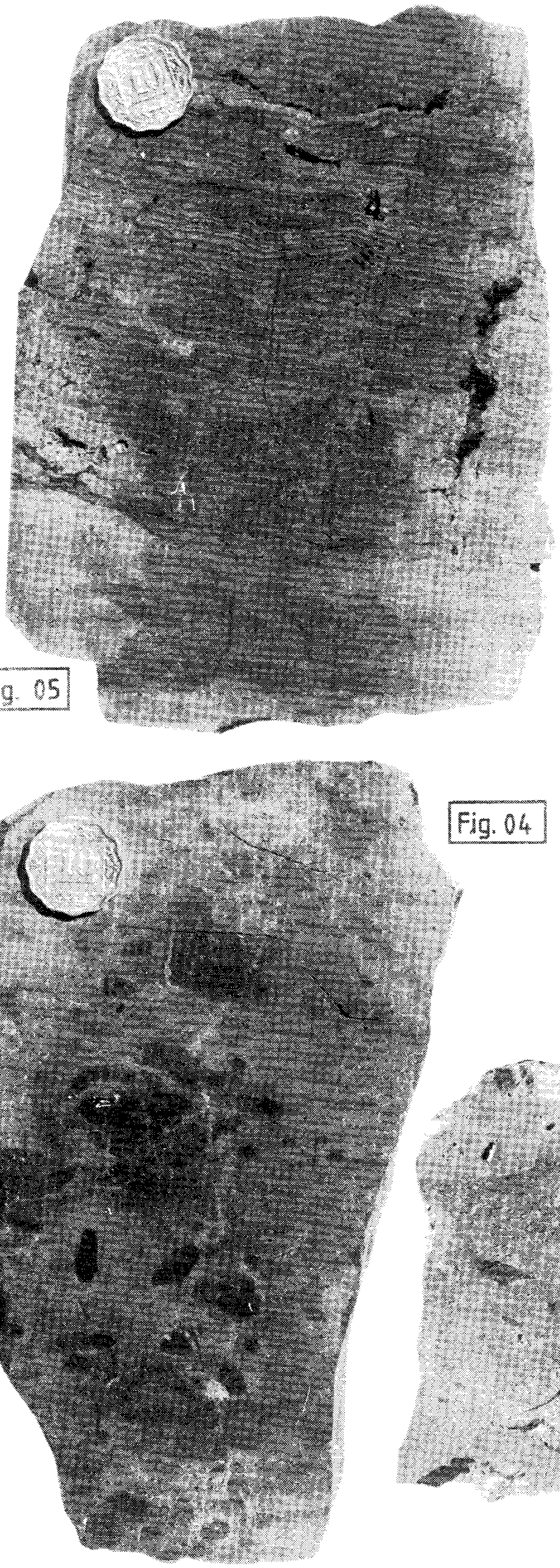

Fig. 05

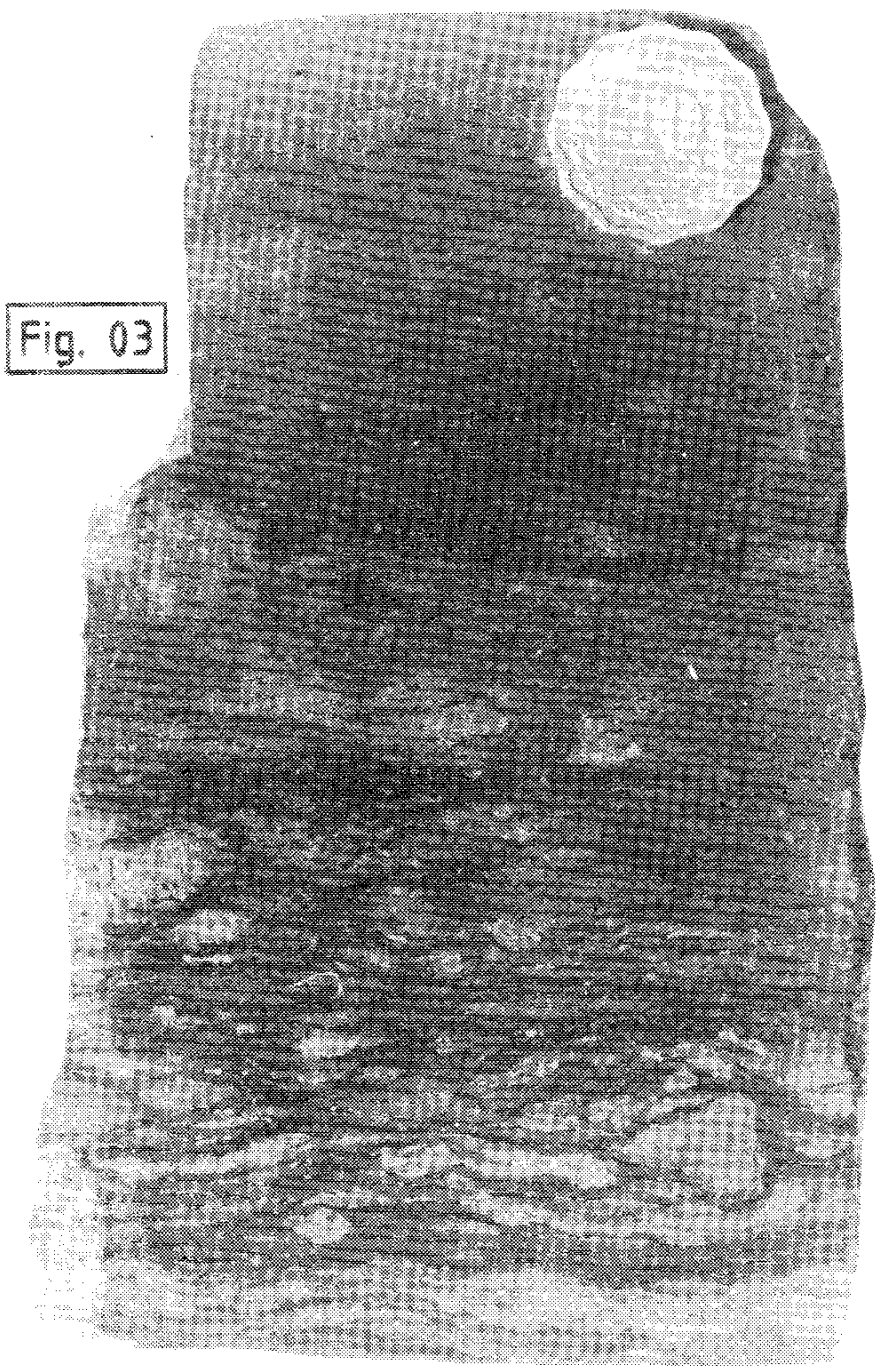

Fig. 03

Fig. 04

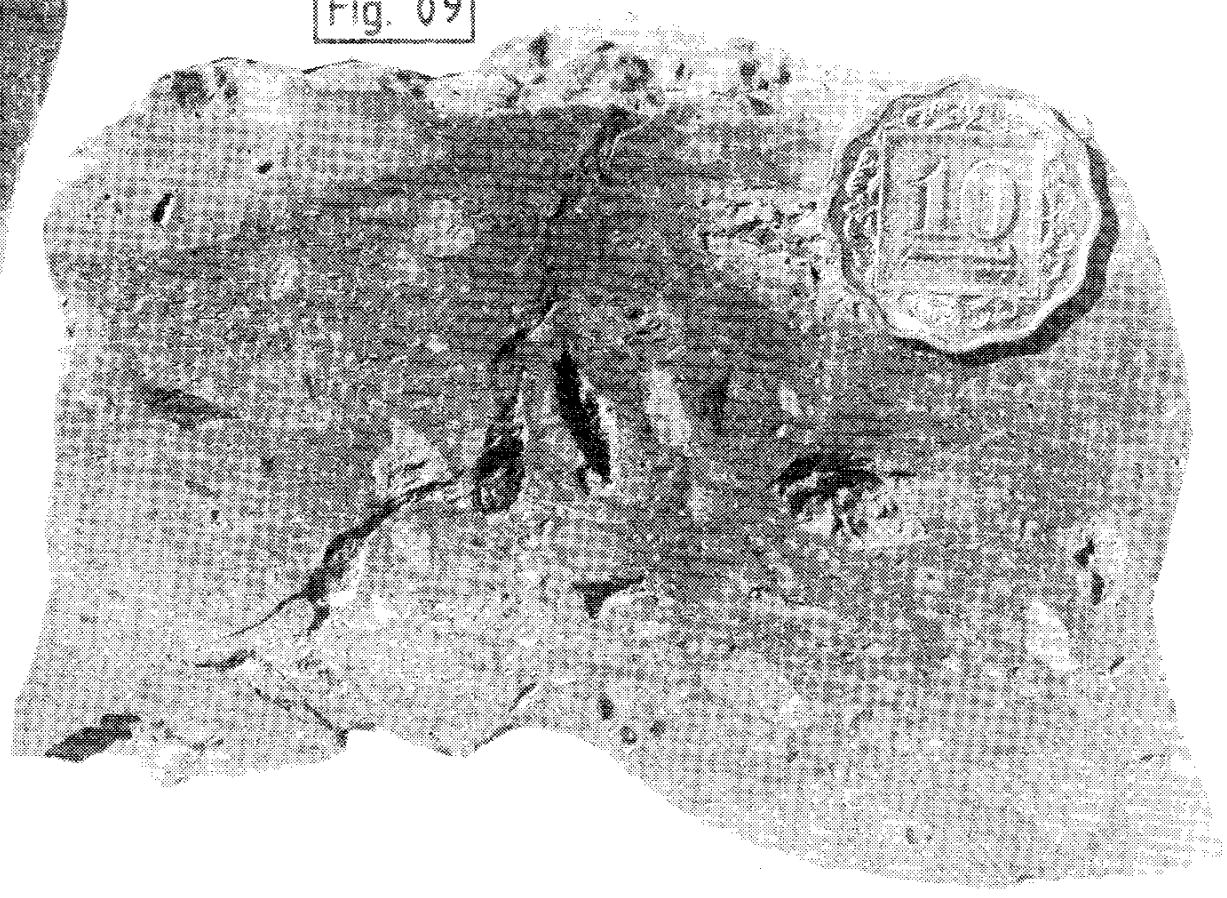

Fig. 09

Figure 3— Flaser-nodular wackestone; flaser nodules consist of loosely packed peloid clusters; compare with Figure 7. Chorgali Formation, Chorgali Pass, Sample 88.3.21.-14.

Figure 4— Mottled dolomite; texture generated by vagrant endobenthonic organisms. Chorgali Formation, Chorgali Pass, Sample 88.2.28.-5.

Figure 5— Stromatolite with desiccation cracks. Chorgali Formation, Chorgali Pass, Sample 88.2.28.-11.

Figure 9— Sedimentary breccia; dark angular fragments consists of soft shale. Chorgali Formation, Chorgali Pass, Sample 88.3.21.-15.

Higher up in the section, above a shaly sequence about 30m thick, there are about 4m of light buff, thin-bedded, very finely to medium grained, crystalline dolomite with shaly intercalations. The dolomite has a dismicritic texture and is porous, containing small vugs. Many of these vugs, and possibly molds are sealed by blocky calcite.

This dominantly dolomitic sequence is 80-90m thick.

Above these beds follow about 70m of greenish shale, with an interlayer of maroon shale near the top. There are two beds of grey and greenish grey mudstone to wackestone close to the top of this sequence. They contain only few ostracods. To the west these beds increase in thickness, and also the maroon shale increases in thickness to more than 1m.

Samples collected from these shales so far proved to be barren of any kind of microfossils e.g. foraminifera, nannoplankton, and dinoflagellates (the corresponding analyses were carried out by Dr. A. Koethe, BGR, during her stay with HDIP Laboratories Islamabad in 1988). The correct depositional environment of these shales is not known. It is customary to consider these shales as the upper part of the Chorgali Formation.

Kuldana Formation

The continuous section ends with a 1.4m thick bed of hard, greyish wackestone to packstone, conformably overlaying the 70m of greenish grey shale. The limestone is basically an ostracod micrite. In addition the rock contains common, locally abundant, thin shelled, small gastropods, fragments of pelecypods and oogonia of charophytes. Charophytes are green algae of fresh water habitat (Johnson, 1961). To the west the fresh water limestone increases in thickness, exceeding 5m.

Gastropods, pelecypods and ostracods occur likewise in fresh water habitats, while charophytes are exclusively fresh water green algae. This bed therefore formed in a fresh water depositional environment.

Fresh water deposits are known from the Kuldana Formation (Shah 1977:78), which is reported to have a conformable contact with the underlaying Chorgali Formation in the Hazara, Kala Chitta and northern Potwar areas. It is therefore concluded, that this bed belongs to the Kuldana Formation.

DISCUSSION

The term "formation" is used in this report according to the Stratigraphic Nomenclature Committee of Pakistan (Rahman, 1962) and the International Stratigraphic Code as cited and interpreted by Dunbar & Rodgers (1966:259 ff.). In this sense, a "formation" is a unit of rocks distinguished from other units by lithologic characters, which reflect the uniform or uniformly alternating conditions under which it was deposited. The concept of time as such does not enter the definition.

A "formation" then, would refer to a sequence of rocks of uniform lithology representing sediments, which were deposited in the same depositional environment. The recognition and definition of depositional environments dates back to J.Walther (1893-1894), and since then it has been given increasing importance (Wilson, 1975; Scholle et al, 1983).

Based on field observations and thin section studies, the Chorgali Formation at it's type locality is – in it's lower part – dominantly dolomitic, and very poor in fossils of any kind. It seems reasonable to apply the term Chorgali Formation to this rock sequence only. The upper limit of the Chorgali Formation then would be indicated by the last dolomitic beds, thus separating the following 70m of greenish grey shale from the lithologic content of the Chorgali Formation at the type locality.

The rich fossil assemblage, as recorded by Shah (1977:77) actually does not refer to the type section, but to lithologic units, which were later on joined with the Chorgali Formation. These are the "Bhadrar Beds" in the Salt Range (Gee, 1981; Gill, 1952), and the "Lora formation" in the Hazara mountains (Latif, 1970).

Shah (1977:77) reports that the Chorgali Formation at the type locality, as well as in the Salt Range is divisible into two parts. However, in the Salt Range "The lower part

Figure 6— Wavily laminated, dolomitized stromatolite layer; (long side of the square in the picture is 36mm long). Photo depicts outcrop situation at Chorgali type locality, about 30m above base of Chorgali Formation; compare with Figure 1.

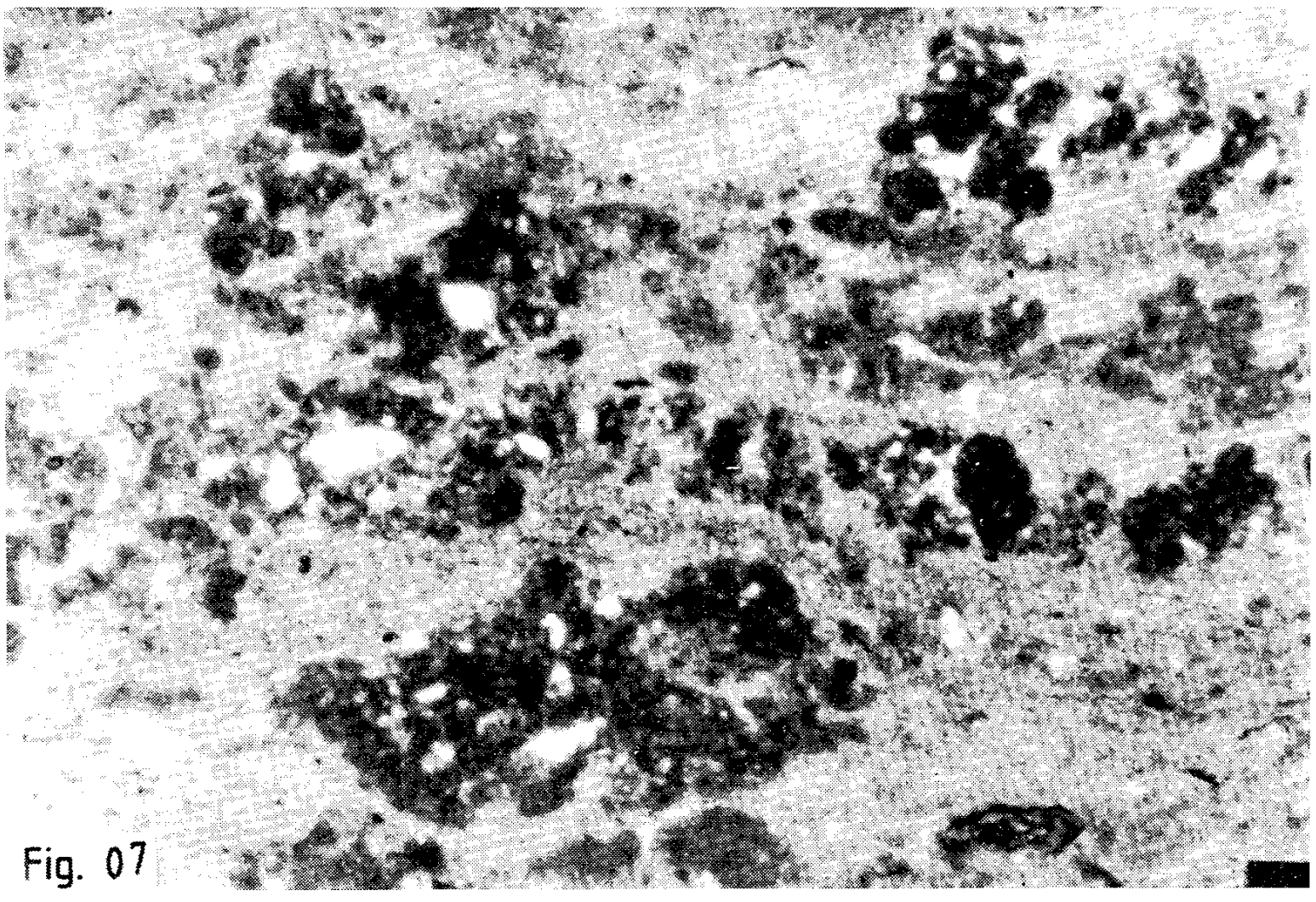

Figure 7— Peloid cluster wackestone with finely crystalline dolomite matrix; outlines of individual peloids lost probably due to to compaction. Chorgali Formation, Chorgali Pass Sample 88.3.21.-14, scale bar = 0.2mm.

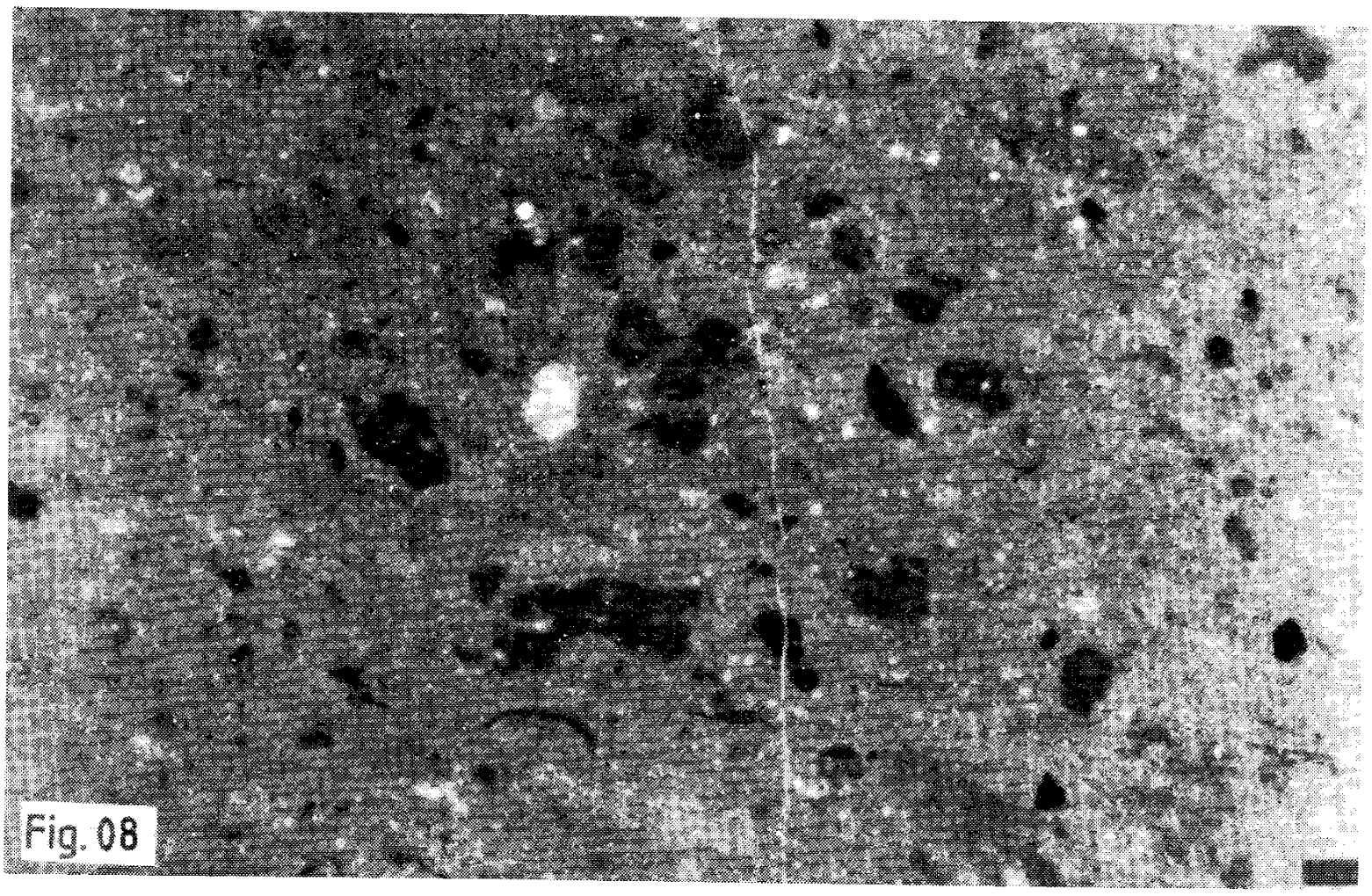

Figure 8— Intraclast wackestone with finely crystalline dolomite matrix; intraclasts probably derived from reworked peloid clusters; rare ostracods. Chorgali Formation, Chorgali Pass Sample 88.6.9.-18, scale bar = 0.2mm.

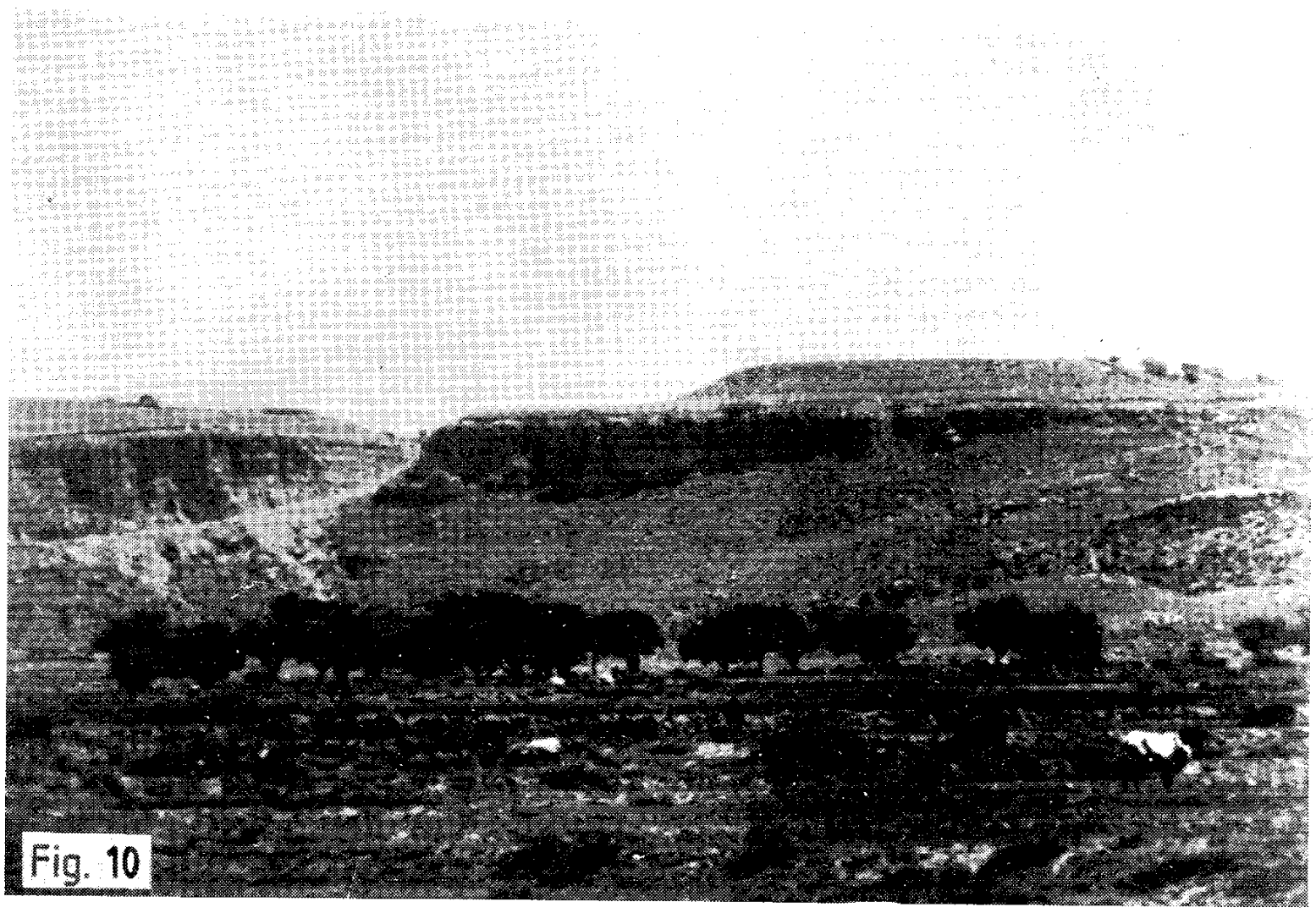

Figure 10— A view of the gentle ridges formed by the Bhadrar beds, on top of Sakesar Limestone, which forms steep cliffs. Bhadrar area, central Salt Range; road leads to Dhok Chhab.

consists of shale and limestone, while the upper part is mainly limestone" – Shah actually refers to the Bhadrar beds, which were studied by Gill (1953) – while at the type locality the situation is reverse: the lower third is dolomite (not limestone!), and the upper two thirds are shale.

Bhadrar Beds

The geological map of the Salt Range (Gee, 1981) indicates the presence of the Chorgali Formation in the area between Pail and Choa Saidan Shah. In the Salt Range this formation was previously known as the "Bhadrar Beds", and this term is noted in parentheses in the legend of this map.

Gill (1953:824) noted, that "the upper layers of the Sakesar Limestone of the western and central Salt Range pass eastward into the lower Bhadrar shales", and that the lower Bhadrar shales, being a clearly marine deposit, are "homotaxial with beds in the west that would be mapped as the uppermost layers of the Sakesar Limestone" (p.832).

According to Gill the separation between Bhadrar beds and Sakesar Limestone is hardly possible in the western part of the Salt Range, since these two rocks are essentially identical in aspect and content of benthonic foraminifera.

Starting from Pail in an eastward direction, the Sakesar Limestone is separated from the Bhadrar beds by thin but conspicuous shales and marls at the base of the lower Bhadrar beds. The upper Bhadrar beds are still limestone. Gill reports that the upper Bhadrar beds are porcellaneous white or cream coloured limestone with *Lockhartia spp.* and *Rotalia trochidiformis*, locally with numerous soritids; in other places abundant chert nodules are present.

On the other hand Gill describes the upper Bhadrar beds as mostly unfossiliferous porcellanous limestone in the eastern exposures, "with an increasing element of argillaceous, dolomitic limestone in the west." Gill is of the opinion that these dolomites probably formed in lagoons. "Whether the lagoon was saline or brackish is not clear, although the occurrence of anhydrite at this horizon elsewhere in the Kohat-Potwar basin clearly suggests a desiccation phase." Gill stated that "in contrast, the lower Bhadrar beds are clearly a marine deposit".

As far as the non-dolomitic part of the Bhadrar beds is concerned, our observations (Jurgan et al, 1988) in the Salt Range, between Pail in the west and the confluence of the Kas Ratani with the Nila Wahan in the east confirm Gill's: the beds consist of thin bedded to bedded, whitish cream wackestone to packstone, alternating with yellowish and yellowish-greenish marl. The sequence has an overall colour of yellowish tan and forms low gentle ridges (Figure 10). The beds are easily distinguishable from the underlying, comparatively hard, cliff-forming Sakesar Limestone, which in this area is grey in colour.

(The thickness of this sequence is rather limited, about 10m due to erosion of the upper layers. Fatmi (1973:51) reports the remaining thickness of 26 feet at Pail, and 19 feet at Nurpur.)

Microscopically the Bhadrar limestone is the same as the Sakesar Limestone, containing alveolinids, nummulites and echinids, indicating the same, fully marine depositonal environment.

Taking into consideration the similarity of the Bhadrar beds with the Sakesar Limestone, and the dissimilarity with the dolomitic Chorgali sequence at its type locality, the Bhadrar beds are clearly a member of the Sakesar Limestone.

At present a comparative study of the dolomitic part of the Bhadrar beds with the Chorgali Formation and the uppermost dolomitic beds of the Sakesar Formation is lacking.

Lora Formation

Latif (1970:16) describes this formation as composed of limestones and marls, light grey to pale grey, and weathering in light yellow and cream colours. The rocks are generally thinly bedded, and show a platy appearance. Based on the content of foraminifera, which indicate an Early Eocene age, Latif correlates the Lora formation with the Sakesar Limestone and the Bhadrar beds, the Shekhan Formation and the Passage Beds. Clearly: "correlation" refers to rocks of the same age, but Latif does not infer a similar lithology.

Our own observations on the Lora limestones revealed a rather common presence of echinid fragments, and establish, together with the content of foraminifera, a fully marine depositional environment. This, and the absence of dolomite suggests to maintain the term Lora formation, and to keep it separate from the Chorgali Formation.

Regional Aspects

According to the present stage of knowledge, during the Early Eocene the sea covered the area from south of the present Salt Range extending beyond the present Hazara Mountains. Sediments of the Sakesar and the Margala Hill Limestone were deposited upon a very gently dipping ramp. A more locally operating influx of clay material, mixing with carbonate material generated the Bhadrar beds.

During the regression, the marine environments changed in the south and southwest into an intertidal to supratidal environment, where dolomitization and precipitation of anhydrite (Meyal wells) and gypsum (Jatta Gypsum, Kohat area) indicate evaporitic conditions. Further to the north however, the sea still covered part of the area, as indicated by the fully marine deposits of the Lora formation.

The 70m of greenish shale at the Chorgali Pass, displaying maroon colours to a very limited extent only,

belong possibly to the Kuldana Formation, in which maroon and reddish colours are so persistent.

CONCLUSION

The Chorgali Formation at its type locality represents a sequence of dominantly dolomitic, thin bedded and laminated rocks and has a thickness of about 80-90m, which formed in an intertidal to supratidal environment. The sequence represents shallowing-upward sedimentary conditions indicating a regression of the sea.

The overlaying shales, about 70m thick, so far proved to be barren of any kind of fossils. At the present stage of knowledge their depositional environment is not satisfactorily determinable. Since the Kuldana Formation is reported to consist dominantly of shales, deposited conformably on top of the Chorgali Formation, it is suggested to include these shales into the Kuldana Formation.

A greyish limestone, on top of the shaly sequence is of fresh water origin and belongs to the Kuldana Formation.

At the type locality, the lower and upper sedimentary boundaries of the Chorgali Formation are conformable with the underlaying Sakesar/Margala Hill Limestone and the overlaying Kuldana Formation. The Chorgali Formation is well exposed, but affected by faults.

ACKNOWLEDGEMENTS

We would like to thank the Director General of Hydrocarbon Development Institute of Pakistan Mr. Hilal A. Raza for his consent to publish this report. Thanks are likewise due to the draftsman of the HDIP, Mr. Ashraf, who skillfully prepared the drawings.

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