DEPARTMENT OF MINES AND ENERGY
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LITHOLOGIES AND INTERPRETATIONS OF THE OBSERVATORY HILL BEDS, MARLA - 1A and -1B.

REPORT NO. 10 OF THE OFFICER BASIN STUDY GROUP

GEOLOGICAL SURVEY

By

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Fossil Fuels Section

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CONTENTS | PAGE

CONTENTS (cont.)

FIGURES

PLATES

APPENDICES

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ABSTRACT

Detailed study of the predominantly carbonate lithologies in cores recovered from Marla-1A,-1B reveals that deposition of the Observatory Hill Beds at this location occurred in a shallow lagoon which developed on a broad, marine platform. Lithologies are mainly finegrained and dolomitic, with regular interbeds of packstones, algal boundstones and sandstones. Environments of deposition are interpreted as peri-sabkha to open lagoon.

A favourable environment for Mississippi Valley-type mineralisation exists throughout the 300 m of penetrated section. No indications of petroleum were noted.

The geological history of the sequence is interpreted and areas are outlined that may warrant the future attention of mineral and petroleum explorationists.

INTRODUCTION

This report presents a detailed description and interpretation of the lithologies of the Observatory Hill Beds in Marla-1A and -1B. It is intended to expand on the well completion report (Benbow, 1980a) and not to replace that report.

Marla-1A and -1B were drilled during 1979 as part of the South Australian Department of Mines and Energy's investigation into the petroleum potential of the Officer Basin (Fig. 1). The two wells were drilled only 15 m apart and full details of the drilling programme are presented in Benbow (1980a). A summary of all previous geological work in the Officer Basin is given by Pitt *et al*. (1980).

AGE AND STRATIGRAPHIC RELATIONSHIPS

The rocks studied in this report are assigned to the Observatory Hill Beds, defined by Wopfner (1969) as thinly interbedded siltstones and cherty carbonates. Outcrops of this formation and its correlative, the Wirrildar Beds, are poor and generally are scattered around the northern and south-eastern margins of the Officer Basin (Fig. 1) (Pitt *et al.*, 1980, p. 216). However, the beds have been intersected in a number of wells in the basin and these are summarised by Pitt *et al.* (1980).

Acritarchs recovered from Wilkinson-1 (Muir, *in* Gatehouse, 1979) and trilobites from Marla-1 (Jago, *in* Benbow 1980a) enable a Tommotian - Early Cambrian age to be assigned to at least the upper parts of the formation. The lower parts of the section may well be late Proterozoic in age.

Stratigraphic relationships between the isolated subsurface intersections of the Observatory Hill Beds are at present uncertain. Byilkaoora-1 drilled a complete section (224 m) of non-marine Observatory Hill Beds, Marla-1A and -1B drilled 296 m of marine beds with the top eroded and the bottom of the sequence not reached. Until palaeogeographic relationships and depositional facies are more precisely determined all Early Cambrian carbonate-clastic sequences in this part of South Australia are being assigned to the Observatory Hill Beds (Pitt *et al.*, 1980).

METHOD OF STUDY

Marla-1A was drilled to a total depth of 215.30 m and Marla-1B to 379.40 m both terminating within the Observatory Hill Beds. The regional dip in this area is negligible and it has been possible to confirm that marker beds in the two wells occur at almost the same levels: the depth differences vary but are of the order of 500 mm, and much of this is considered due to inaccuracies of drillers' measurements.

LOGGING

Both wells were fully cored through the Observatory Hill Beds (from 83 m depth) and it was therefore decided to study only Marla-1B in detail. The core was cut in half to allow textures and structures to be seen more easily than on the outer surface. The cut core was logged visually at the Glenside Core Library and a preliminary pictorial log drawn up.

The pictorial log (Appendix I) is modelled on the method used by Selley (1978, Fig. 0.1), that is, for clastic rocks a scale is used with the Wentworth grain size increasing to the left of a vertical base line, thereby attempting to present an immediate impression of predominant grain size. The sequence in Marla-1B, although containing interbedded and sometimes thick clastic sequences, is nevertheless mainly carbonate and a method was designed which would allow the clastics and carbonates to be shown on the same log but using different criteria. The carbonate scale used in the litholog (Appendix I) also runs from the same vertical base line and the textural gradation from mudstone to grainstone is, to some extent, designed to represent the relative energy levels acting during deposition of the carbonate. This carbonate scale is in no way intended to represent grain sizes and is entirely separate from the clastic scale.

The final litholog for Marla-1B was drawn up after all petrologic work was completed and it incorporates data from Marla-1A. It is intended to show the major characteristics of each rock unit without using lengthy descriptions: rock colours, bedding types, unit boundaries, accessory features and sample points are all shown graphically for each rock unit logged.

ACETATE PEELS

Over 40 acetate peels were made from cores from both Marla-1A and -1B. The samples were generally 150 mm long and were chosen to cover a wide range of carbonate lithologies. Etching and staining procedures were those of Davies and Till (1968) and peels were made using acetate drafting sheets.

The acetate peels were studied under a conventional petrological microscope and photomicrographs of some are used as illustrations in this report (Plates 1, 2, 5).

THIN SECTIONS

Thirty-five thin sections were cut from selected samples taken from both Marla-1A and -1B. Twenty-two of them have been described by petrologists at the Australian Mineral Development Laboratories (AMDEL) and copies of these descriptions appear in Benbow (1980a). The remainder were used to help in drawing up the final litholog.

Four of the thin sections have been used for photomicrographs to illustrate this report (Plates 3, 4, 6-10).

DESCRIPTION OF CARBONATE LITHOLOGIES

All allochemical terms used throughout this report are those common to all modern carbonate literature. Textural terms are those of Dunham (1962).

ALLOCHEMS

Intraclasts

Intraclasts are the most common allochems in the Observatory Hill Beds in Marla-1B. They range from small (less than 1 mm), subrounded clasts (Plate 1) to large (10 mm or more), angular and platy ones which commonly are very little removed from their place of origin. Plates which display a clear algal origin are not included in this category (see "Stromatolites and Algal Mats").

Intraclasts at Marla are composed of calcite and dolomite mudstone and no coarser textured clasts were recognised.

Peloids

The term "peloid" is used in this text to mean a small, pellet-like object for which no mode of origin is recognised. This term was introduced by McKee and Gutschick (1969) and in no way implies a faecal origin.

Most of the peloids at Marla are ovoid to round, 1 mm or less in length and most commonly occur unassociated with other allochems. Their outlines can be difficult to discern owing to recrystallisation effects.

A less common category of peloids logged in Marla is slightly larger and more irregular than those already described and most probably is intraclastic in origin (Plate 1). They may occur associated with small intraclasts and the differentiation between these two classes of allochems can be difficult to determine.

Ooids

Ooids are rare in these rocks but, where they occur, they are well-rounded and well-sorted (Plates 2, 3, 4).

Recrystallisation and chertification commonly have obscured much of the structure of the ooids but several retain some of their original concentric texture (Plate 2).

Fossil Fragments

Fossil fragments are extremely rare and have been recorded only in the top parts of the Marla sequence (Thornton, 1978; Jago in Benbow, 1980a) and at 332.99 m. Early Cambrian trilobites have been recovered from the top of the section in Marla-1 (Jago, op. cit.) and characteristic hooks and fragments also are recognised in peels from 87.85 m and possibly 107.00 m, and in a thin section from 332.99 m.

"Mudballs"

"Mudballs" occur in a few rock units below 288 m (Fig. 2). In a cut core, they appear very similar to oncolites but when viewed under a microscope they are scarcely discernible from their matrix and show none of the concentric laminae associated with oncolites. Also, they have no nuclei and occur only in mudstone matrices which contain no other allochems or indicators of shallow, high energy waters.

These "mudballs" could be pisolites associated with the formation of calcrete. However, their microscopic appearance does not correspond closely with that reported in the literature (Nagtegaal, 1969; Esteban, 1976). Wilson (1975, p. 82) suggests that such balls can be made by the diggings of arthropods; since the range of "mudballs" in Marla occurs within that for burrowing (Fig. 2), this interpretation could be feasible. For the moment the origin of these minor allochems remains an enigma.

Extraclasts

Extraclasts are almost entirely quartz grains and granules with rare feldspars, micas and heavy minerals. In the predominantly carbonate rocks they occur either with intraclasts, or without other allochems and in a carbonate mudstone matrix.

The quartz grains are commonly sand sized (0.5 to 1.0 mm), and some granules occur also. They are subrounded to rounded and generally show some grading (Plate 5).

Algal Plates

Stromatolitic material is recorded at Marla down to 309.20 m (Fig. 2) and much of it occurs as algal mats and broken mats (algal plates). The plates commonly are associated with and overlying the mats and, in some places, they are replaced by chert

(96.00 m). Many allochems recorded as intraclasts may in fact be of algal origin, but their distinction is not considered important with respect to environmental interpretations.

MATRICES

The term matrix is used here to denote any material surrounding allochems: mud (micrite), neomorphic (recrystallised) spar and cement.

Mud (micrite)

Mud, both calcite and dolomite, is a very abundant constituent of the Observatory Hill Beds in Marla-1A and -1B. Clay- and some silt-sized quartz grains commonly are incorporated in the carbonate muds.

Calcite muds are all slightly ferroan and are of primary origin.

The pure, fine-grained dolomite muds are interpreted to be generally of very early diagenetic origin. Early dolomitisation in these rocks is pervasive but may be accompanied by some minor, late dolomitisation (Plate 6).

Neomorphic Spar

Considering their Palaeozoic age, these strata show very little evidence of recrystallisation, and the resultant formation of neomorphic spar, from the abundant calcite micrite originally deposited.

Neomorphic spar has been recognised using the criteria summarised by Bricker (1971, p. 149). It is rarely extensive but tends to be patchy and more prevalent in predominantly allochemical lithologies than in "pure" mudstones. Heavy recrystallisation is recorded in some peloidal lithologies and one rock unit (88.10 - 88.40 m) shows a typical "ghostiness" and in parts closely resembles a "grumeleuse texture".

Cement and Vein Fills

Grainstones are rare in Marla-1A and -1B and most packstones are well-endowed with mud, hence cement is rare. When present, it is ferroan to very ferroan calcite; no dolomite cement has been recognised.

Most of the recognised cement is bladed to drusy and all of this kind belongs to an early, first generation. In a few samples two generations of calcite cement are discernible (87.85 m, 107.00 m, 166.55 m, 295.25 m): the first is bladed to drusy, and the second coarse, blocky very ferroan calcite (Plate 1). The late generation commonly occurs in veins (107.00 m) but can also be seen replacing allochems (87.85 m, 107.00 m, 166.55 m) (Plate 1) and as an interparticle cement (295.25 m).

CARBONATE ROCKS

Mudstones

The dominant lithology in Marla-1A and -1B is mudstone, both calcite and dolomite (Appendix 1). It occurs throughout the section interbedded with boundstones, coarser-grained carbonates and clastic rocks.

The mudstones range from pure carbonate through slightly silty varieties to a few units with scattered (< 10%) allochems or quartz grains and granules.

Both calcite and dolomite mudstones occur above 175.50 m, whereas below that depth only dolomite has been recognised.

Wackestones

The most common wackestone is one in which the grains are sand- to granule-sized quartz and not carbonate allochems (e.g. 204.40 m, 208.20 m). Although such rock units technically may not be wackestones, because of their extraclast grains, it is considered that similar conditions existed during deposition of both quartz and allochemical wackestones. Within some of the quartz wackestones the grains tend to be concentrated in layers or graded over a few centimetres. Minor amounts of peloid and "mudball" wackestones also occur.

All of the wackestones have a dolomite mud matrix.

Packstones

Intraclast and peloid packstones are common; some contain only one allochem type but many have both. Sorting of the peloids is good but is variable for intraclasts. There are rare algal plate, "mudball" and quartz grain packstones. Packstones have both calcite and dolomite mud matrices: peloid packstones are predominantly dolomite, intraclastic rocks have both.

Grainstones

Grainstones are rare in Marla-1A and -1B and, owing to recrystallisation and chertification (219.55 m, 225.35 m), are hard to identify. They occur only as thin lenses or interbeds (Plates 3 and 4).

All allochem types have been identified within grainstones and they occur in both calcite and dolomite rock units.

Boundstones

Stromatolites and algal mats occur throughout the section down to 309.20 m depth.

Stromatolites (columnar) are rare: a good example, approximately 100 mm high, occurs at 148.50 m and smaller varieties at 247 m, 266 m and 282 m.

By far the most common algal material occurs as mats (and their associated broken plates, see "Algal Plates", page 6). Most of these mats are dolomite and the thickest developments occur below 200 m where they can be over 10 m thick (Fig. 2).

EVAPORITES (excluding Dolomite)

No evaporitic minerals, other than dolomite, have been positively identified in peels and thin sections of Marla-1A and -1B, and nowhere in the sequence do evaporites constitute rock-forming minerals (Fig. 2; Plates 7 and 8).

Some evidence of original evaporites occurs at 146.75 m where angular blades, subparallel to bedding, up to several millimetres in length and replaced by quartz and length-slow chalcedony strongly suggest the former presence of evaporite minerals (Folk and Pittman, 1971) (see "Silica Replacements", page 13) (Plates 7 and 8). Other possible evaporites are recorded at 327.64 m (see T.S. description, in Benbow (1980a)) and in several rock units of the core below 287.60 m. These occurrences are less diagnostic than those at 146.75 m: small irregular vugs are lined with calcite and may be moulds of earlier small, evaporite minerals.

DIAGENESIS OF CARBONATES

All of the carbonates have undergone lithification and many of them, particularly allochemical rocks, display a number of other diagenetic features which can aid in interpreting the sequence.

Recrystallisation and cementation have been discussed previously (see page 7).

Micrite Envelopes

Micrite envelopes are not extensively developed but have been recorded on intraclasts, peloids and some ooids at 107.00 m (Plate 1), 166.50 m, 219.50 m and 225.35 m. In some instances they have provided a "shell" for late sparry fill (Plate 1).

Birdseyes

Possible birdseyes have been recorded at 83.00 m, 307.50 m, 313.75 m, 320.75 m, 320.15 m and 338.60 m. All are seen in dolomite mudstones or wackestones. Those at 83.00 m occur parallel to bedding. Many of the other occurrences could be interpreted as small, irregular evaporite moulds although in some examples they appear too irregular for evaporites. It is probable that below 300 m both evaporite moulds and birdseyes exist in close association (Fig. 2); they both develop in similar environments and in this respect their accurate identification is not considered essential.

Nearly all of the birdseyes are partially to entirely filled with late, coarse calcite spar.

Burrows

Burrows are early diagenetic features, having developed during sedimentation in very shallow waters or on "hardgrounds". They have been recognised at Marla-1A and -1B predominantly below 280 m with a few near the top of the section (Fig. 2).

The burrows are nearly all irregular, mottled and neither vertical nor horizontal with respect to bedding. It is not possible to identify what organisms caused them.

A few rock units have been entirely bioturbated and all original bedding destroyed (360.80 m, 368.65 m) but mostly the burrowing has been less drastic.

Dewatering and Slump Features

The distribution of dewatering and small-scale slump (soft sediment deformation) features is shown on Figure 2. They are more abundant at the top of the section, in the mixed calcite and dolomite rock units.

Upward injection of beds is common. Especially good examples occur between 121.50 m, and 123.50 m where some injections are 100 mm in height; the average is 40 mm. These features contain abundant secondary chalcedony and small amounts of mica, ?nontronite and pyrite (see thin section descriptions in Appendix II in Benbow (1980a)). Abundant injection features occur also at about 170 m to 180 m; this is a brecciated zone containing abundant sulphides and dolomite which is coloured a green-grey by the inclusion of muscovite, chlorite and regularly interlayered chlorite-montmorillonite (see Appendix II).

Stylolites

Stylolites occur throughout the sequence and are particularly abundant in calcite rocks (mudstones and coarser textured lithologies) down to 158.60 m. An intraclast packstone at 166.50 m has an excellent development of stylolitic rock unit boundaries (see Appendix I).

Stylolites formed relatively late in the diagenetic history of these strata and their development probably accounts for much of the late secondary cement and coarse vein fills (see "Cement and Vein Fills", page 7).

Dolomite

Dolomite is the most common mineral in the Observatory Hill Beds at Marla-1A and -1B. Below 175.50 m it is the only rock-forming mineral and above that depth dolomite and calcite rock units are interbedded with calcite ones (Fig. 2). Much of the dolomite is very fine-grained (generally less than 0.1 mm, and commonly 0.01 to 0.02 mm) (Plate 6), equigranular and is interpreted as very early diagenetic in origin, having replaced an original calcite mudstone (e.g. 121.93 m, 124.70 m).

Similarly fine-grained, pervasive dolomite also occurs in rocks which clearly contained at least a few allochems and which were deposited with calcite mud (e.g. 122.64 m, 295.88 m and 332.99 m). These lithologies also are interpreted to have been dolomitised soon after deposition and may, in fact, have been altered at the same time as those mentioned above. Original calcite mud and the fact that "ghosts" of allochems are still visible may mean that lithification had occurred, at least partly, prior to dolomitisation.

A few thin sections clearly demonstrate the existence of later, coarser dolomitisation and the development of some associated porosity (e.g. 146.70 m, 231.35 m, 280.30 m and 347.33 m). Some of the coarser dolomite rhombs show the distinctive zoning of late-developed crystals (Plate 6) (Scholle, 1978, p. 132). In some cases the coarser-grained dolomite areas give the appearance of neomorphic (recrystallised) spar and it is believed that these could be the result of recrystallisation of early dolomite rather than the introduction of later dolomite (e.g. 122.64 m, 124.70 m and 307.20 m). The differentiation between these two latter categories is not always clear and it is possible only in rare cases to make unequivocal statements concerning the timing of much of the dolomitisation.

Silica Replacements and Void Fills

Silica replacements and void fills are common. On the litholog (Appendix I) only chalcedony has been distinguished from all other silica replacements which are identified as chert.

(i) Chalcedony: in hand specimens chalcedony can sometimes be seen filling voids and fractures but it is most commonly identified under crossed-nicols where it shows a typical fibrous, radial texture (Plates 7 to 9). An interesting development of chalcedony occurs at 146.75 m where it is seen, along with ordinary secondary microcrystalline quartz, replacing distinctly angular and platy ?evaporite casts (Plates 7 and 8). This chalcedony is length-slow and this is consistent with the conclusion of Folk and Pittman (1971) that length-slow varieties are distinctive of sediments deposited in evaporitic environments.

(ii) Chert: true chert is only that which has a fine, microcrystalline texture (see illustrations in Scholle, 1978). It is seen in ooid grainstones at 219.50 m and 225.35 m where chert has replaced the ooids (inside micrite envelopes) and a dolomite matrix; at 219.50 m, a coarser-grained quartz acts also as cement (Plates 2 to 4).

(iii) Microcrystalline Quartz: nearly all of the material logged as chert is, in fact, microcrystalline quartz much coarser in size than true chert and commonly filling voids or acting as replacements. It varies in size from very fine (and hardly discernible) to several millimetres (megaquartz of Scholle (1978), p. 141): when acting as a cement it commonly shows a radial texture (Plates 3 and 4).

(iv) Authigenic Quartz Crystals: scattered authigenic quartz crystals occur throughout the section. They are rare but are readily identifiable when present: and some retain carbonate cores (107.00 m) (Scholle, 1978, p. 141).

Celestite

Celestite occurs as a rare secondary mineral throughout the section. In one sample (121.93 m) (Plates 9-10) it constitutes 15% to 20% of the rock; elsewhere it is present only in trace amounts. It is interpreted as a late diagenetic feature (see T.S. description, 121.93 m, in Benbow (1980a)). Celestite commonly occurs as a secondary mineral in rocks deposited in a sabkha environment (Scholle, 1978; p. 135).

DESCRIPTION OF CLASTIC LITHOLOGIES

Nearly all of the non-carbonate grains in the Observatory Hill Beds in Marla-1A and -1B are quartz, with up to 25% feldspar in only a few rock units and traces of micas, heavy minerals, pyrite and lithic grains throughout.

The sandstones and siltstones at Marla have calcite and dolomite cements: hence, a complete gradation exists from extraclast quartz wackestones (see page 8) and silty carbonate mudstones to carbonate-cemented sandstones, siltstones and claystones. Many units logged in these wells fall between the end members and there are numerous examples of thinly interbedded clastic rocks and carbonates (or calcareous clastics) (e.g. 116.00 m, 138.00 m, 178.00 m, 343.80 m).

The sandstones are predominantly fine- to medium-grained, subrounded to rounded, graded in small-scale (10 mm) cycles and some show channelling and cross-bedding (e.g. 116.00 m, 138.00 m, 149.85 m). Many of the sandstones contain mudstone intraclasts and thin, mudstone interbeds (e.g. 130.15 m, 152.50 m, 183.90 m, 196.60 m).

The best primary porosities developed in the sequence are in sandstones.

DEVELOPMENT OF POROSITY

CARBONATE ROCKS

Overall the carbonate lithologies encountered in Marla-1A and -1B are not appropriate for the development of primary porosity: grainstones are very minor and reefs unknown. A small amount of birdseye (fenestral) porosity may be developed, but much of it seen in this study has been filled or lined by calcite (279.20 m, 281.00 m, 307.45 m).

A few examples of secondary porosity have been recorded. The most noteworthy is that at 225.35 m (Plate 2) in which part of an ooid grainstone has been replaced by chert. All the ooids are now fine-grained, true chert; only patches of the matrix were replaced (or cemented) by chert and some areas of matrix remain void. The chert is seen to be replacing an earlier dolomite and rare dolomite rhombs are seen "floating" in the chert. This provides an unusual example of interparticle porosity associated with chertification (Plate 2).

A small amount of mouldic porosity, resulting from the leaching of evaporites, may be developed. In many cases it is difficult to differentiate it from birdseye (fenestral) porosity (see above).

CLASTIC ROCKS

The best porosities recorded in this study are developed in the coarser clastic rocks (sandstones). They are primary interparticle porosities between quartz and other grains in the more poorly-cemented rock units (e.g. 130.00 m, 230.40 m, 294.00 m). Visual porosity is estimated to be fair to good.

Some of the primary porosity in Marla -1A and -1B has been infilled by minerals (fluorite and sulphides); the part played by these porous strata in mineralisation is discussed below.

MINERALISATION

The major secondary minerals encountered in Marla-1A and -1B are fluorite and sulphides (predominantly pyrite). Figure 2 illustrates the clear zoning of these two minerals within the sequence: fluorite occurs only in the top 120 m, and sulphide is absent from the top 60 m. Very fine-grained pyrite is disseminated throughout the sequence (see thin section descriptions in Benbow (1980a)) and these occurrences are not logged. All sulphides reported in Appendix I are easily visible in hand specimen and are post-depositional pore-filling materials.

FLUORITE

Nearly all of the recorded fluorite is purple in colour and is easily seen in hand specimen. Eighty-six percent of these fluorite occurrences are in carbonate rocks (predominantly calcite packstones) and the majority of these are associated with late calcite veins, vugs and stylolites (e.g. 83.70 m, 91.50 m, 107.60 m). Minor amounts of fluorite are recorded in primary pores in algal material (88.40 m) and sandstones (100.15 m, 152.50 m).

SULPHIDES

Apart from one definite record of chalcopyrite at 139.45 m, all sulphides logged probably are pyrite. In coarser-grained, porous lithologies some cubes up to 7 mm are developed, but generally the pyrite is seen as a non-cubic, pore-filling mineral.

Seventy-one percent of the recorded sulphide occurrences fill pores in fine- to medium-grained sandstones and areas up to 5 mm across have been noted (e.g. 181.05 m, 181.95 m, 182.05 m). The remainder of the pyrite occurs in a variety of predominantly dolomitic carbonates.

Although the sulphides are scattered throughout the sequence, a concentration occurs between 177.00 m and 183.20 m (see Appendix I). Here a variety of lithologies share an abundance of soft-sediment injection features, brecciation and a green-grey clayey material identified as dolomite with muscovite, chlorite and mixed-layer chlorite-montmorillorite (see Appendix II).

Some features of the mineralisation in Marla-1A and -1B are analogous to those recorded in large-scale Mississippi Valley-type lead-zinc deposits elsewhere in the world (Jackson and Beales, 1967):-

(a) pyrite and fluorite are zoned and associated with relatively simple lithologies;

(b) they occur in chertified limestones, dolomites and sandstones;

(c) the area has not been subjected to significant post-depositional deformation and is close to the margin of a sedimentary basin;

(d) an apparent general absence of igneous sources for the mineralising fluids;

(e) deposits are close to the present-day surface; and

(f) brecciation and sedimentary injection are common.

ENVIRONMENTS OF DEPOSITION

The Observatory Hill Beds in Marla-1A and -1B is a sequence of carbonate and clastic interbeds averaging 0.5 m to 2.0 m in thickness. Many of the carbonates are silty and the clastic lithologies are calcareous and dolomitic.

CARBONATE FACIES

Evidence such as micrite envelopes, peloids, intraclasts, algal material, burrows and channelling indicates that the entire sequence was deposited in shallow (no more than a few tens of metres) quiet waters. The trilobites attest to an Early Cambrian marine environment and the abundance of quartz grains indicates that a land area, acting as a detrital source, was nearby.

It is possible to refine this broad interpretation into three carbonate facies, and their distribution is shown on Figure 2:-

(i) Peri-Sabkha, 380 m to 280 m: this facies is characterised by dolomite, some evaporites, burrows and "mudballs". No units in this facies indicate deposition in a true sabkha environment - thick evaporite beds are absent - but the lack of algal material clearly indicates a hostile and basically evaporitic environment marginal to a true sabka.

(ii) Restricted Lagoon, 280 m to 170 m: a dolomitic but not evaporitic, algal-dominated facies with active burrowing organisms. This environment is envisaged as less saline and severe than the peri-sabkha but nevertheless restricted lagoonal conditions, with perhaps some short-lived subareal exposure, existed throughout.

(iii) Open Lagoon, 170 m to 83 m: the presence of calcite rock units, rare trilobites and a decrease in algal material relative to the restricted lagoon facies indicate deposition in an environment more marine than the two lower facies but still on a platform and protected from open marine influence. The increase in the incidence of cross-bedding and channelling in the top 40 m (Fig. 2) relative to the deeper rock units probably indicates proximity to the shelf margin.

The facies described above correspond closely with the Standard Facies Belts numbers 7 and 8 of Wilson (1975, p. 26-27) and may record a transgressive episode that resulted in mainly carbonate deposition in the landward parts of a broad platform lagoon.

CLASTIC FACIES

The clastic rocks are not easily defined in terms of separate facies: the sandstones are lithologically similar throughout the sequence. They record the deposition of detrital quartz and other grains in tidal channels across a carbonate lagoon. The rounded to sub-rounded quartz grains encountered in the sandstone probably derived originally from Middle Proterzoic schists, granitoid rocks and quartz veins like those of the Ammaroodinna Inlier, which crops out 30 km southwest of Marla (Fig. 1) (Krieg, 1972). Poorly known regional extensions of this "basement high" are presumed also to be the source of some of the conglomerates and arkoses of the Late Proterozoic-Early Cambrian Wallatinna Formation (Fig. 3) (Benbow, 1980b ; Townsend and Robertson, 1980). It is likely that reworking of this formation produced the lithic grains recorded in Marla-1A and -1B.

The clastic interbeds commonly are 0.5 m thick and rarely are thicker than 1 m. Thus they are a relatively minor component of the penetrated facies and their significance is peripheral to the interpretation of the carbonate depositional environment. The litholog (Appendix I) records constant influxes of detrital material (predominantly quartz) into the shelf lagoon with a noticeably higher clastic component between 116.00 m and 201.50 m. This may reflect a more prolonged period of minor tectonic activity along the Ammaroodinna "basement high".

CYCLES

Within this interpreted record of marine transgression it is possible to identify numerous cycles (not rhythms) within all three of the carbonate facies. Assuming that an episode of continuous deposition (a cycle) results in gradational boundaries between rock units within the cycle but in sharp upper and lower boundaries to the cycle, thirty-two whole or part cycles may be recognised in the Observatory Hill Beds at Marla-1A and -1B. Seventeen complete cycles are comprised of Mudstone - Packstone/Grainstone/Boundstone/Wackestone/Sandstone - Mudstone; fifteen part cycles are recognised also. Criteria applied to confirm this concept include erosional bases (e.g. 110.80 m, 223.50 m), and burrows (e.g. 234.80 m, 350.10 m) and micrite envelopes (107.00 m, 219.10 m) at the tops. Some cycles also vary in colour from grey at the base to buff at the top (e.g. 234.80 m to 229.80 m), indicating possible subaerial exposure towards their finish.

The significance of these cycles from only one well is difficult to discern. They do not appear to parallel any of the well-documented cycles elsewhere in the world, e.g. Yoredale cycles, U.K.; oolite-grainstone and lime mud-sabkha cycles of the Williston Basin; "loferites" of the Alps in Europe (see Wilson, 1975, for summaries of all of these). Until more data are gathered from the marine facies of the Observatory Hill Beds it is impossible to propose a model for their origin. A much clearer picture of the Early Cambrian palaeogeography is needed, and future studies of these beds should endeavour to elucidate the causes and environments of the cycles, as an understanding of them will lead to a clearer understanding of the whole basin during the Cambrian.

GEOLOGICAL HISTORY

The overall lack of recrystallisation and similar degenerate diagenesis in Marla-1A and -1B indicates that the Observatory Hill Beds there have never been very deeply buried. Outcrops of Ordovician and Devonian strata in the Mt. Johns Range (Fig. 1) total little more than 2 000 m thickness (Krieg, 1973) and the Marla area was marginal to both the Permian Arckaringa and Mesozoic Great Artesian basins of deposition. Wopfner (1964) states that west of the Lake Eyre Lineament the Permian and Mesozoic sediments were deposited on a shelf which underwent repeated exposure and received only a relatively thin veneer of sediments. It is likely that the maximum Permian depositional thickness occurred in the Boorthanna Trough (400 m; Townsend, 1976) and that sediments in the Marla area were considerably thinner. Therefore it is probable that the Observatory Hill Beds at Marla have never been buried much deeper than 2 500 m to 3 000 m and that nearly all of this burial had occurred by the end of the Devonian Period. The comparative lack of diagenesis and low-grade metamorphism has enabled an attempt at unravelling the geological history of these beds. Many of the thin sections and acetate peels examined contain one or more features which help in discerning this history (Fig. 4).

Figure 4 attempts to outline the order in which post-depositional processes acted on the Observatory Hill Beds. Parts of the sequence are doubtful and some processes may have been almost synchronous (e.g. celestite occurs with dolomite in a vein at 108.58 m; early dolomitisation and the commencement of diagenesis frequently are penecontemporaneous with deposition). A clear indication of part of the history is gained at (i) 121.93 m where vugs are lined first with chalcedony and then celestite; (ii) at 146.70 m where early dolomite, replacing a calcite mudstone, has been partially replaced by chert and chalcedony and the whole has been cut by a later, coarsely-crystalline calcite vein (Plates 3 and 4); (iii) fluorite occurs with coarse, late calcite in veins at 83.00 m.

The ninth stage shown on Figure 4, which is of major economic significance, may have been attained during the late Palaeozoic when the Observatory Hill Beds were buried and still sufficiently porous to provide a "plumbing system" for the up-dip transport of hot, metal-bearing brines. Upon contact with hydrogen sulphide in the sequence, metallic sulphides were deposited mainly in primary, interparticle pores. The conclusion that mineralisation occurred after dolomitisation, chertification and brecciation agrees with observations by Jackson and Beales (1967, p. 387).

Source rocks analysed from Marla-1A generally have a low total organic carbon content and are immature to marginally mature (McKirdy in Benbow, 1980a). However, analyses of the non-marine carbonates in Byilkaoora-1 and ?marine carbonates at Wilkinson-1 and Wallira West-1 (Fig. 1) show the Observatory Hill Beds elsewhere along the eastern margin of the Officer Basin to have much better potential to generate petroleum (McKirdy & Kantsler, 1980). It is possible that suitable reservoirs exist both in the Observatory Hill Beds and in other Late Proterozoic or Palaeozoic formations (see Pitt et al., 1980, p. 219).

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

The work outlined in this report demonstrates that a fully-cored and carefully logged stratigraphic well can provide much information concerning environments of deposition, habitats of minerals and the geological history of an area. All of these data can then be used to outline areas for further exploration.

Despite the absence of both the stratigraphic top and base of the Observatory Hill Beds in Marla-1A and -1B, the 300 m penetrated section clearly demonstrates the progress of a marine transgression across an area lying near a landmass which was contributing a supply of quartz detritus. This warm Early Cambrian sea spread across a stable shallow platform and hence carbonate to evaporitic sediments predominated. By Walther's Law of Facies, and knowing that the northeast-trending Ammaroodinna "basement high" lay to the northwest of the Marla area, it can be postulated that sediments of a more evaporitic and clastic nature were deposited between Marla and the "high" and more open-marine sediments away from it. Using this model it is possible to suggest areas in which facies of especial interest to mineral and petroleum explorationists may exist:-

(i) Sabkha Facies: these strata may be dolomitised, porous and evaporitic. They are the most likely hosts for Mississippi Valley-type mineralisation and also could provide excellent petroleum reservoirs (with the less-dolomitised and less-porous strata of the peri-sabkha facies as cap rocks). Rocks of this facies may be below 380 m in Marla-1B and at increasingly shallower depths towards the Ammaroodinna "high" (Fig. 5).

(ii) Shelf Margin facies: grainstones and minor packstones, with either primary interparticle porosity or secondary inter- and intraparticle porosity derived from solution and, perhaps, dolomitisation. Again these strata are possible hosts for Mississippi Valley-type mineralisation (algal-rich, dolomitic rocks are more likely) and, with open marine, fine-grained cap rocks, would provide excellent petroleum reservoirs. Rocks of this facies may have been eroded from the Marla area but could remain close to the surface (provided erosion has not removed them entirely) in the more open-marine parts of the shelf (Fig. 5).

(iii) Clastic Interbeds: any of the carbonate lagoonal to sabkha facies believed to occur between Marla and the Ammaroodinna "high" will contain increasingly thicker interbeds of sandstones. These could provide porous reservoirs, interbedded in predominantly fine-grained carbonate cap beds, for both minerals and petroleum. These traps may be stratigraphic in nature with grain size and thickness decreasing away from the Ammaroodinna "high".

Although containing only some evidence of Mississippi Valley-type mineralisation, the sequence intersected in Marla-1A and -1B indicates that mineralising fluids may have been circulating in this area at a time when some porosity existed. Given suitable conditions, petroleum also may have been trapped.

The drilling of stratigraphic wells and their subsequent detailed logging and interpretation might well lead future explorers to the discovery of carbonate-hosted Mississippi Valley-type mineral deposits and to petroleum accumulations.

ACKNOWLEDGEMENTS

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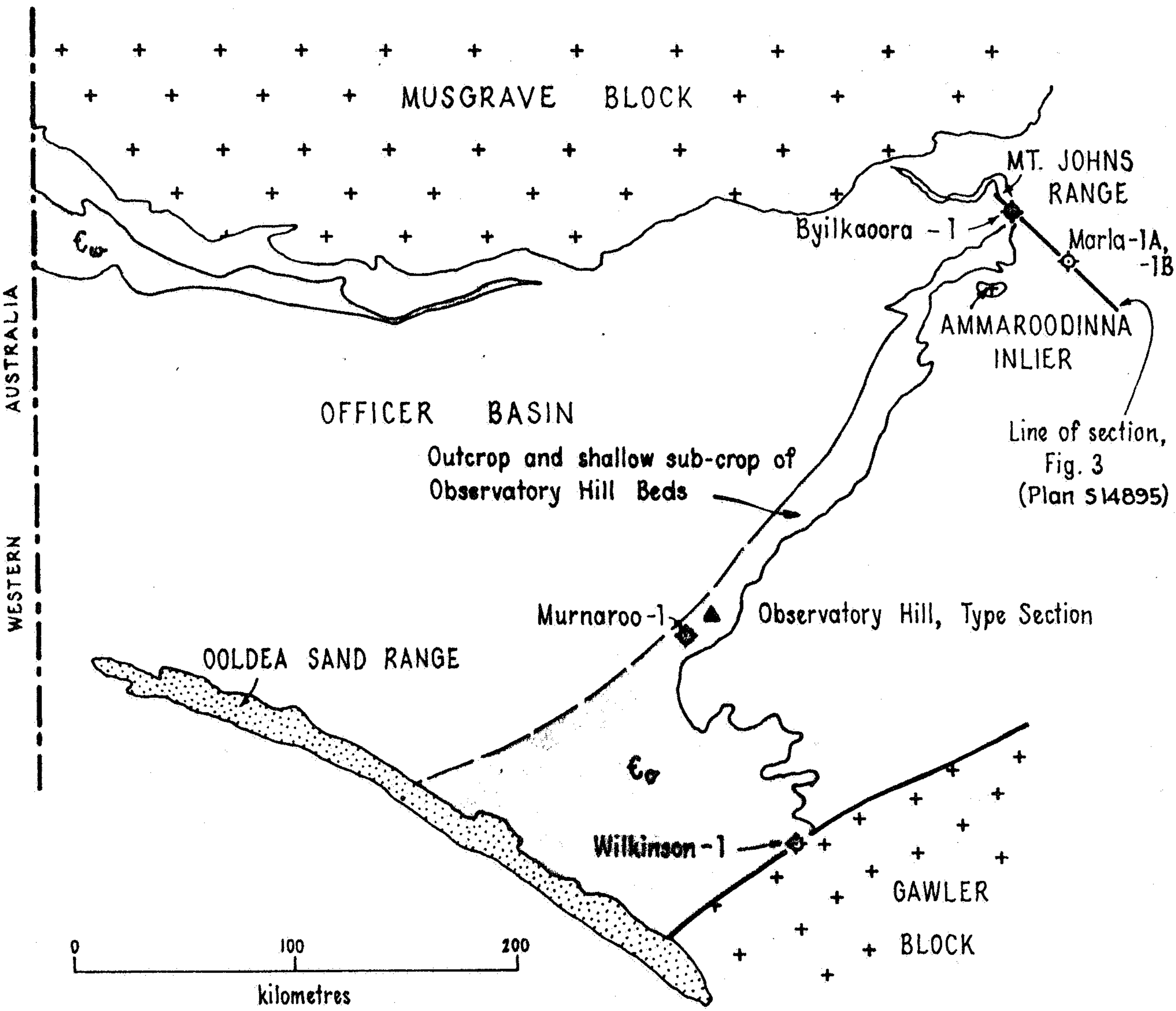


(Adapted from Pitt et al., 1980)

Fig. 1

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MARLA - 1A, - 1B
SOUTH AUSTRALIAN PORTION, OFFICER BASIN
LOCALITY PLAN

COMPILED B. Youngs	B CDO 18.7.80 DATE
DRAWN T. E.	SCALE As shown
DATE 13·6·1980	PLAN NUMBER
CHECKED	S 14893

2005

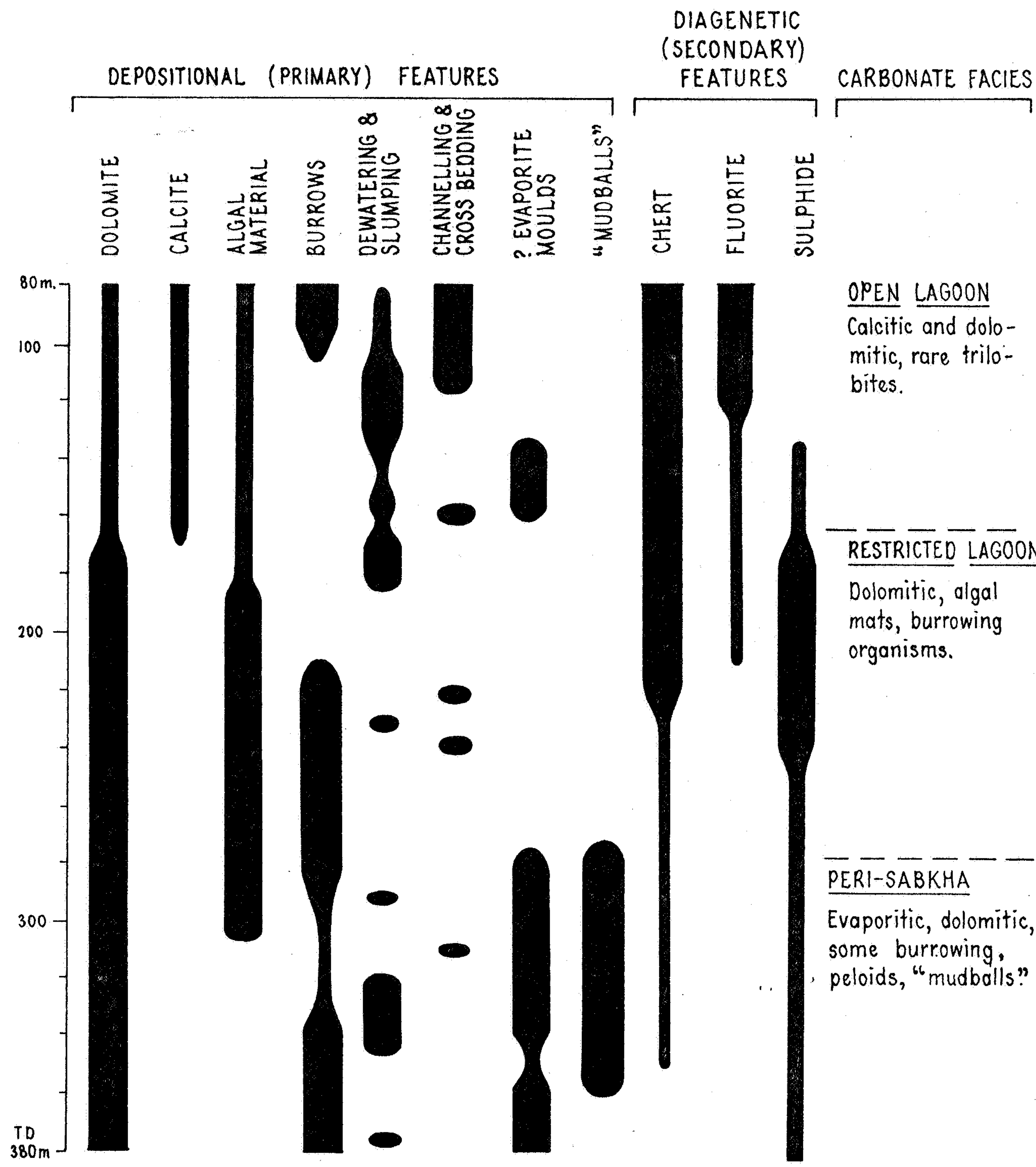


Fig. 2

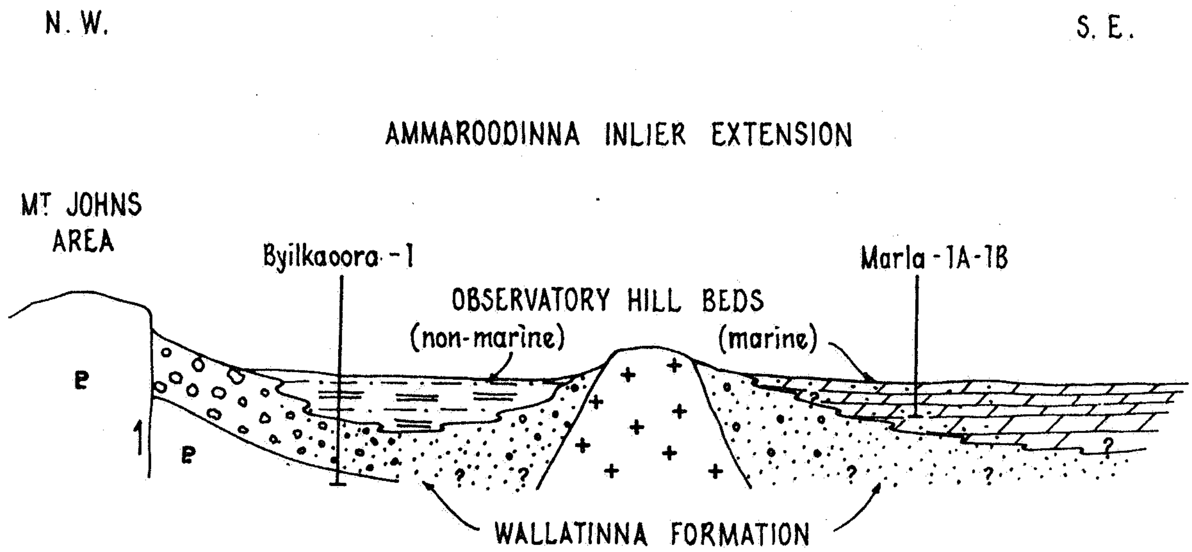
DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

MARLA – 1A, – 1B

OBSERVATORY HILL BEDS

SCHEMATIC REPRESENTATION OF THE RELATIVE ABUNDANCES AND VERTICAL DISTRIBUTION OF SOME MINERALS, SEDIMENTARY FEATURES AND CARBONATE FACIES

COMPILED B. Youngs	CDO 18·7·80 DATE
DRAWN T. E.	SCALE —
DATE 13·6·1980	PLAN NUMBER
CHECKED	S 14894



(No Vertical or Horizontal Scales)

See Figure 1, for approximate line of section (Plan S14893)

(Byilkaoora - 1 : see Benbow and Pitt, 1979 ; Marla - 1A - 1B : see Benbow, 1980a)

Fig. 3

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED B. Youngs	CDO DATE 18.7.80
MARLA - 1A, - 1B	DRAWN T. E.	SCALE —
DIAGRAMMATIC SECTION THROUGH NORTHEASTERN OFFICER BASIN, SHOWING FORMATION RELATIONSHIPS TOWARDS THE END OF DEPOSITION OF THE OBSERVATORY HILL BEDS	DATE 17·6·1980	PLAN NUMBER
	CHECKED	S 14895

2905

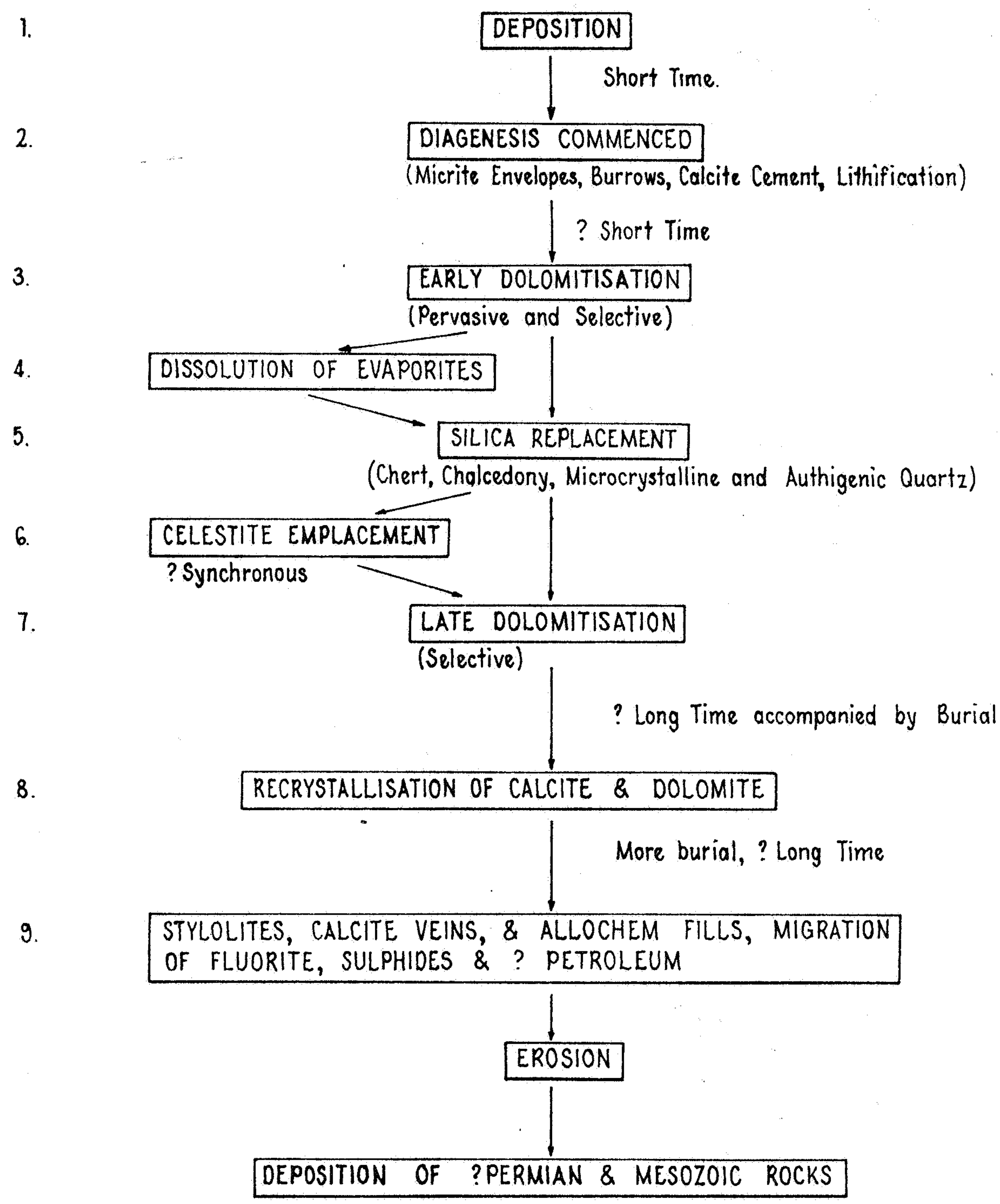


Fig. 4

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MARLA – 1A, – 1B

SCHEMATIC REPRESENTATION OF PROBABLE GEOLOGICAL HISTORY OF THE OBSERVATORY HILL BEDS IN MARLA-1A,-1B

COMPILED B. Youngs	CDO 18.7.80 DATE
DRAWN T. E.	SCALE —
DATE 18·6·1980	PLAN NUMBER
CHECKED	S 14896

2005

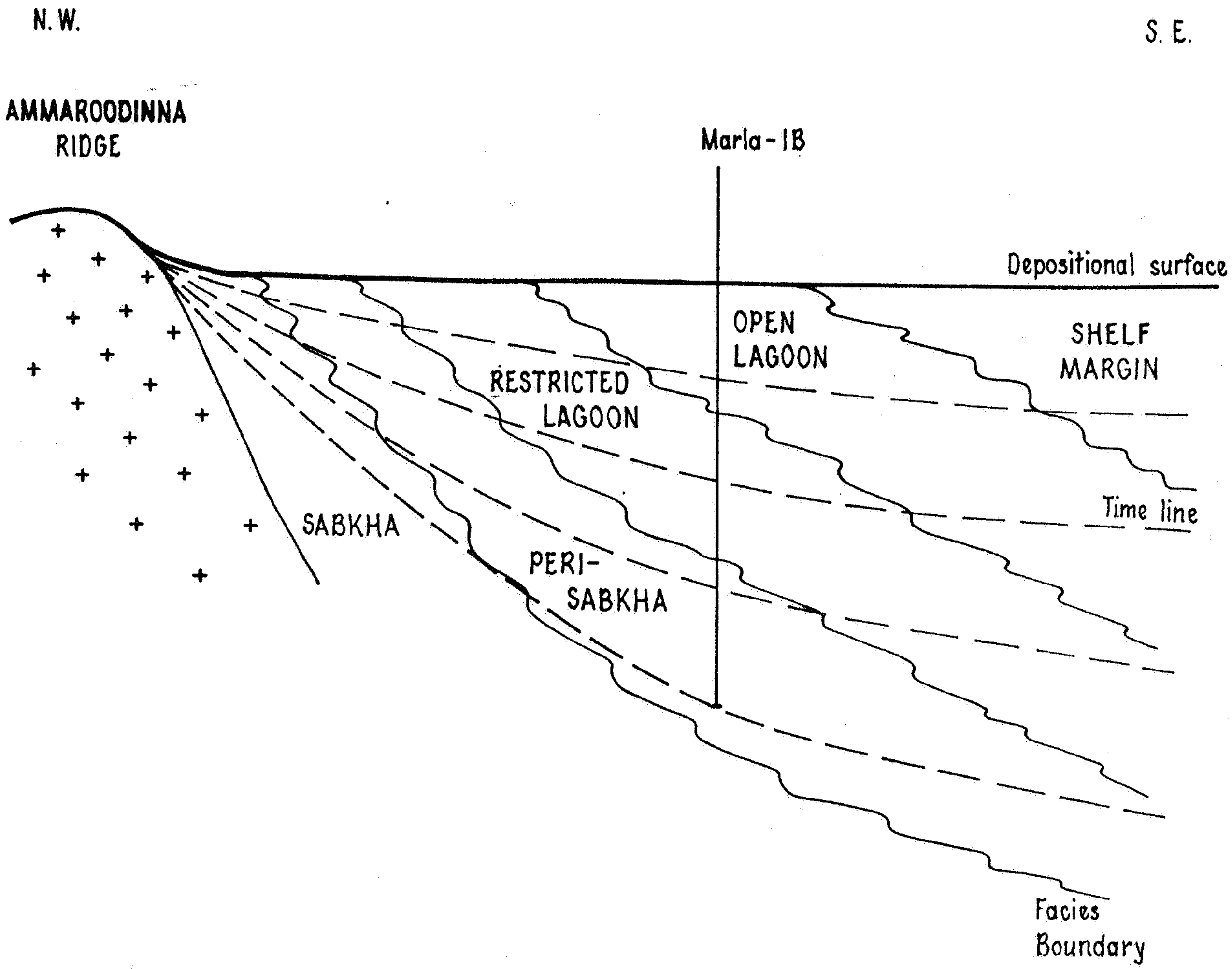


Fig. 5

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MARLA - 1A, - 1B

DIAGRAMMATIC REPRESENTATION OF SPATIAL RELATIONSHIP OF FACIES IN THE MARLA AREA AT THE TIME WHEN STRATA AT 83 METRES WERE BEING DEPOSITED IN MARLA 1-B

COMPILED	B. Youngs	CDO	DATE 18.7.80
DRAWN	T. E.	SCALE	—
DATE	18-6-1980	PLAN NUMBER	
CHECKED		S 14897	

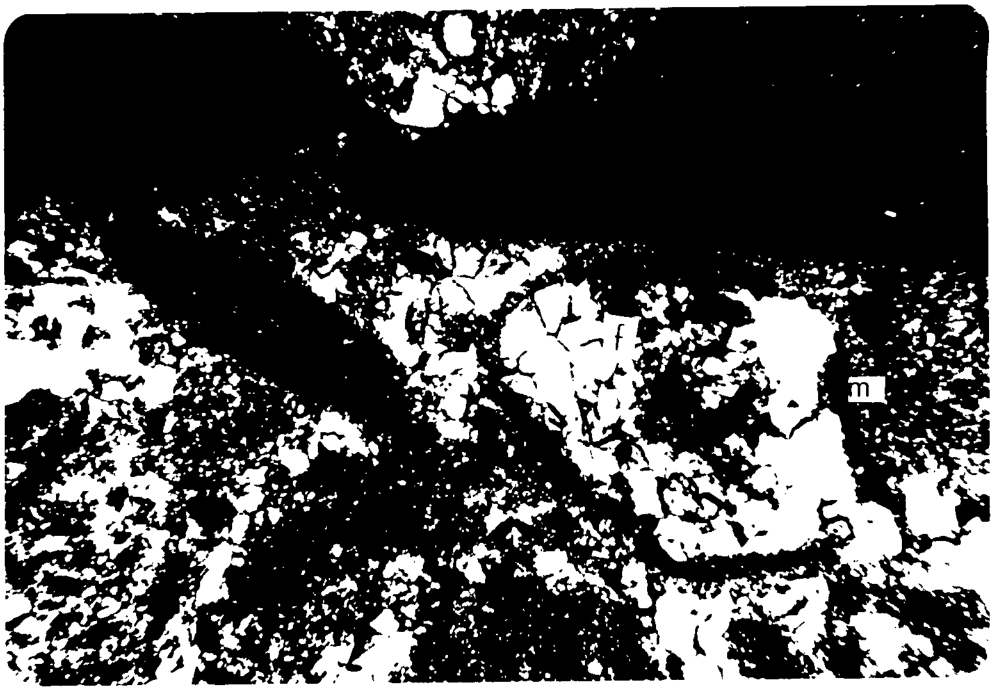
2005

Plate 1: Intraclast and ?peloid grainstone showing micrite envelope (m) around one grain and a later coarse, calcite infill (f). Stylolite at top of picture.

Marla-1B, 107.00 m, acetate peel, plain light.
Photo No.: 31675

Plate 2: Chertified ooid grainstone with secondary interparticle porosity. Many ooids retain their original concentric textures.

Marla-1B, 225.35 m, acetate peel, plain light.
Photo No.: 31676



0.5 mm

1.0 mm

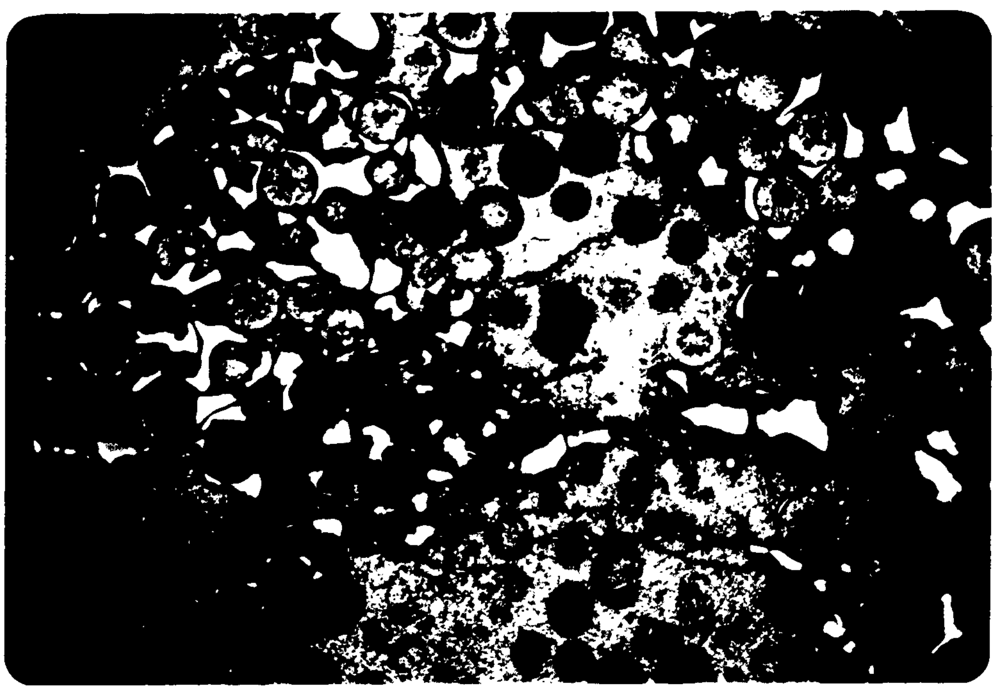


Plate 3: Chertified ooid granstone lens (a few ooids at the base remain unchertified) in a dolomite mudstone. Rare dolomite rhombs "float" in the chert. A late calcite vein cross cuts the lens vertically.

Marla-1B, 219.50 m, thin section, plain light.
Photo No.: 31677

Plate 4: As above. Shows microcrystalline quartz (q) replacing and cementing ooids.

Marla-1B, 219.50 m, thin section, crossed nicols.

Photo No.: 31678

0.5 mm

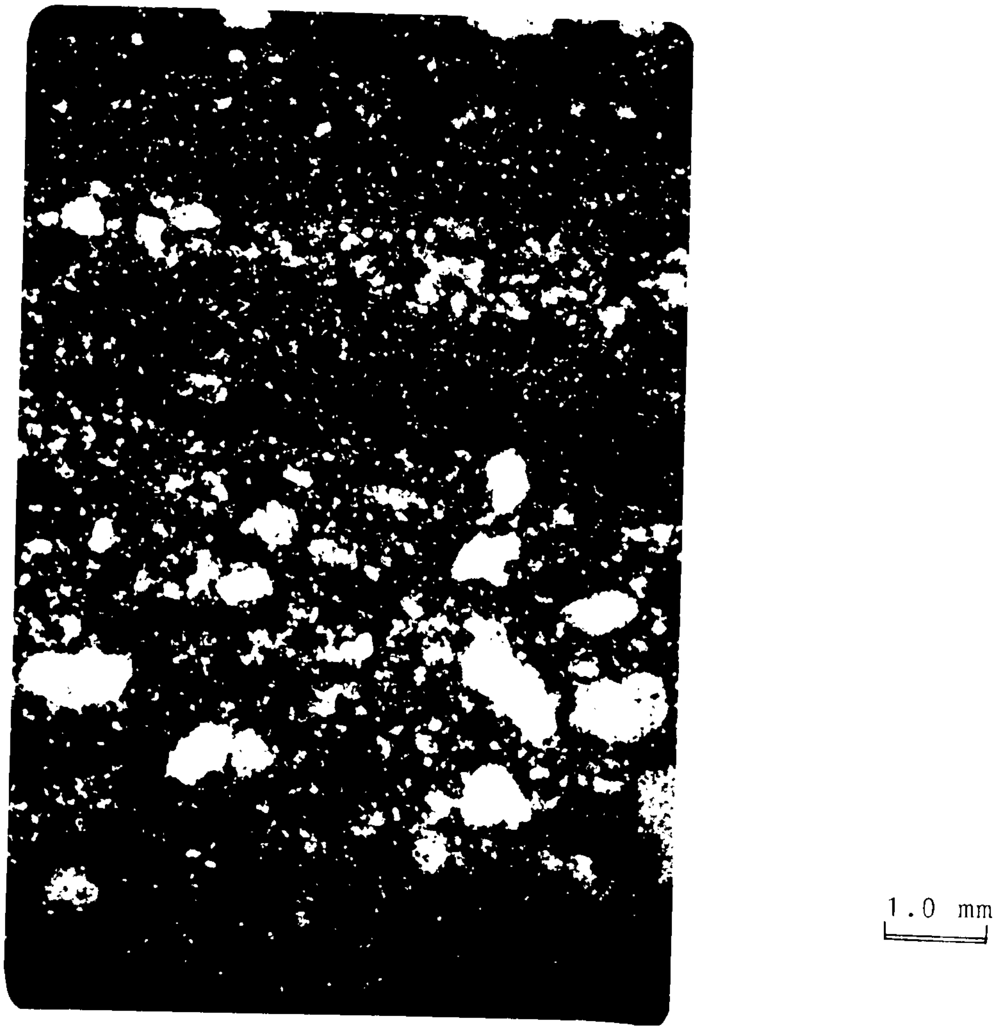
0.5 mm

Plate 5: Graded quartz grains in a dolomite boundstone.

Marla-1A, 201.80 m, acetate peel, plain light.
Photo No.: 31679

Plate 6: Dolomite mudstone showing rhombs and development of porosity. Large, zoned rhombs may be later.

Marla-1B, 231.35 m, thin section, plain light.
Photo No.: 31680


1.0 mm

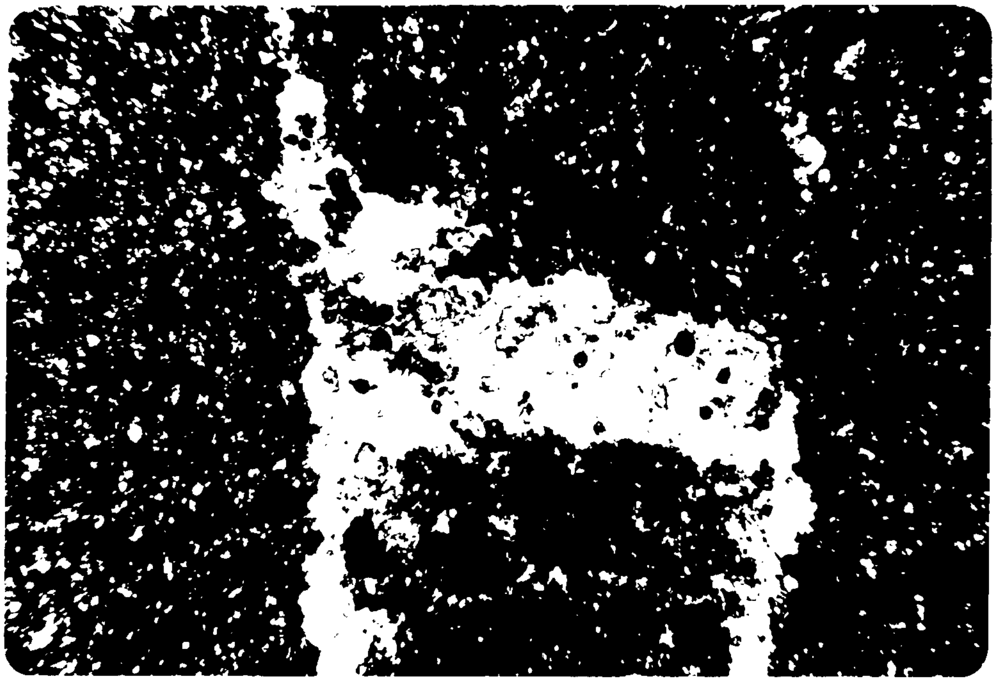

0.5 mm

Plate 7: Dolomitic mudstone containing casts of ?evaporite minerals.

Marla-1B, 146.75 m, thin section, plain light.
Photo No.: 31681

Plate 8: As above showing chalcedony (c) and microcrystalline quartz (q) infilling the casts.

Marla-1B, 146.75 m, thin section, crossed nicols.
Photo No.: 31682



0.5 mm

0.5 mm

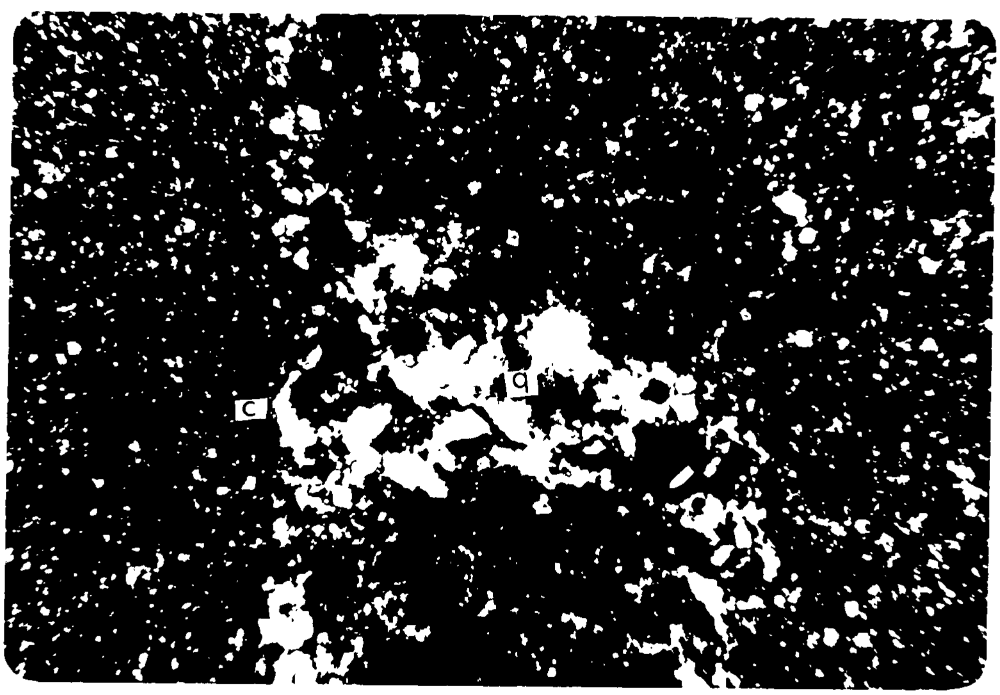


Plate 9: Dolomitic mudstone containing an area of dolomite (d), celestite (ce) and chert (ct) replacement. Dolomite rhombs "float" in the chert, i.e. they are earlier.

Marla-1B, 122.00 m, thin section, plain light.
Photo No.: 31683

Plate 10: As above showing chert as chalcedony (c) and microcrystalline quartz (q). This plate suggests that chert replacement occurred before celesite (ce).

Marla-1B, 122.00 m, thin section, crossed nicols.
Photo No.: 31684

0.5 mm

0.5 mm

APPENDIX I

Litholog, Marla-1B

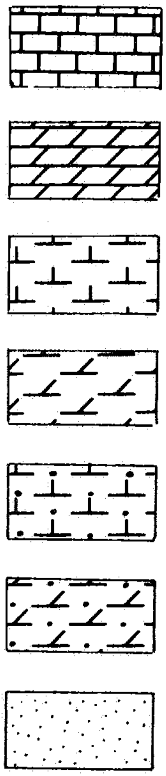
Compiled by B.C. Youngs,

and

S.K. Chaku (below 200 m)

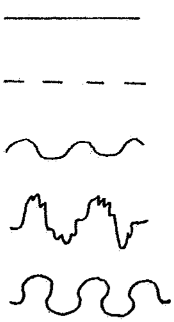
LEGEND FOR MARLA 1-B LITHOLOG

ROCK TYPES



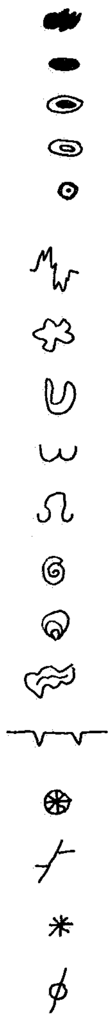
- Limestone (calcite)
- Dolomite
- Calcareous claystone
- Dolomitic claystone
- Calcareous siltstone
- Dolomitic siltstone
- Sandstone

ROCK UNIT BOUNDARY TYPES



- Sharp
- Gradational
- Erosional
- Stylolitic
- Deformed

ALLOCHEMS AND SEDIMENTARY FEATURES



- Intraclasts
- Peloids
- "Mud balls"
- Oncolites
- Ooids
- Stylolites
- Birdseyes
- Burrows
- Channels
- Dewatering, slumping
- Fossil fragments
- Stromatolites, algal mats
- Algal plates
- Mud cracks
- Vugs
- Microfaulting
- Evaporite minerals
- Porosity

ROCK COLOURS

Bf	Buff
Bl	Black
Bn	Brown
Gr	Grey
Gn	Green
Cm	Cream
Pk	Pink
Pl	Pale
Md	Medium
Dk	Dark

BEDDING THICKNESS

Lm	Laminated (0.5 mm)
V.Tn	Very thin (5-10mm)
Tn	Thin (10-100mm)
Md	Medium (100-300mm)
Tk	Thick (300mm-1m)
V.Tk	Very thick (1-3m)
Ms	Massive
Ind	Indistinct
Brwd	Burrowed
Stylo	Stylolitic

ACCESSORY MINERALS

Calc	Calcite
Ccp	Chalcopyrite
Cd	Chalcedony
Ch	Chert
Fl	Fluorite
Qutz	Quartz
Sl	Sulphide
Ab	Abundant
R	Rare

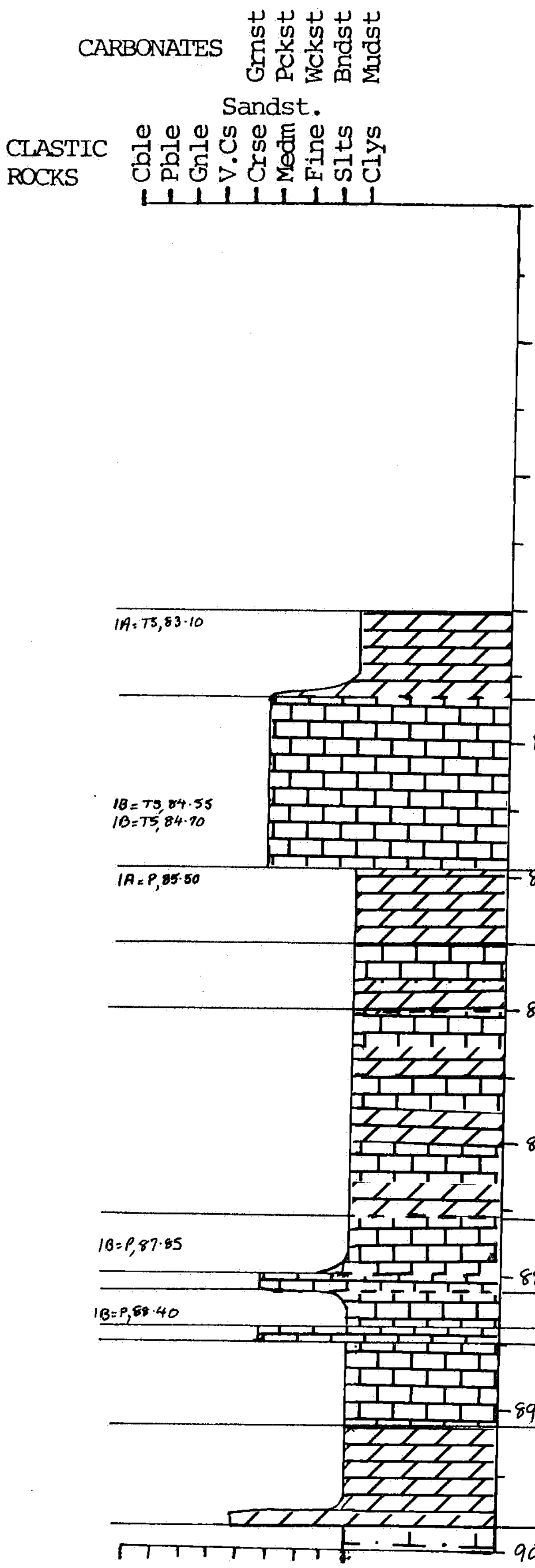
Sample points are indicated - 1A, 1B = well number, TS = thin section, P = acetate peel.

MARLA 1-B

LITHOLOG

Latitude : 27° 28'
Longitude : 133° 44' 55"

Logged by B.C. Youngs



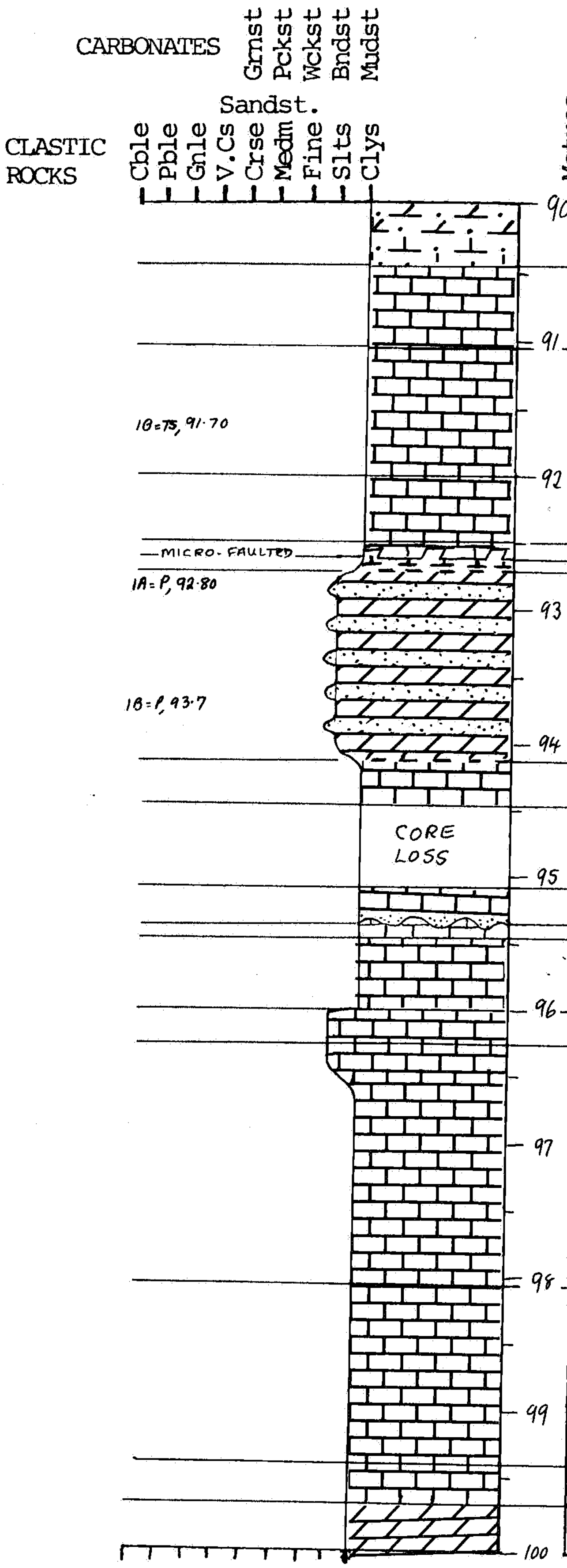
Metres	Colour	Bedding		Description
83	Bf	Lm - V.Tn	? Fl	V. f-grnd. Rare clay + mica grns. Fl. in vert. veins + ? b-eyes //l to bdg. Calc. in b-eyes.
84	Md. gr	Ind	Ab Ab Fl ?	Angular → subrdd. intras. in buff mtx. Fluorspar is zoned in T.S.; occurs in veins, stylos, b. planes + some burrows. Is both purple + colourless.
85	Bf	Tn	Fl	Silty throughout, with concentrations of silt in some parts. Fl in sub-vert. veins.
	Bf - Pl. gr	Lm - Ind		Layers of rdd-subrdd qutz grns (v.cse - gran) upto 10 mm thick. V. fine lamns.
86–87	Bf ↓ Bf + gr	Lm - V.Tn	?	Lamnd. → v. thin c some thin intra. beds. V. fine, dk. bitum. lamns. De-watering @ 86·40 m.
	Dk. gr + Bf	Md	R Fl R R R	Thin interbeds of wackest. + packst. 2 genrns. cement.
88	Gr - gr	Tn	Fl	Intra. pkst. c stylo'c. intra. beds. Fl in mtx.
	gr	Md	Ab	Some rexn. → "grumeleuse"
	Md. gr	Tn	Fl	Alg. pl. packst. (rexd) c Fl in pores of algal pls.
89	Md. gr		R	
	Bf + Pl. gr	Lm - Tn	Ch R	Few v. cse. → gran grns in beds upto 10 mm thick; some silt → v.f. sst. 30 mm chert breccia at base, infilled c buff mudst + mudst. intras. Subrdd. frags.
90	Md. gr	Tn	Fl R	Fl in fine veins + pores //l to bdg. pls.

MARLA 1-B

LITHOLOG

Latitude : 27° 28'
Longitude : 133° 44' 55"

Logged by B.C. Youngs



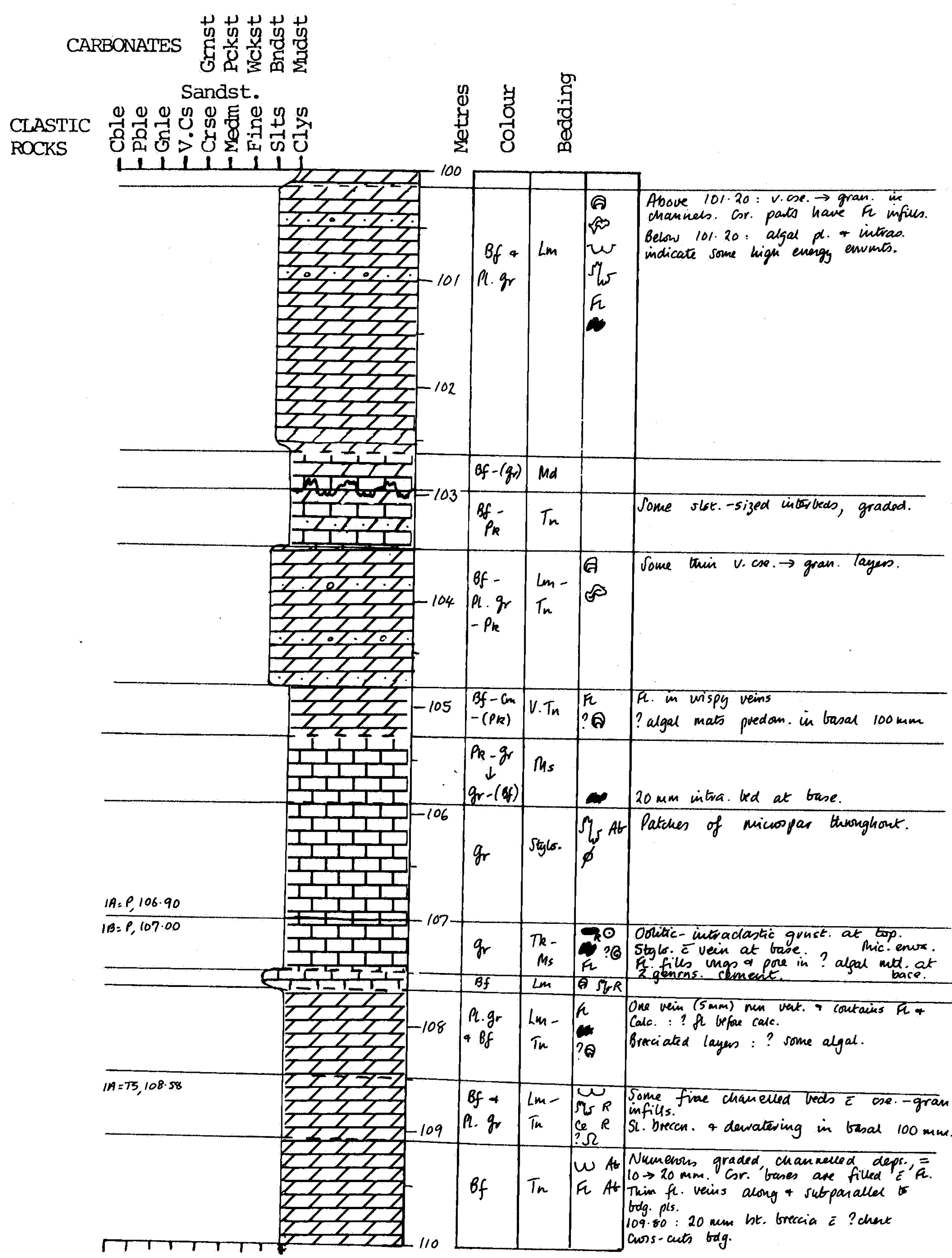
Colour	Bedding	Structures	Description
Bf → Pl. gr	Md	Fl	Basal 15 mm = buff-pink, calc., sltst. → sst. c̄ scattered qutz grns above it. Stylolitic base.
Pl. gr c̄ (Bf-Pk)	Tn	Fl	One bed (40 mm) of buff-pink, calc. sltst. has injected into unit above.
Md. gr		Fl, calc., Ch, R	Rexd, c̄ fl. + calc. in vugs. Some fl also in stylos. Grst. lens @ 91·15 has Fl cement. One level has a 15 mm intra. Pkst. Rare chert intras. + ? burrows at base. Rare qutz xls.
Bf	V. Tn	Fl, R	Grades down to intra. wkst. layers. Grst. in basal 10 mm.
Gr-Bf	V. Tn		
Pk-(Bn)	Pc	Fl	Fl in veins. Thin sandy beds betwn. mudst.
Bf	Lm - V. Tn	At, At, Ch, R	Fine interbeds of algal mats + algal plate pckst. c̄ flat to shallow-channelled ssts. Some cse. layers have grans.
Pl. Bf-Cm	V. Tn-Tn	R	Thin, algal layers at top.
	Tn		Prob. as above. Channelled base
Pl: Md. gr	Tn		
Md. gr	V. Tn - Tn		Finer bedding + stylo'c b.p's at base.
Md. gr	Md		Cherty + carb. algal plates + mats.
Bf-(gr)	V. Tn	?	Boundst. at top, grades down to interbedded mudst. + channelled ssts. Some cse. + gran. qutz grns. in some beds. All mudst. may be algal. Intra. bed @ 97·90 → 98·15 : in situ breccn.
Pk-gr	Ms	R	Vert. calc. vns., some bdg. pl. + stylo. calc. also. Stylos. increase downwards
Md. gr	Tn	Fl	Vugs → 2 mm filled c̄ calc. then fl. Fl veins off stylo. ? burrowed.
Bf + Pl. gr	Lm - V. Tn	Fl	? algal lamn. towards base.

MARLA 1-B

LITHOLOG

Latitude : 27° 28'
Longitude : 133° 44' 55"

Logged by B.C. Youngs

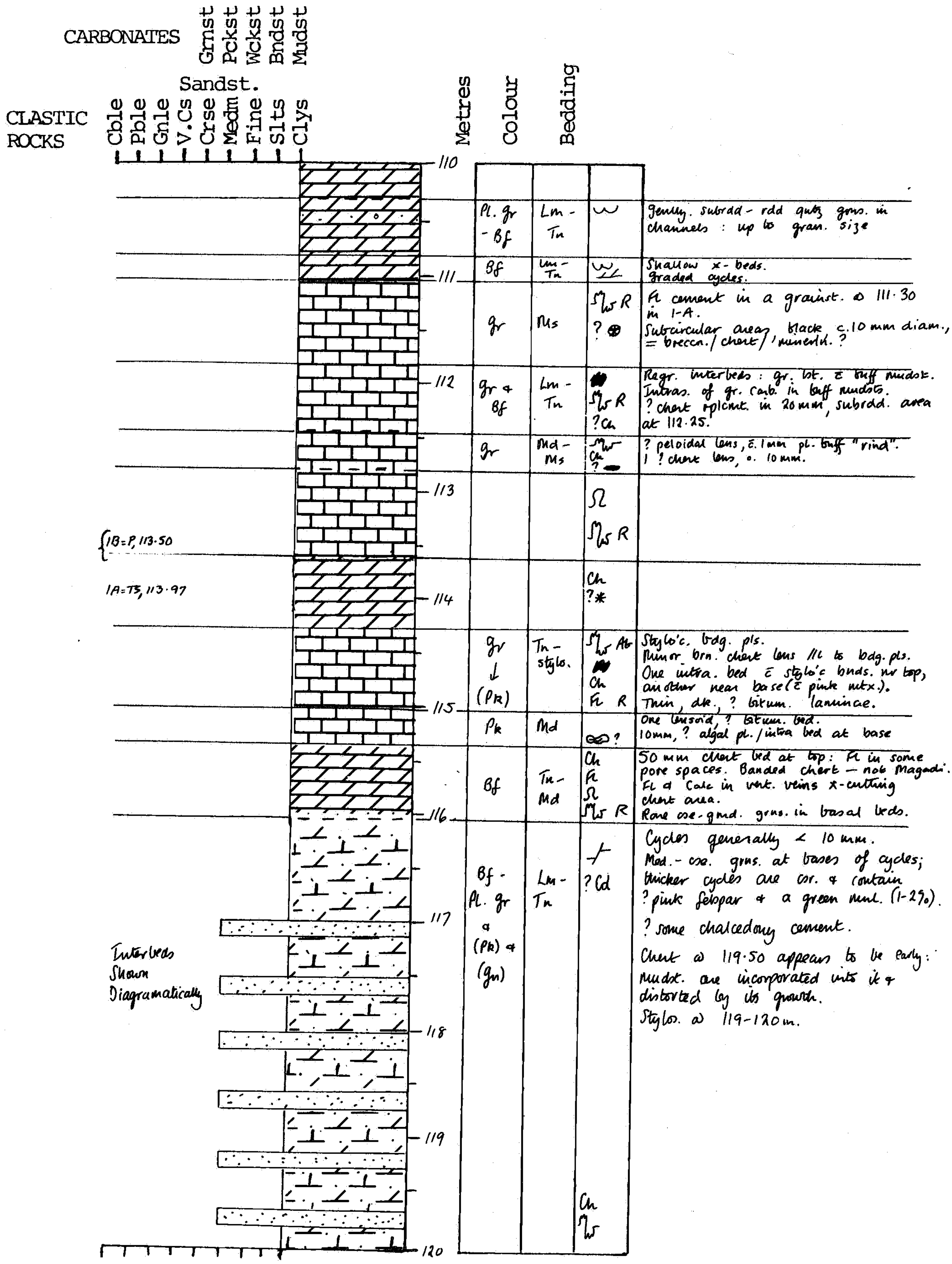


MARLA 1-B

LITHOLOG

Latitude : 27° 28'
Longitude : 133° 44' 55"

Logged by B.C. Youngs



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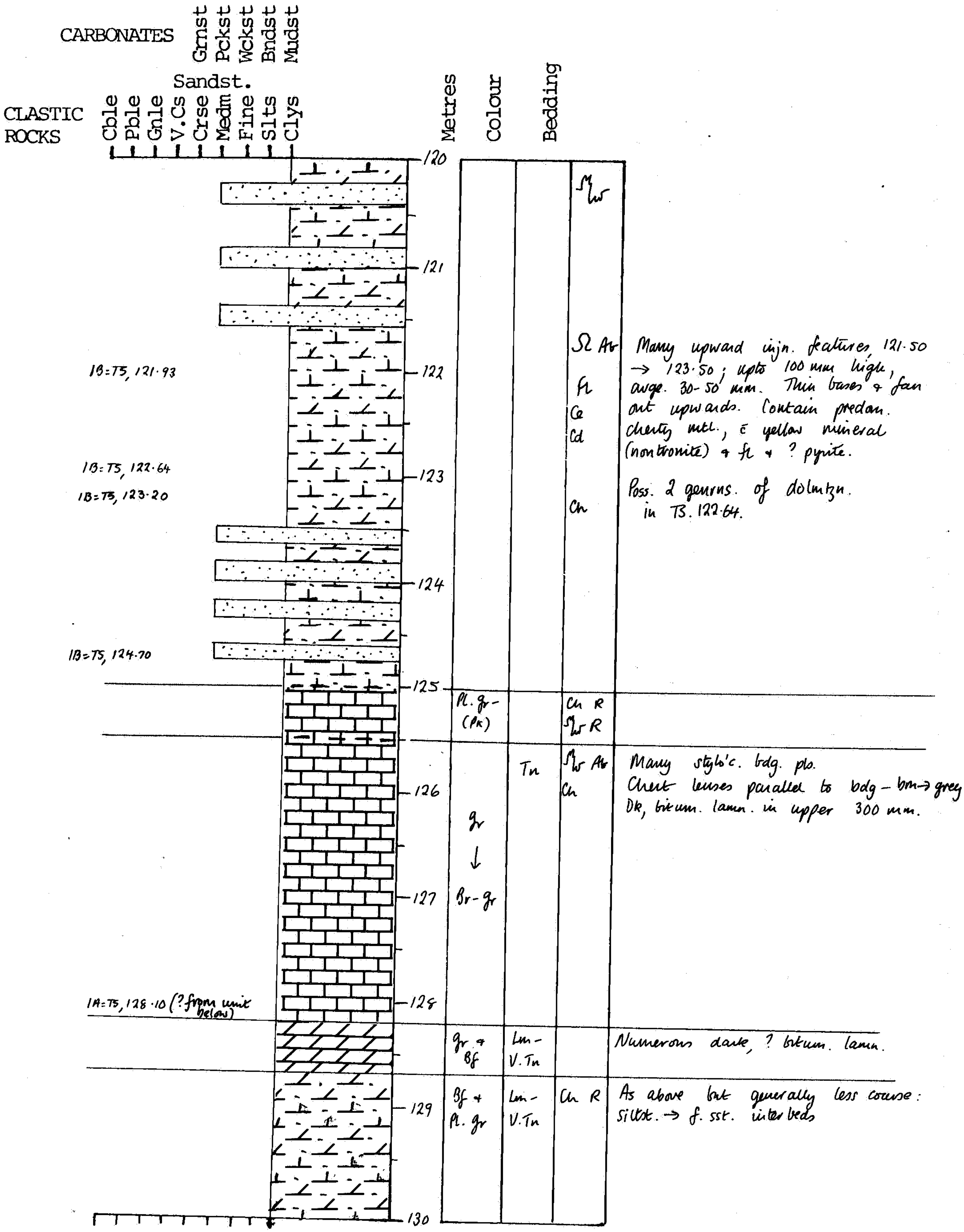

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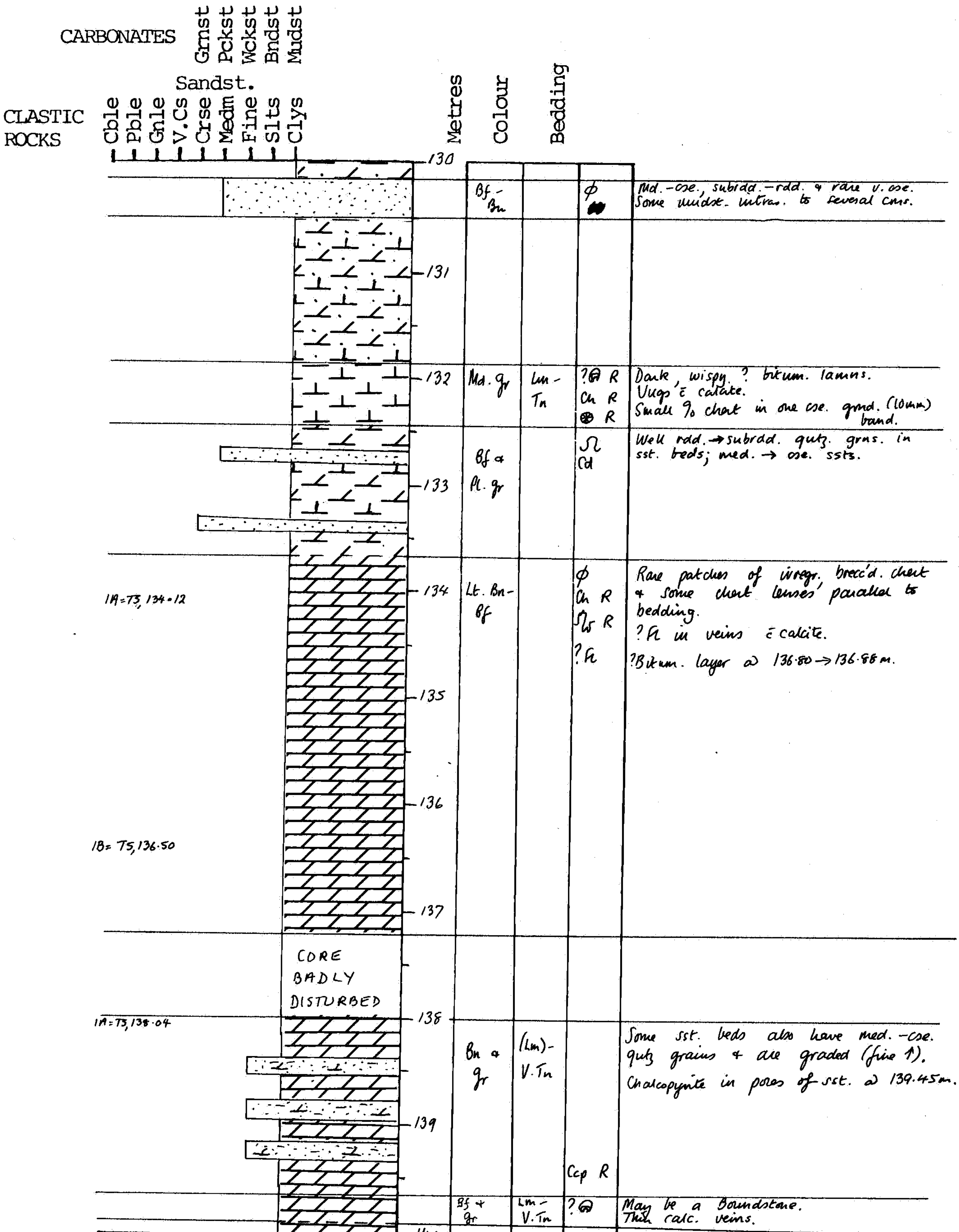

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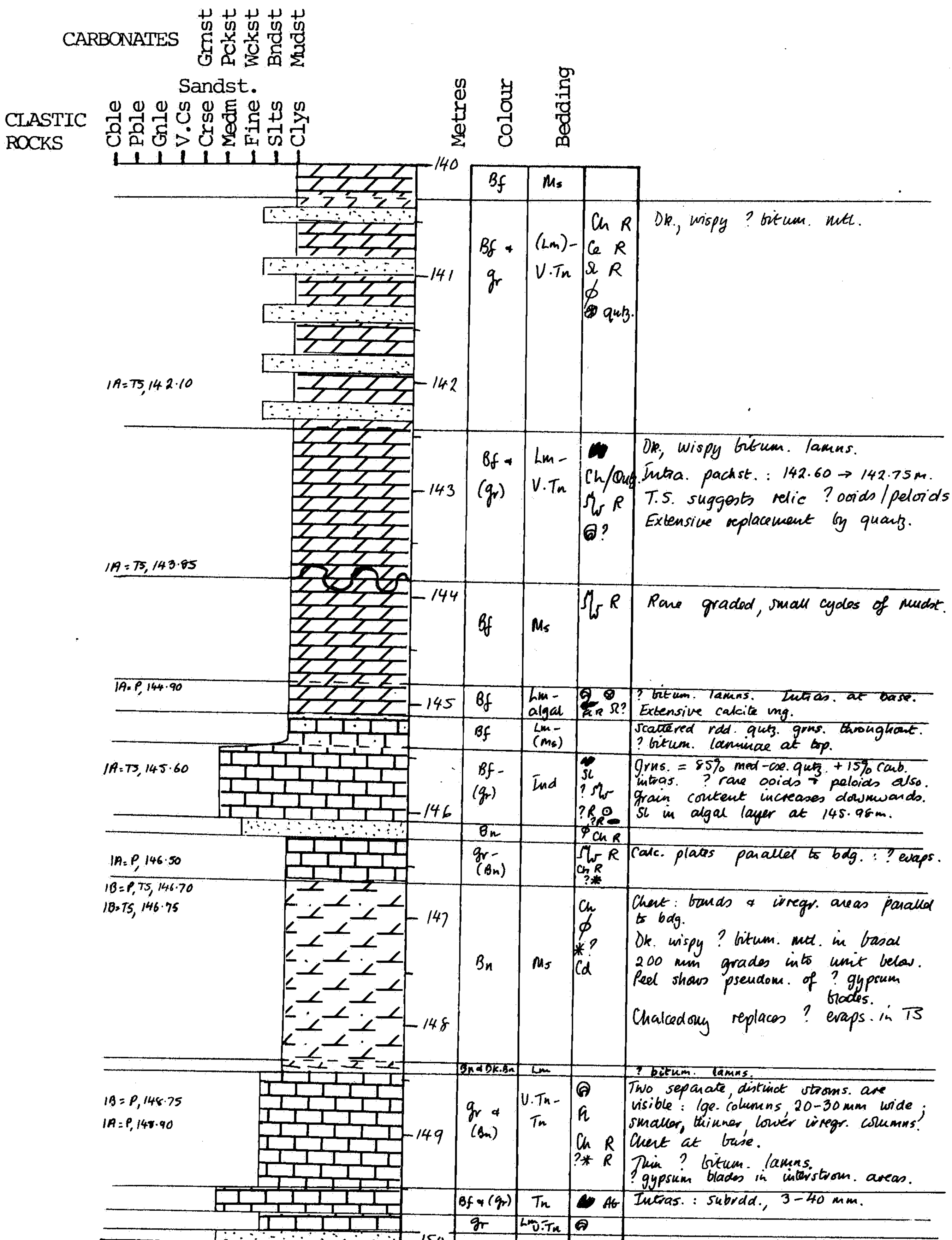

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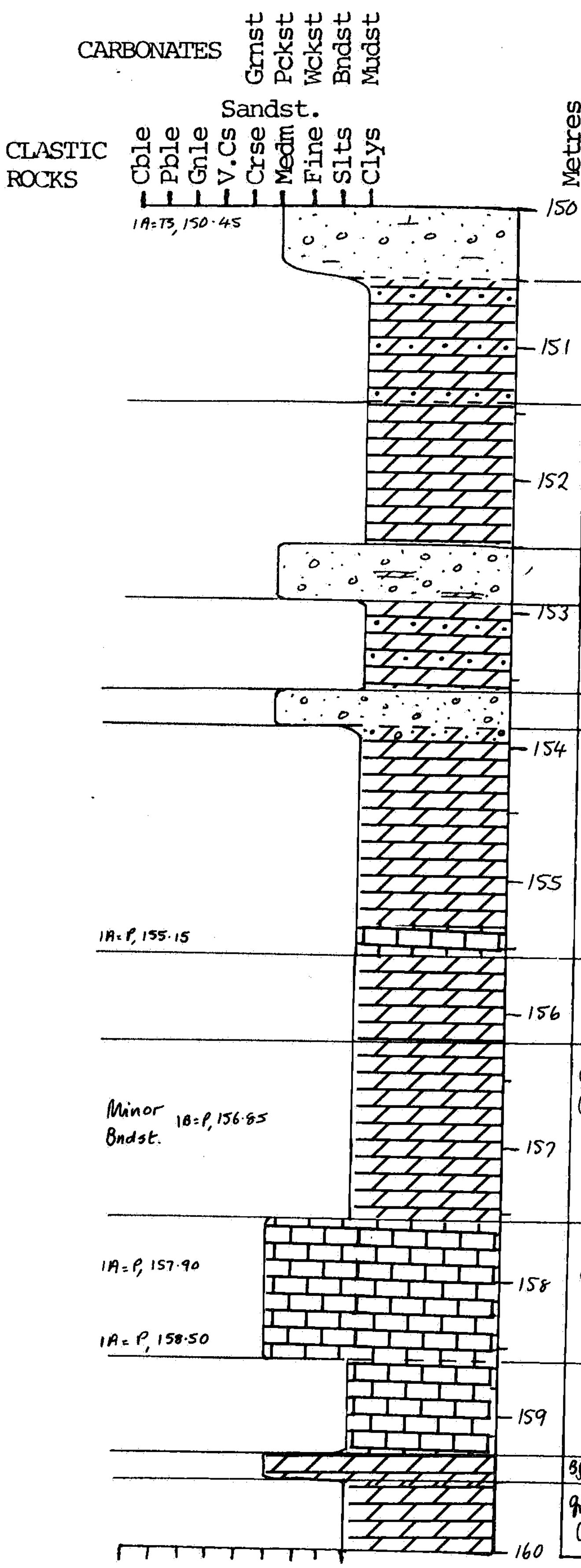

Colour	Bedding	Symbols	Description
gr	Tn	Calc. ?	Predom. f-med, subrdd. grns. + some layers c̄ subrdd-rdd. cse-gran. Some grading. Calc. veins. Basal 200 mm = cgr., c̄ metam., acid vdc., mudst. intras. + ? algal plates.
gr + Bf	Lm		Some mudst. beds are algal. V. thin, fine sst. interbeds. Dk. ? bitumn. lamns.
Lt. gr - gr	V.Tk - Ms	R	Fine vert. calc. veins.
gr		Fl	As for 150 m c̄ Fl cut. @ 152.85 m. Some mudst. beds.
gr	Lm - V.Tn		
Bf + Pl. gn	V.Tn - Tn	Sl	Gran. + pebble layers c̄ sst. Sulph. in 5 mm pore.
gr - (Bn)	Lm - V.Tn	Ch	Cse., late calcite vein-filling spar.
Bf + (gr)	Lm - V.Tn		Dk, thin, ? bitum. lamns. throughout.
gr + (Bf)	Lm - V.Tn		
gr	Ms - Tnd	Ab, Ab, ?, ?? Fl, Ch	Some intras. : result from extensive stylotization. Pervasive chert at 158.50 m. Also some grnst. c̄ drusy cmt? Some pckst., microspar / rexn. Structure "grumeleuse" — hard to identify!
gr	Lm - V.Tn	R	Thin, ? bitum. wisps throughout. Soft sedmt. defm. at top.
Bf + gr	V.Tn		Soft sedmt. defmn. ↓ at 159.40m.
gr + (Bf)	Lm - V.Tn	?	Channels are shallow, c̄ rare qutz. grns. → grans. Bitum. lamns. ? algal lamns.

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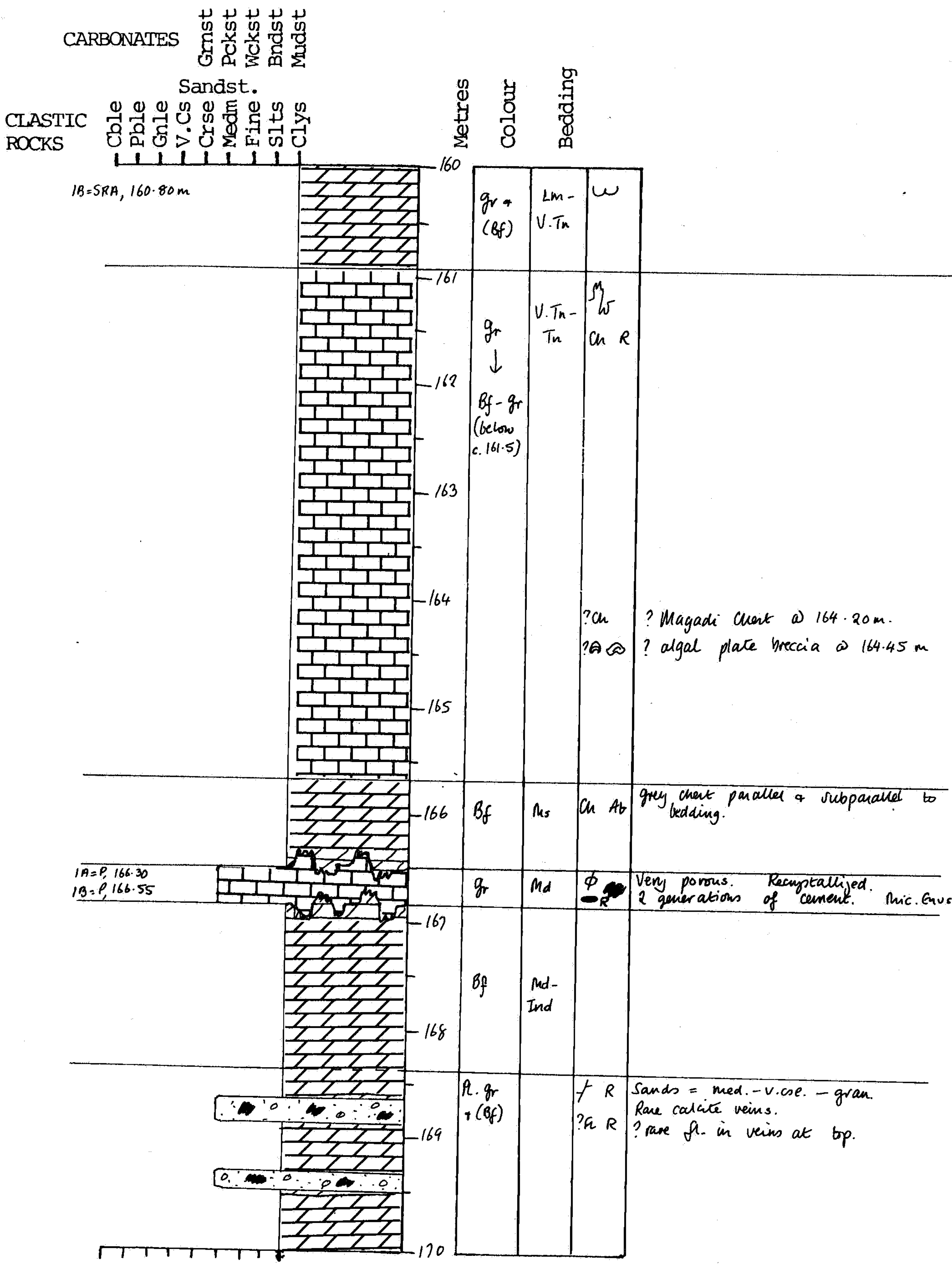

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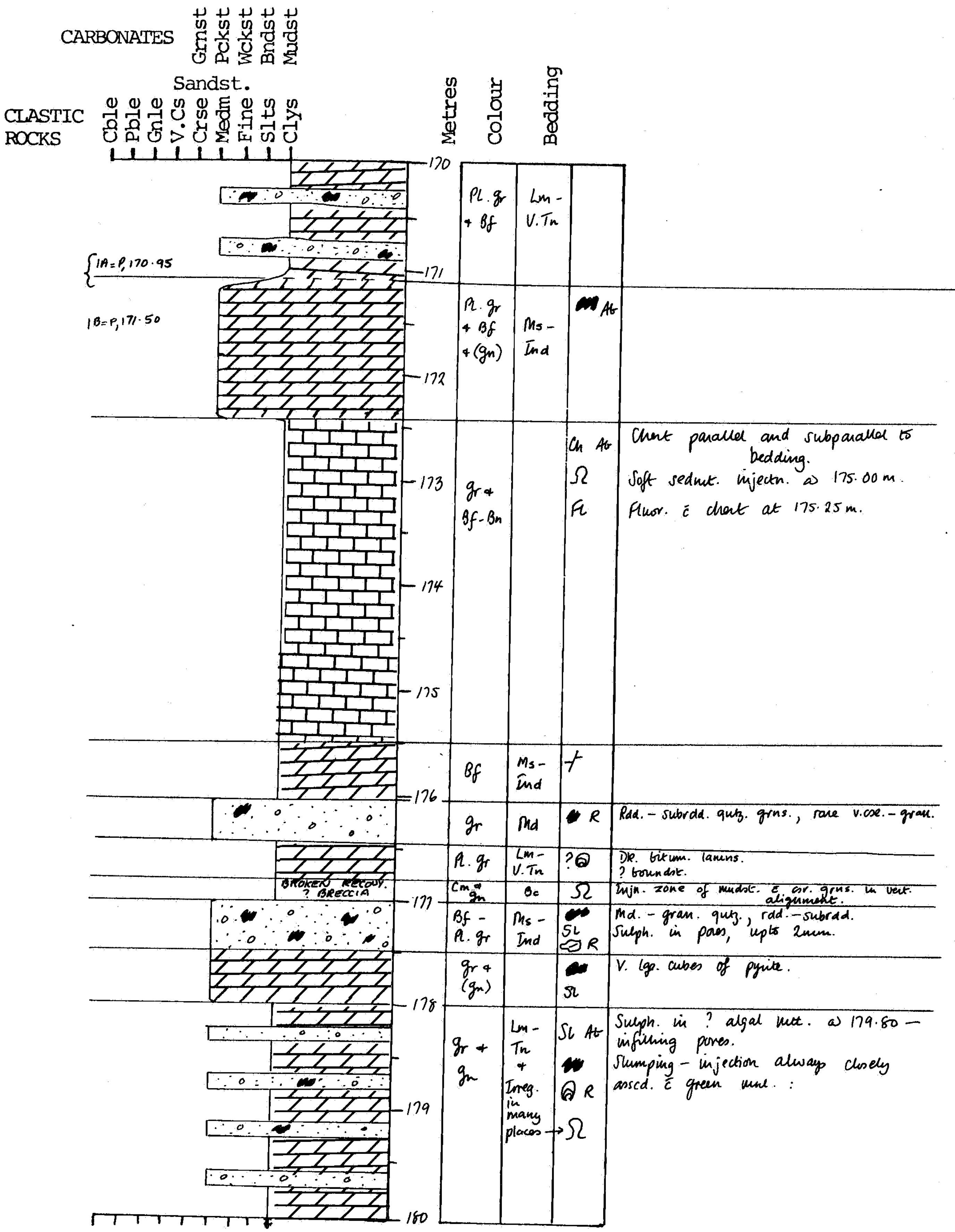

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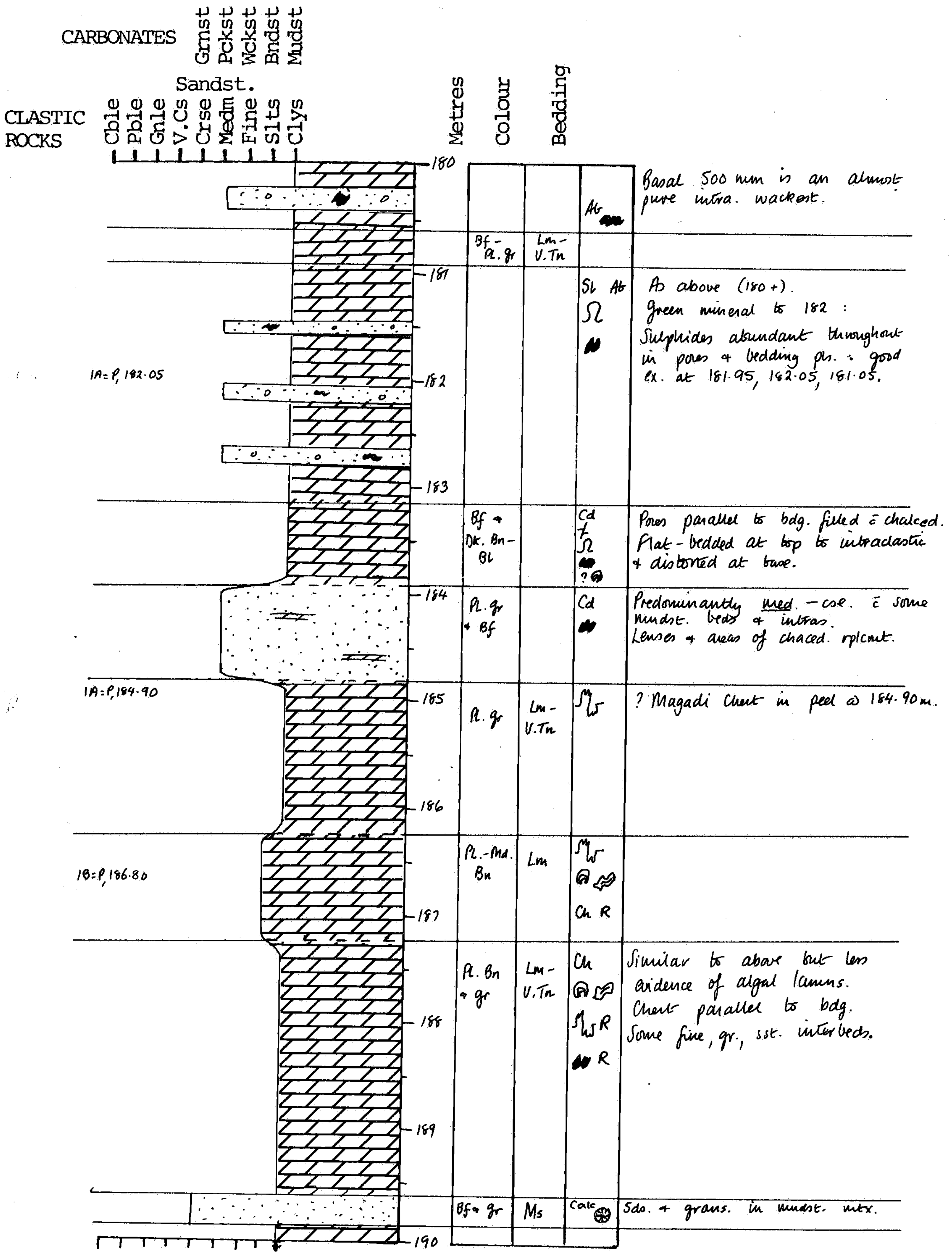

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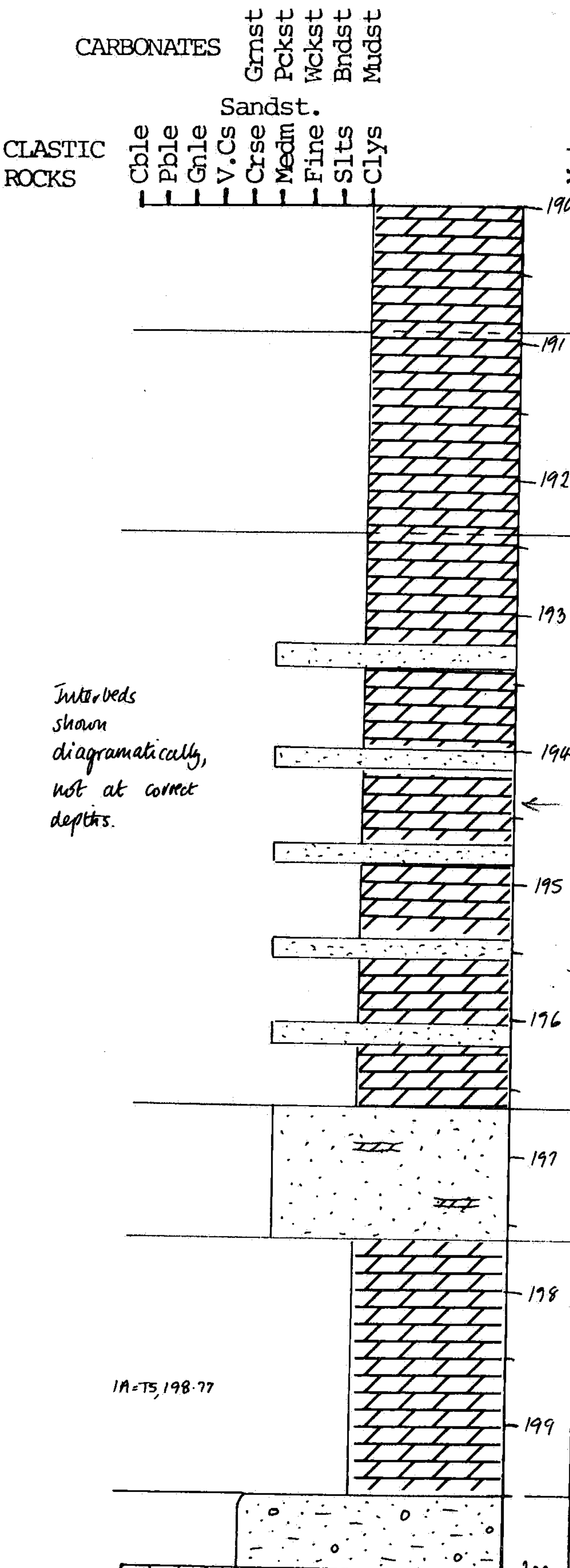

Metres	Colour	Bedding		
190–191	gr	Lm–V.Tn	[nodule symbol] R, Cd, Mw R	Rare, thin med. ssts. Irregr. concentric chalcedony.
191–192.4	Bn–gr	Lm–V.Tn–(Tn)	Ch, Mw R	Chert parallel to bedding.
192.4–196.7	gr		Cd, [nodule symbol]	Some thin, ? bitum. wisps. Chalcedony generally parallel to bdg. Hopper xtals
196.7–197.7	gr & (Bf)	V.Tn–Tn	[nodule symbol]	Mudst. layers & intras. & rdd.–subrdd. v.cse.–grans. in sst. No good grdg.
197.7–199.7	gr	Lm–Tn	Ch, [fault symbol], Mw R, [symbol] R	Some algal mats @ 198.45m. Chert associated c̄ microfaulting & a small-scale breccia.
199.7–200	gr	Tn	[nodule symbol], [fault symbol]	Some lge.-scale, normal faulting. Predom. med.-cse. sst.

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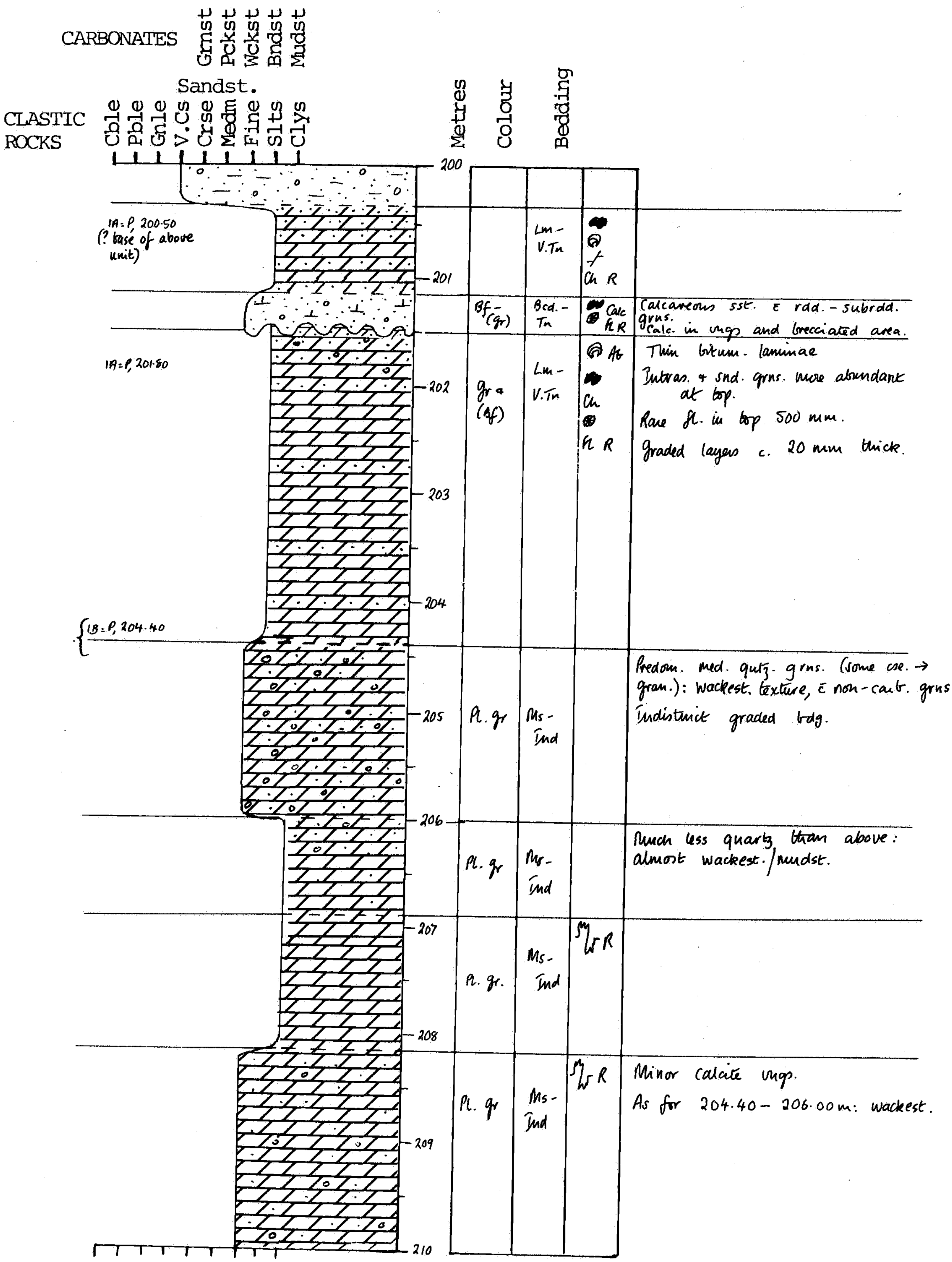

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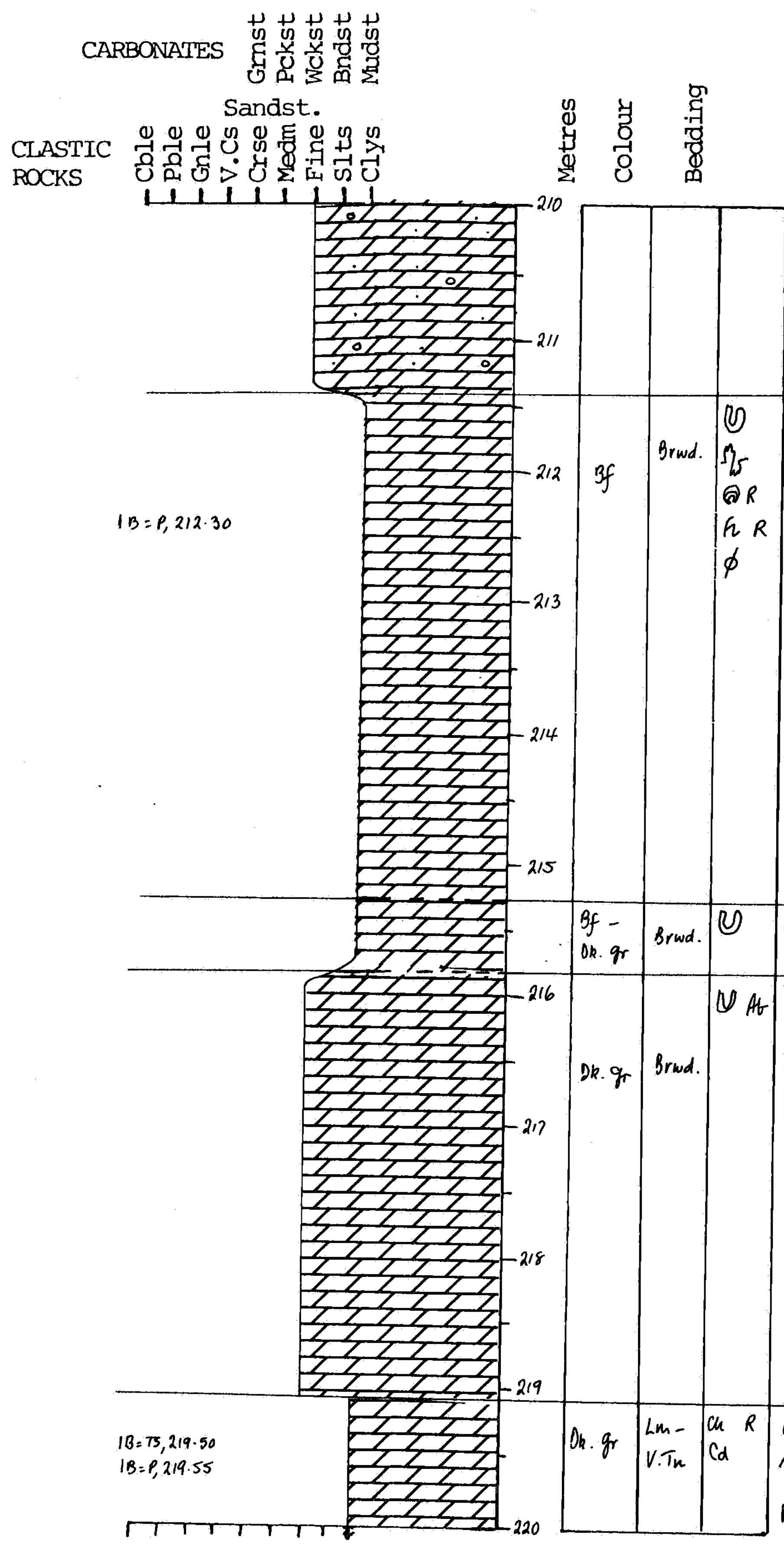

	Colour	Bedding		
211.4–215.3	Bf	Brwd.	U, ∫, @ R, Fl R, ϕ	Dismicrite. Minor calc. veining c̄ Fl. + Qwtz. Thin bitum. laminae, 214.40–214.70m.
215.3–215.9	Bf – Dk. gr	Brwd.	U	As above but darker.
215.9–219.05	Dk. gr	Brwd.	U Ab	Thin (cm.+) peloidal packst. beds. Heavily burrowed. Calcite veining.
219.05–220	Dk. gr	Lm – V.Tn	Ch R, Cd	Calcite veining. An 8mm ooid grst. lens @ 219.55: chertified/chalcedony. Micrite envelopes.

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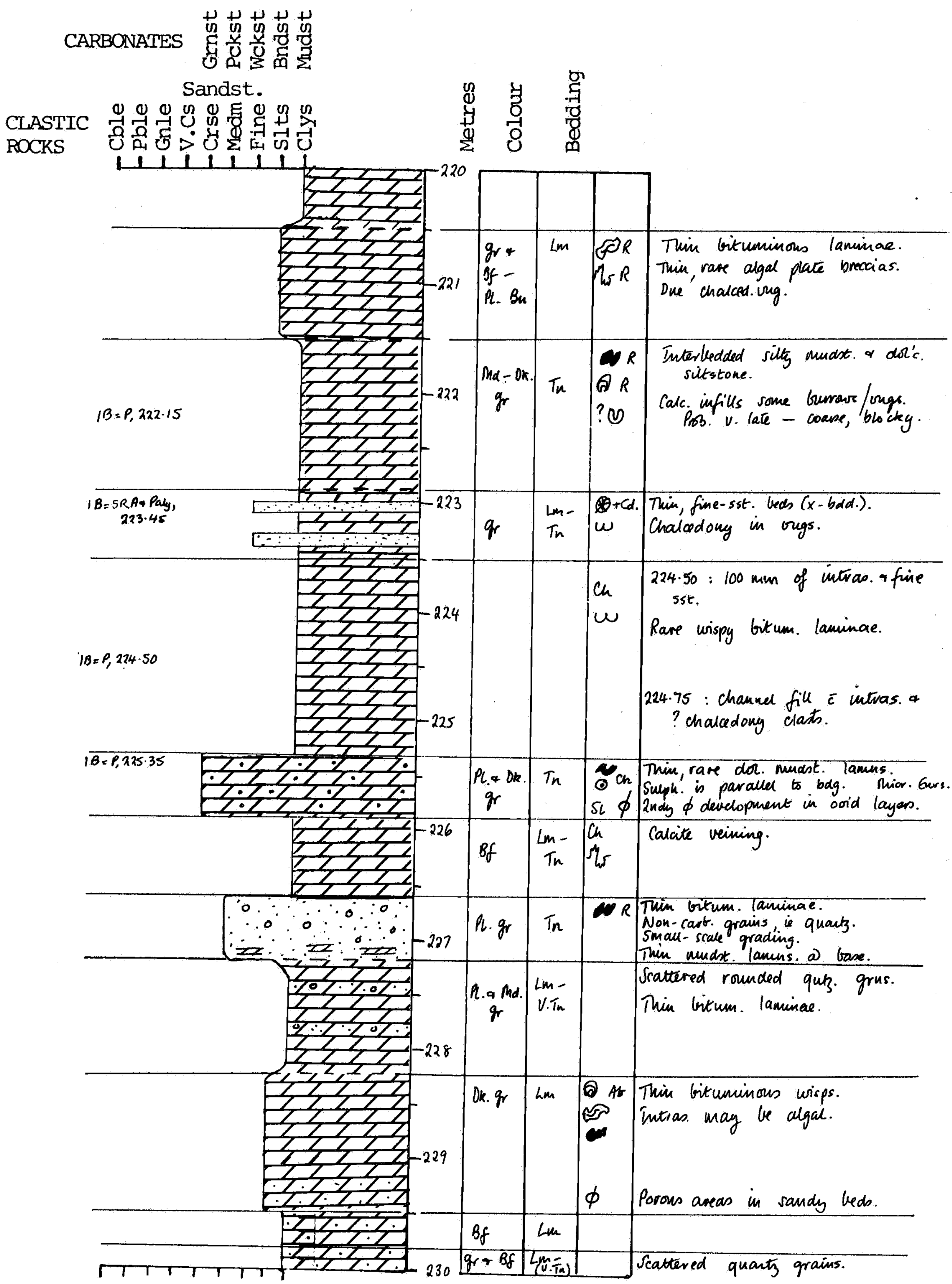

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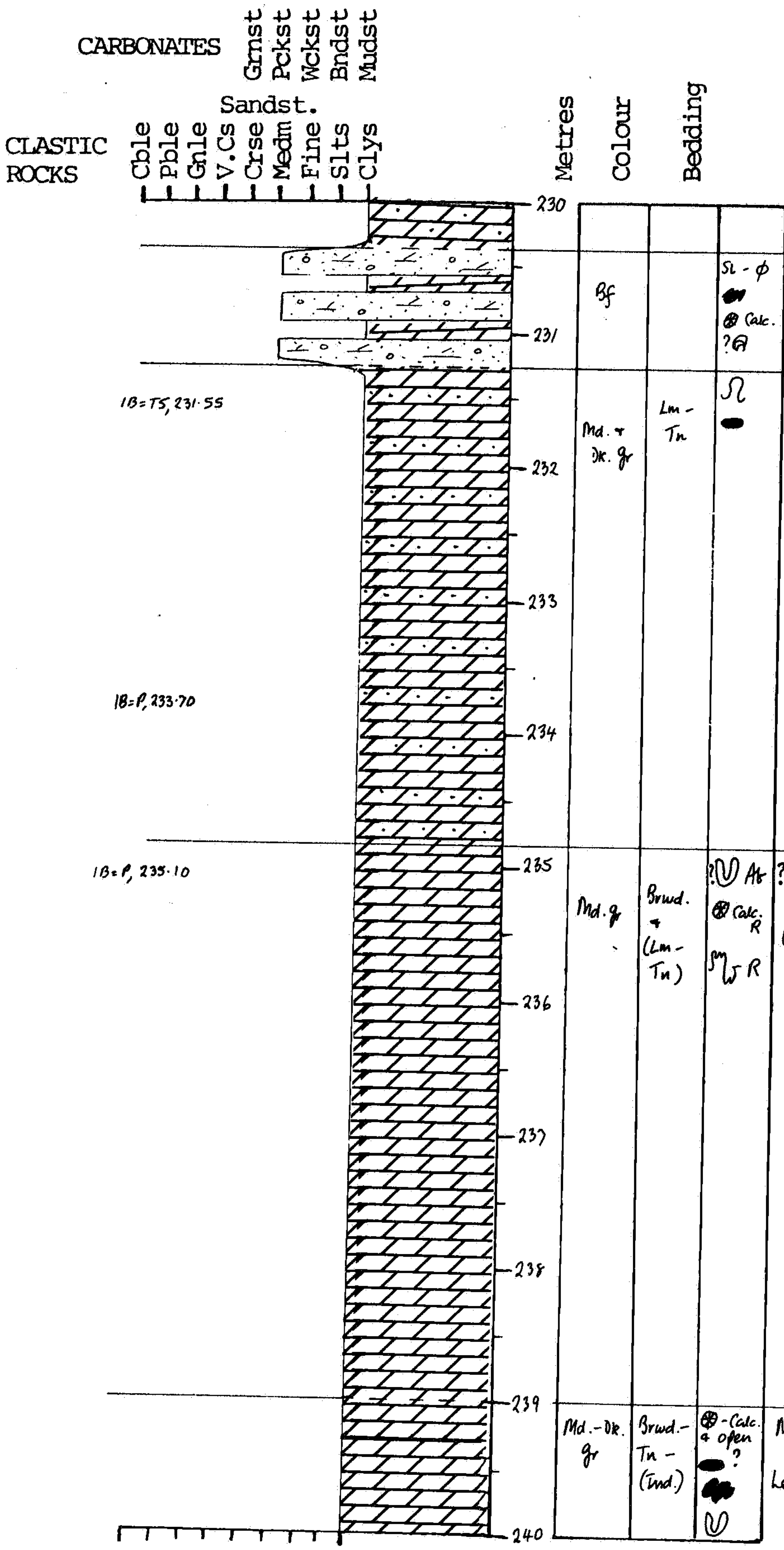

230.15 : φ bed c̄ sulphides.
Some sand grains are down to fine-grnd.
Dol. mudst. lamns. + intras.
Some intras. ? algal.

Fine sst. - sltst. thro'out, some pure mudst.
Thin dk., wispy bituminous lamns.
Calcite veining (ferroan calcite), v. late = cse.
233·70 : peloidal packst. interbeds.
2 generns. dolmtzn. in T.S. - coarse, zoned 2ndy. xls.

?Burrowed, esp. top 150 cm. Brecciation also: ? due to burrowing.
Calcite veining + rare vugs.

Much as above but peloids and intras.
Less burrowing than above. Some burrows are filled c̄ calcite, then ? dissolved.

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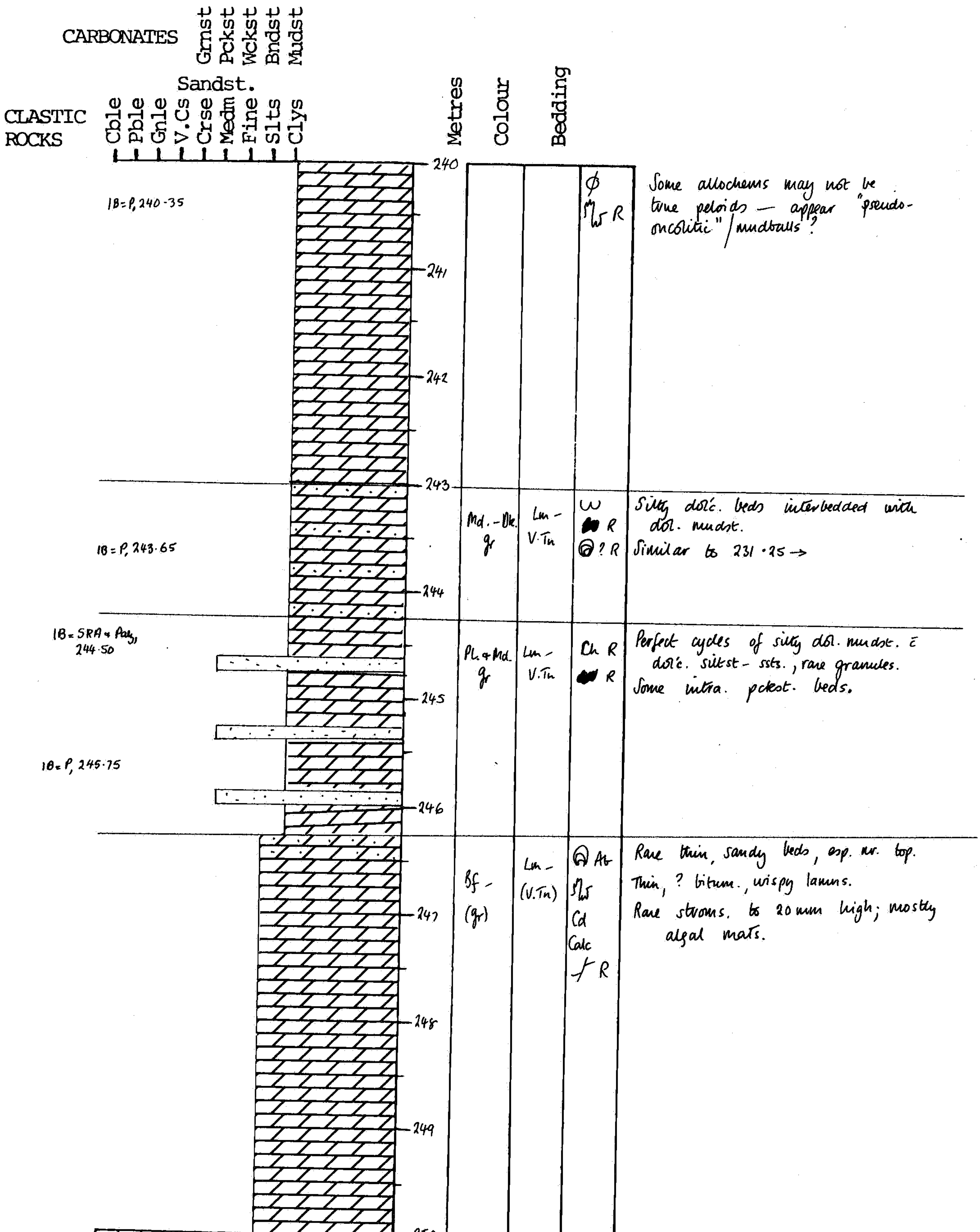

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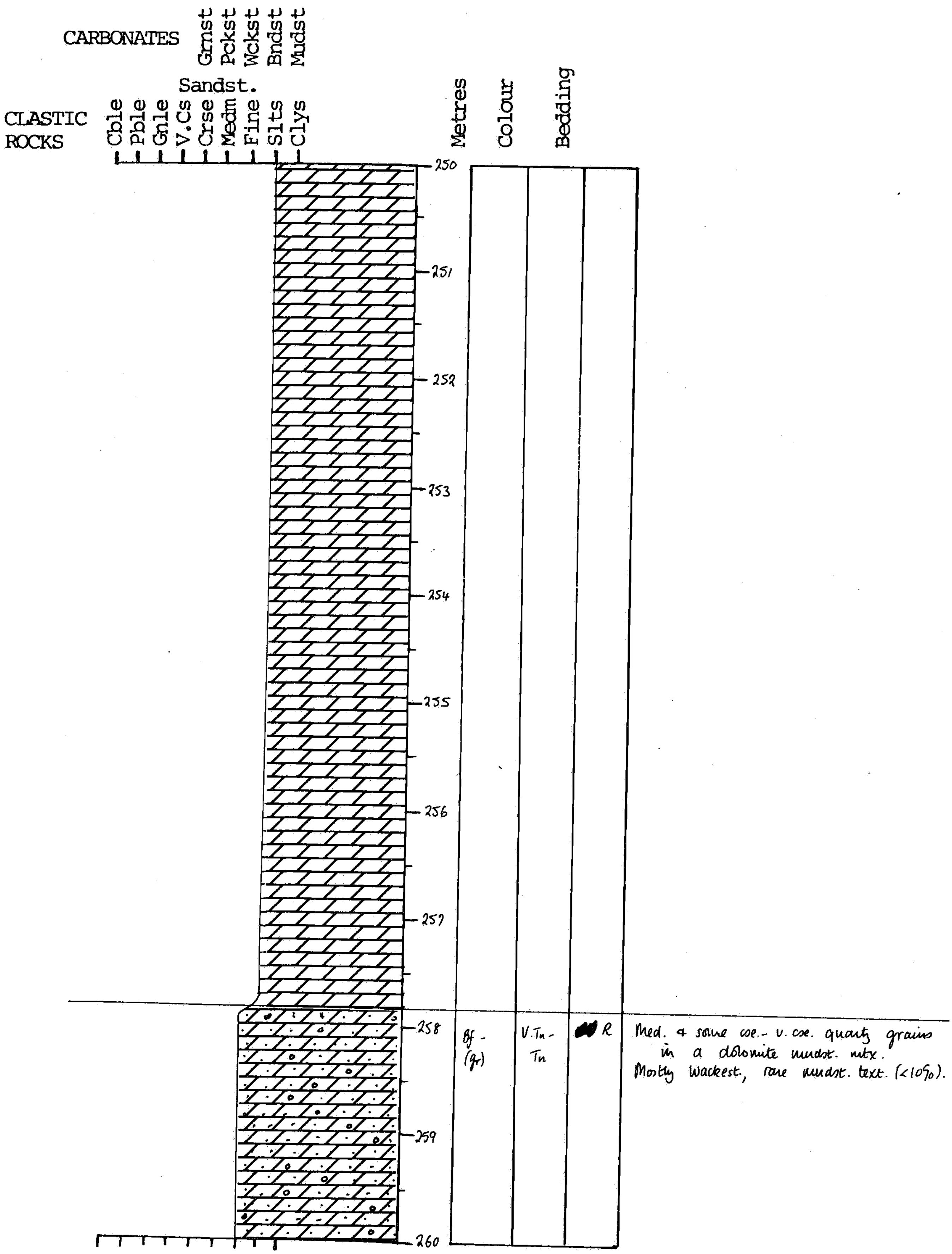

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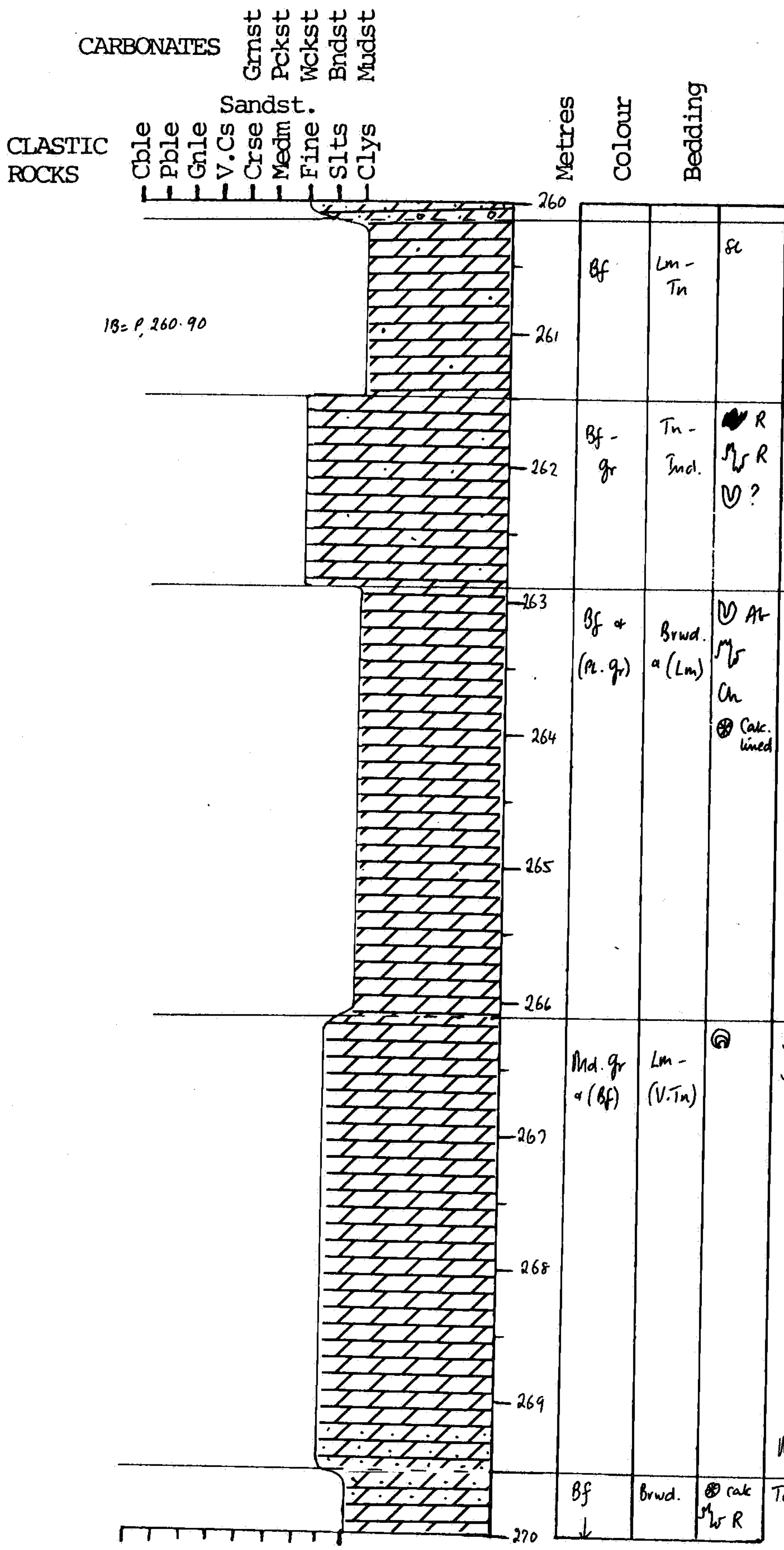

Rare sst. grains.
Rare dk. bitumns. lamns.
Calc. vein ē sulph. blebs to 3 mm.

As above, ē rare packst. beds. Fine - med. sd. grns., ē rare cse. - v. cse.
? burrowed in basal 150 mm.

Stroms. to 20 mm, mostly mats.
Some rexn. → micropar.

Med. - cse. qutz. grns. at base.

Top 100 mm : buff, ē scattered qutz. grns.

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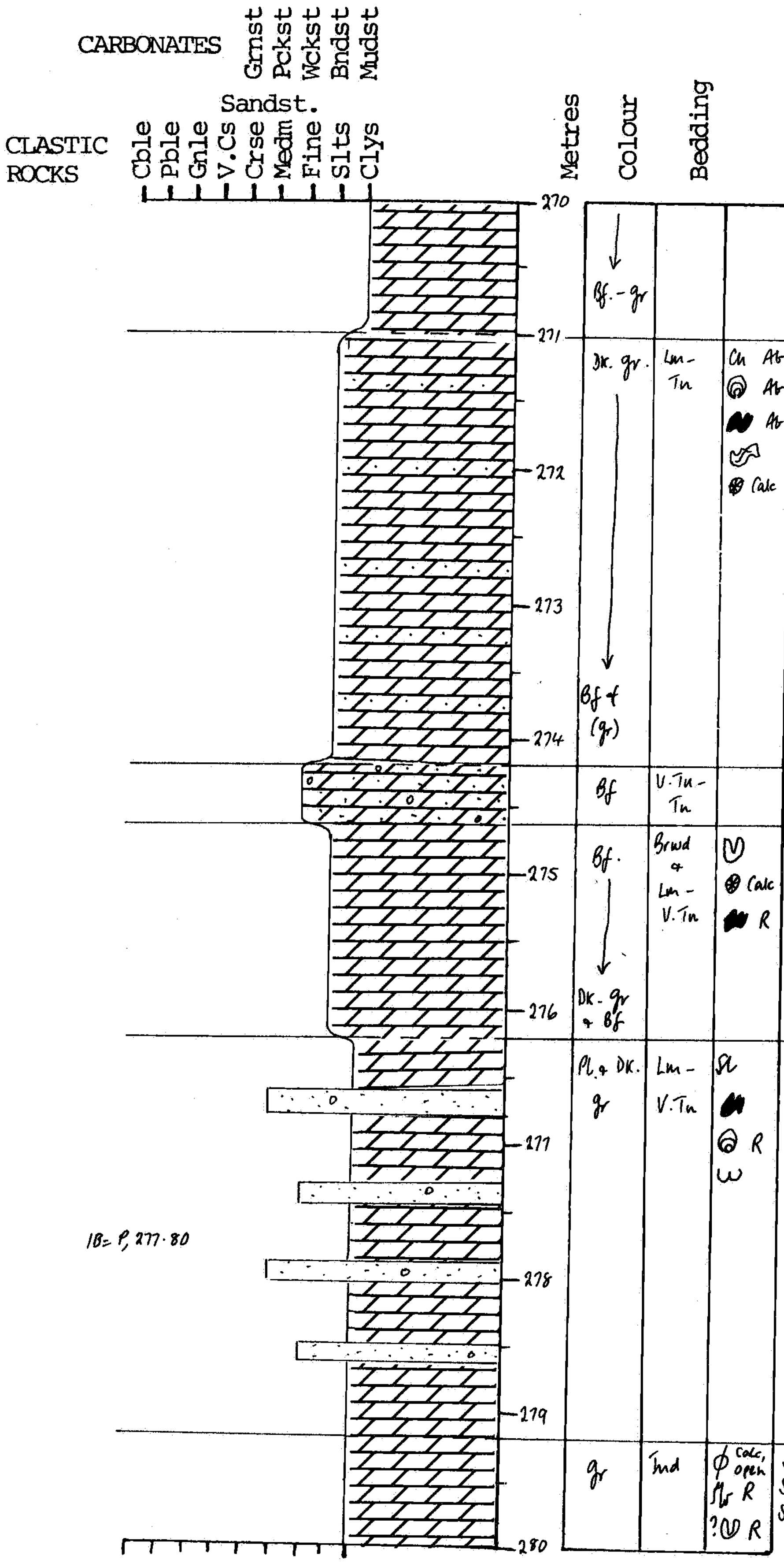

Thin wispy bitum. lamns.

Generally mats, rare small stroms.
Fine - med. qutz. grns. throughout.

Allochems are qutz. grns.
Some grading.

Burrowed in parts : some boundst. text. remains.
Thin dk, bitum. lamns.

Graded beds in ssts. Some cse. - v. cse. grans. in ssts. Channelling also.
Minor algal mats throughout.
Sulphide in ssts.
Intraclast pckst. beds in parts.

Some "mudballs" in ϕ zone.
Some ϕ may be due to birdseyes.
Some areas suggest dolmn. of a pel./intra. pckst. (T.S).

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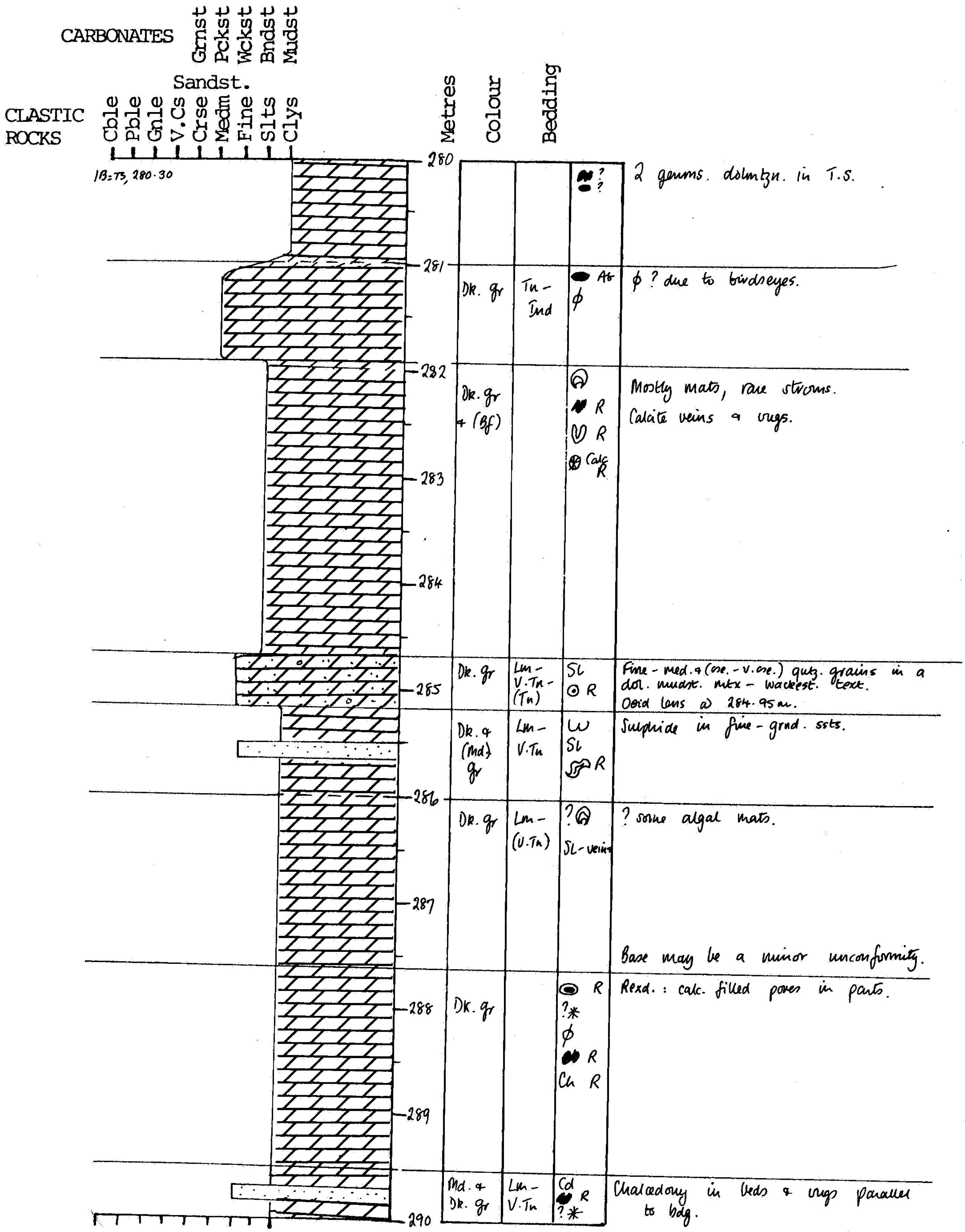

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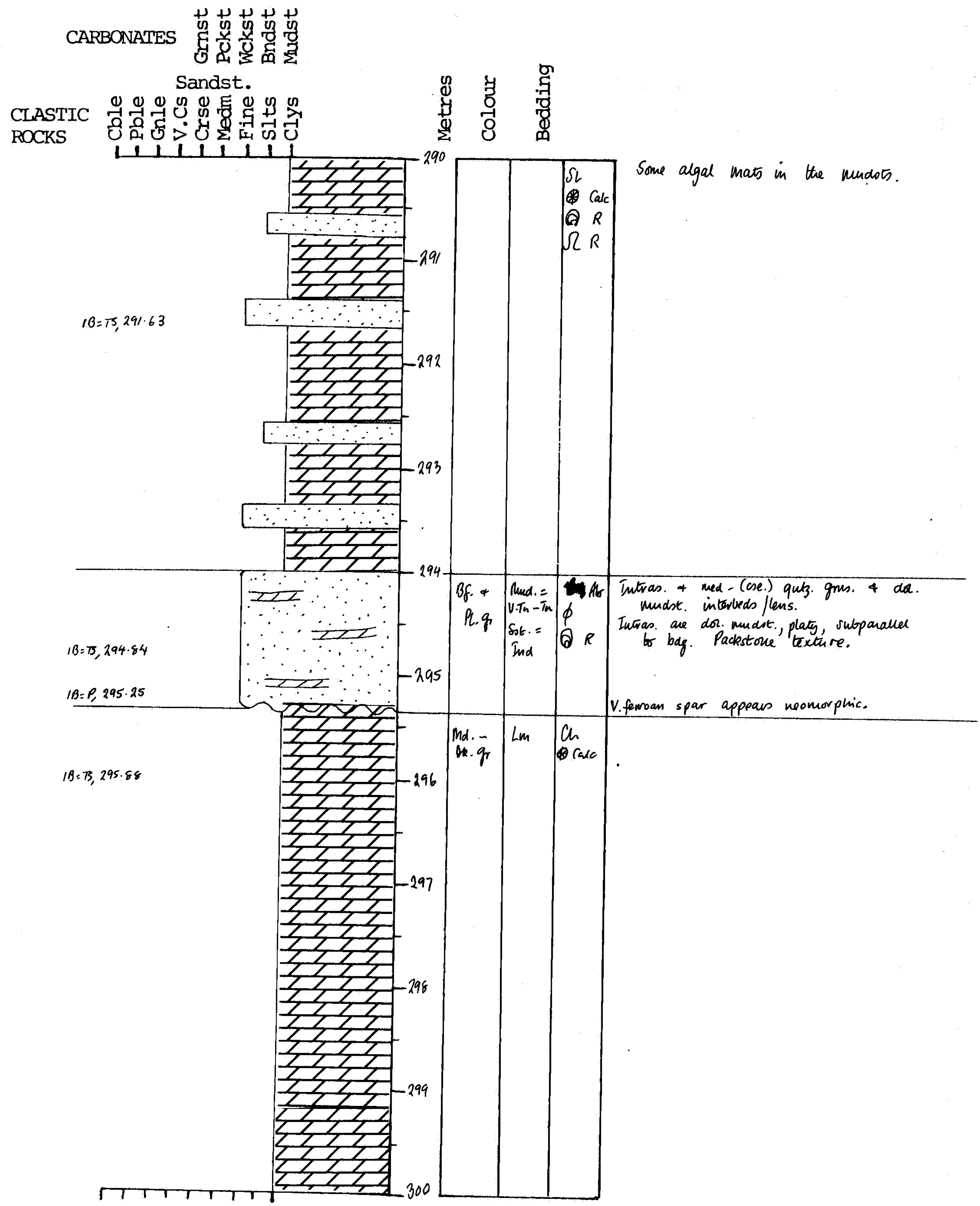

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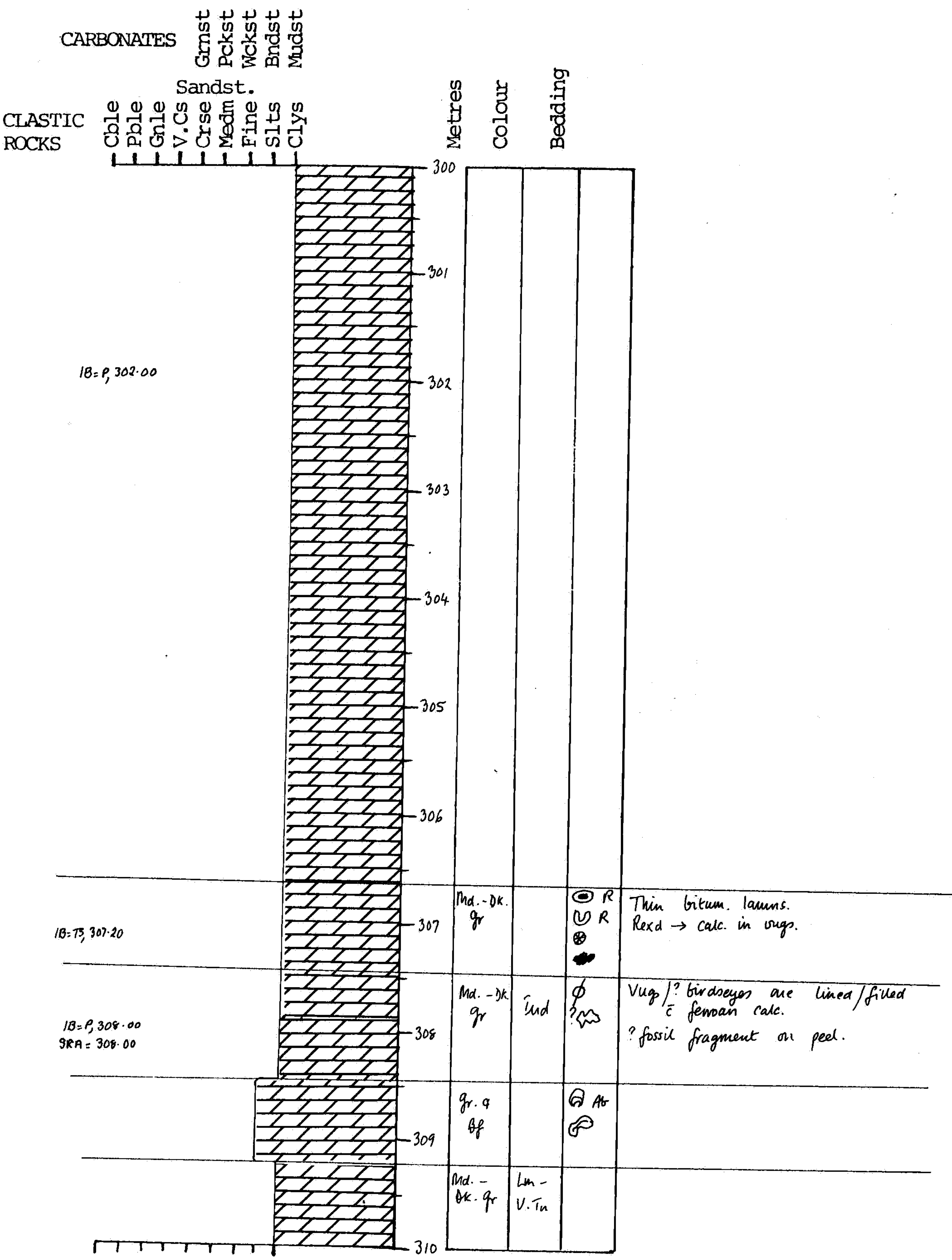

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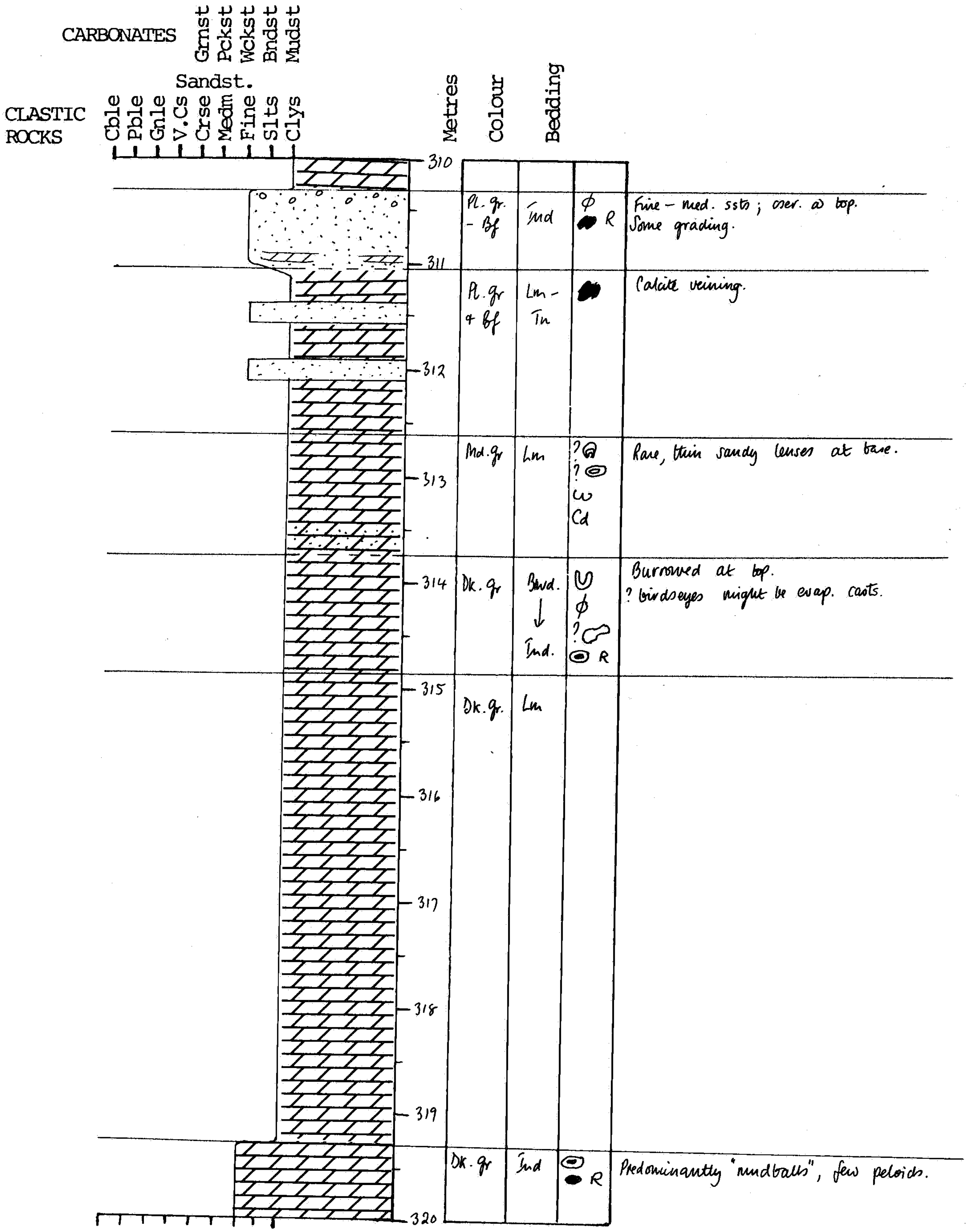

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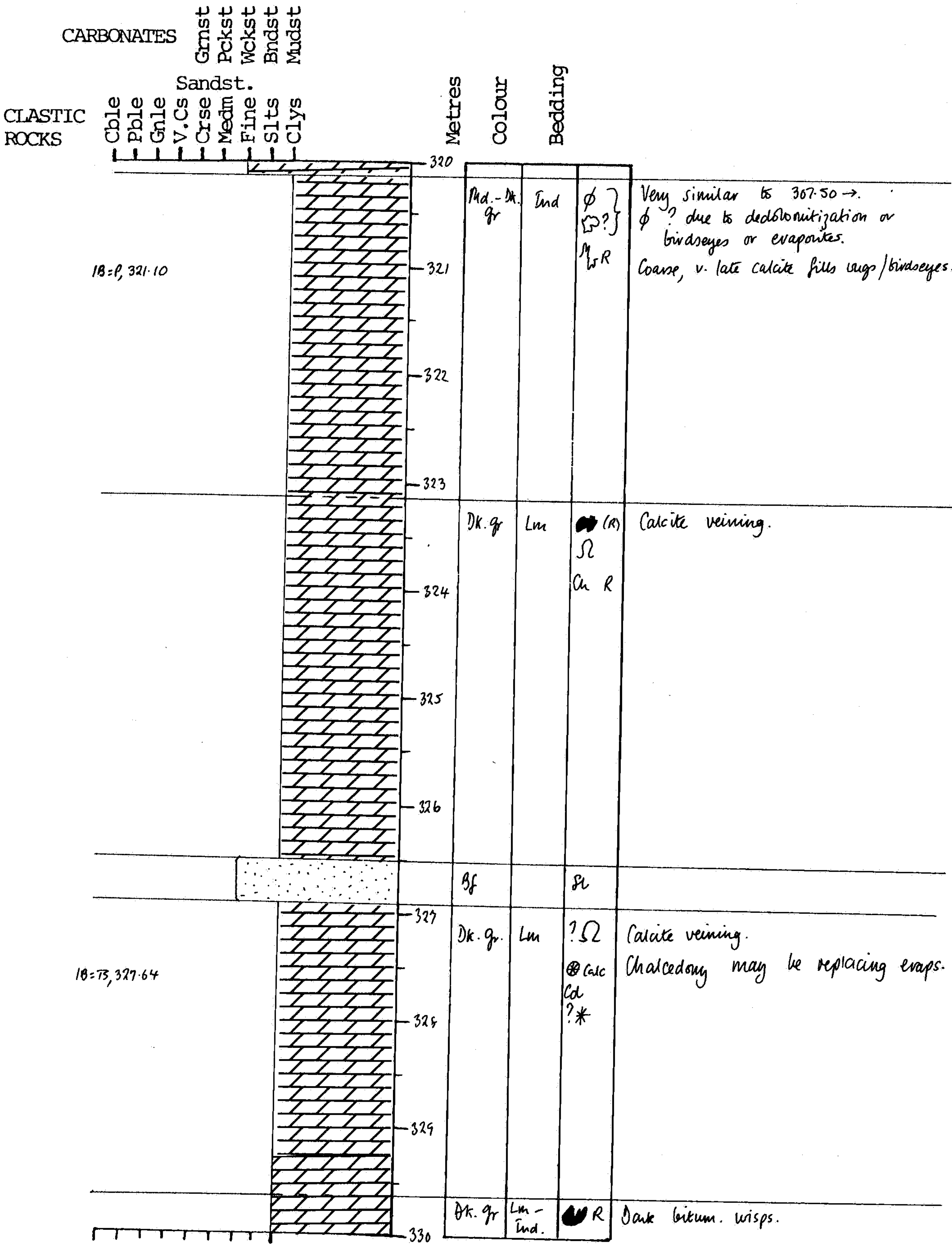

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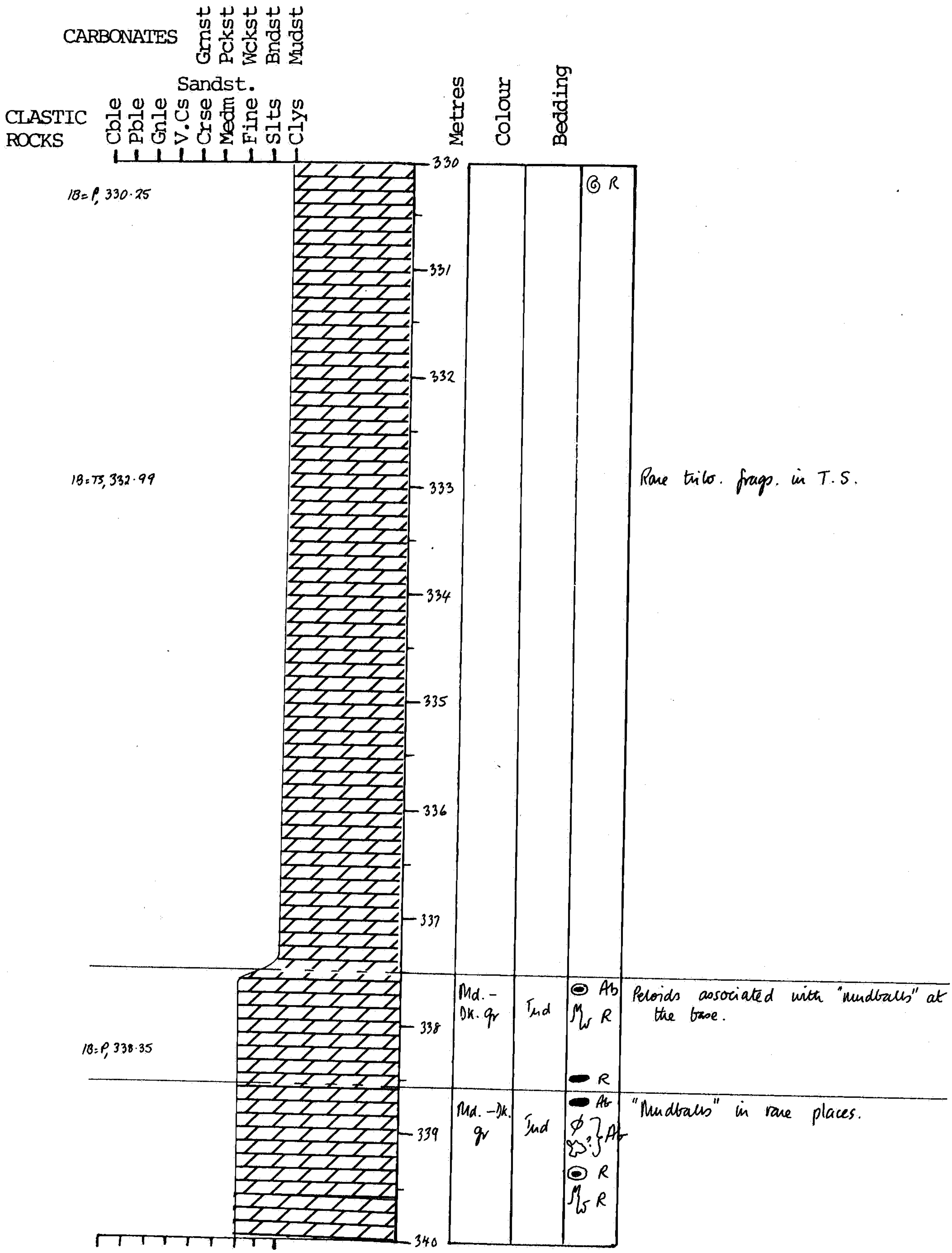

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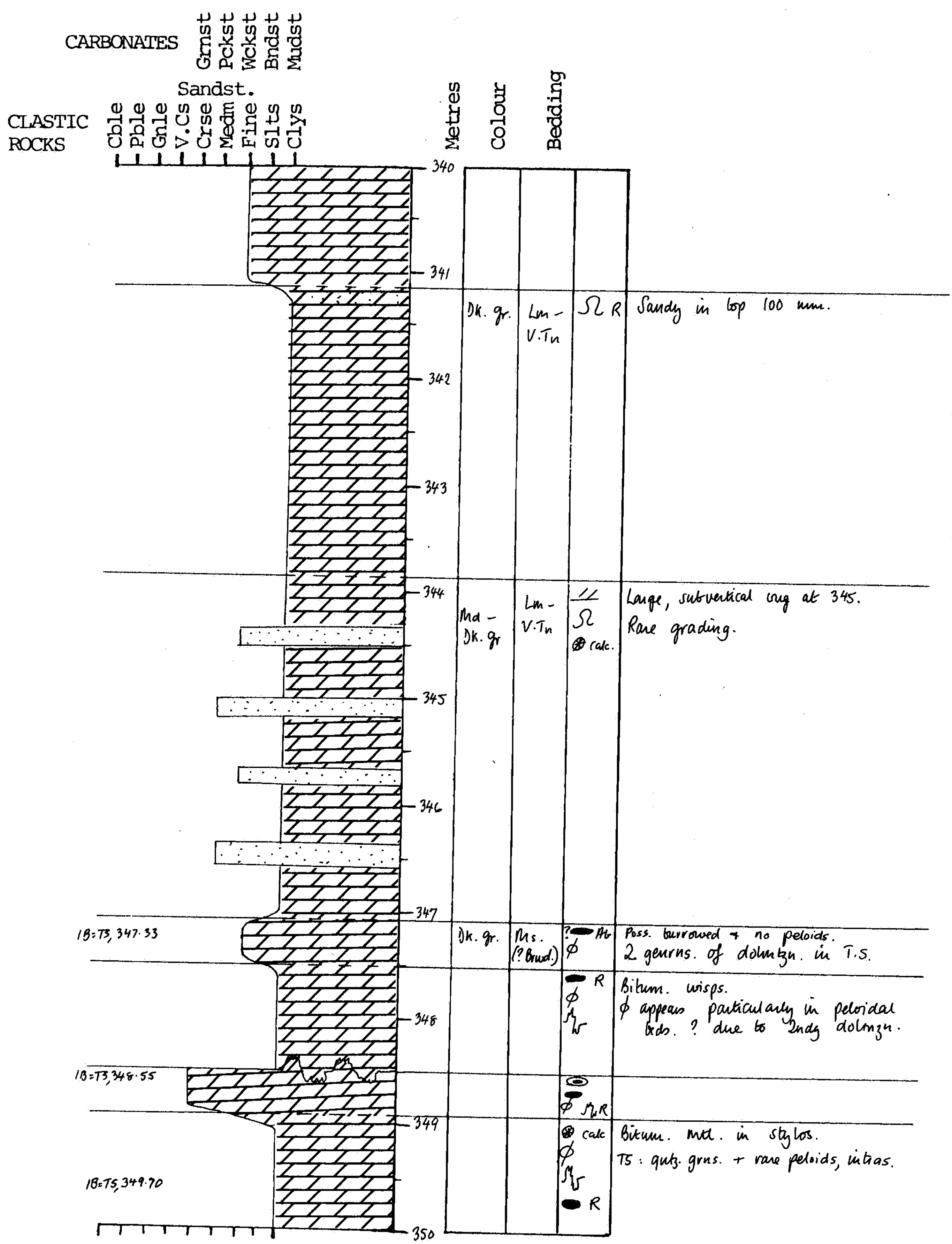

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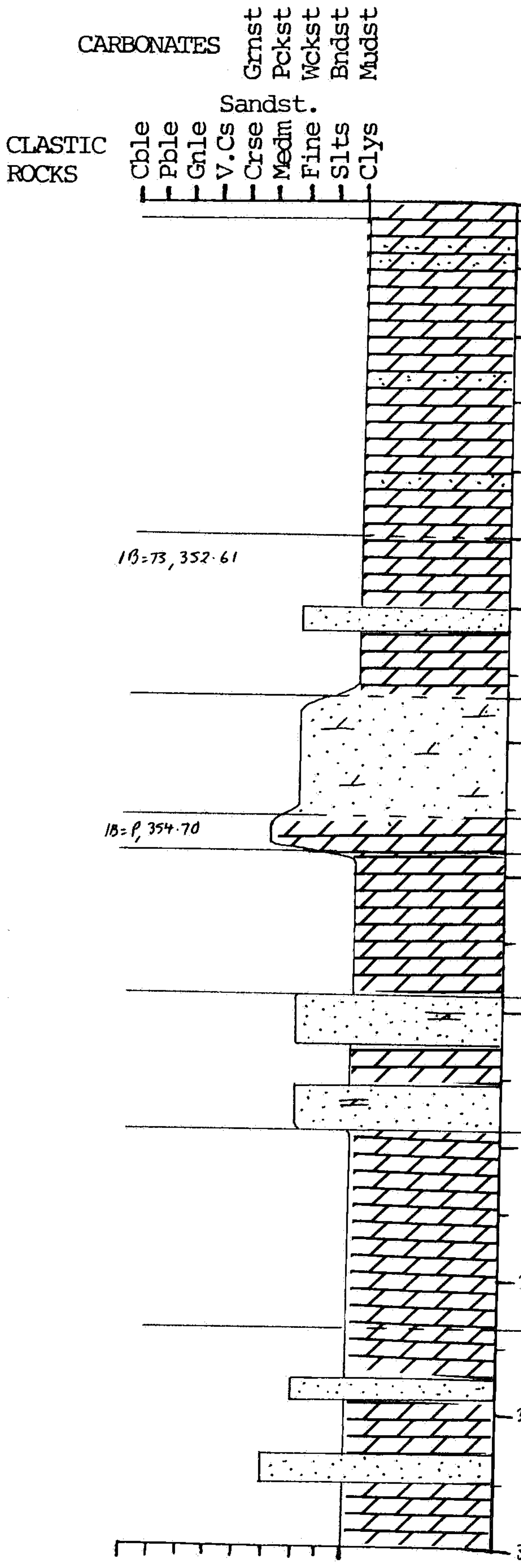

Metres	Colour	Bedding		
350–352.4	Dk. gr	Lm - Tn & (Brwd.)	R; Cn R; R; R; R	Burrowed: 350.30, 351.27. Intras.: 350.75. Sulphide in rare thin sst. lenses.
352.4–353.5	Dk. gr	Lm - Tn	R	Sst. have graded beds. Quartz/chalced. - lined vugs in sst.
353.5–354.6	Dk. gr.	Ms	R	Muddy sst. Calcite veining.
354.6–354.8	Dk. gr			Calcite veins.
354.8–355.9	Dk. gr	(Lm) - Ind	R; R; ? R	
355.9–356.9	Bf	Ind		Rare mudst. interbeds.
356.9–358.4	Dk. gr	Lm - V.Tn		Calcite veins. Wispy bitum. lamns.
358.4–360	gr. & bf	Mud. = Lm - V.Tn	R; SL R, in sand.	Intras. at top. Veining c̄ chalcedony. Vein @ 358.50m. Sulphides in ssts.

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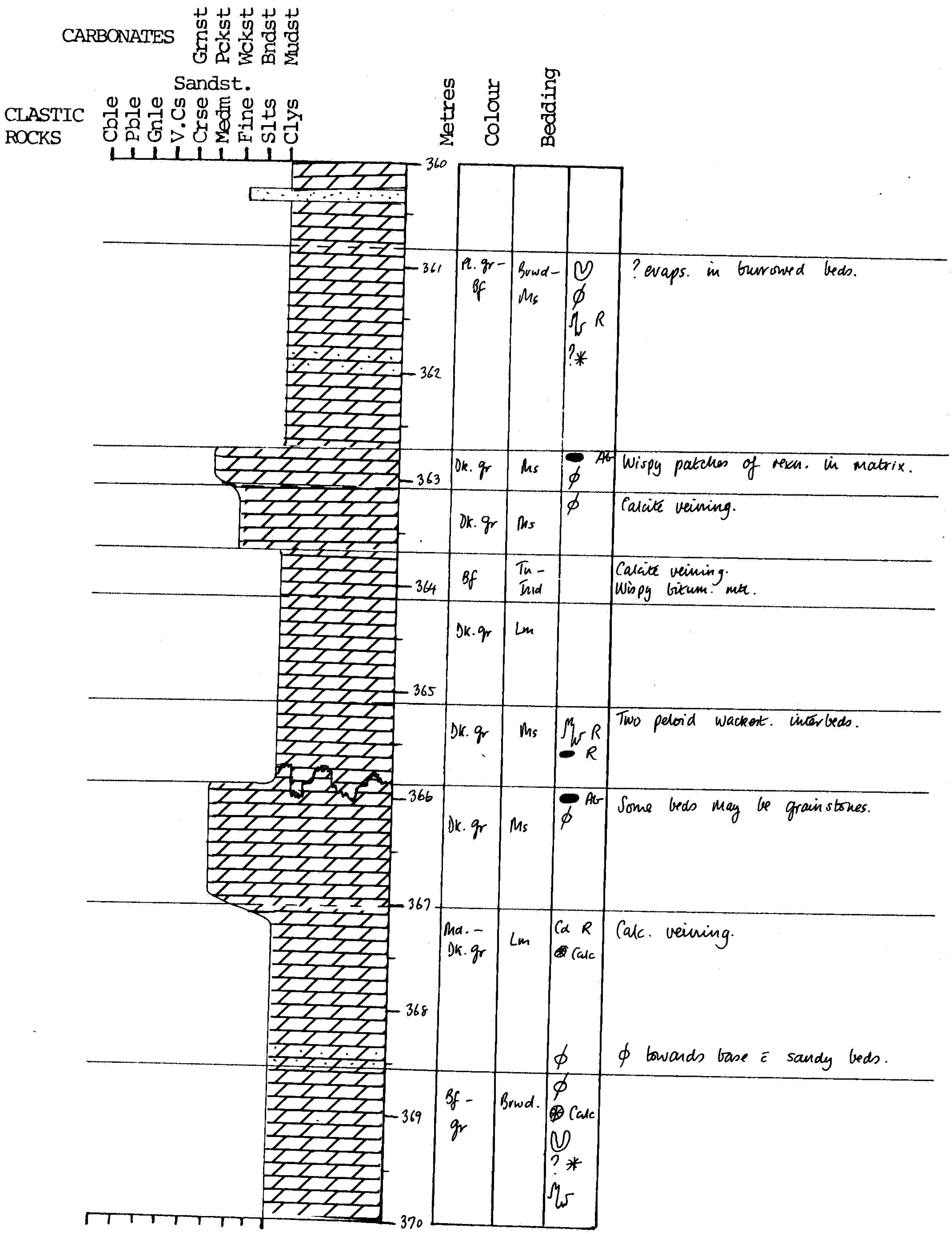

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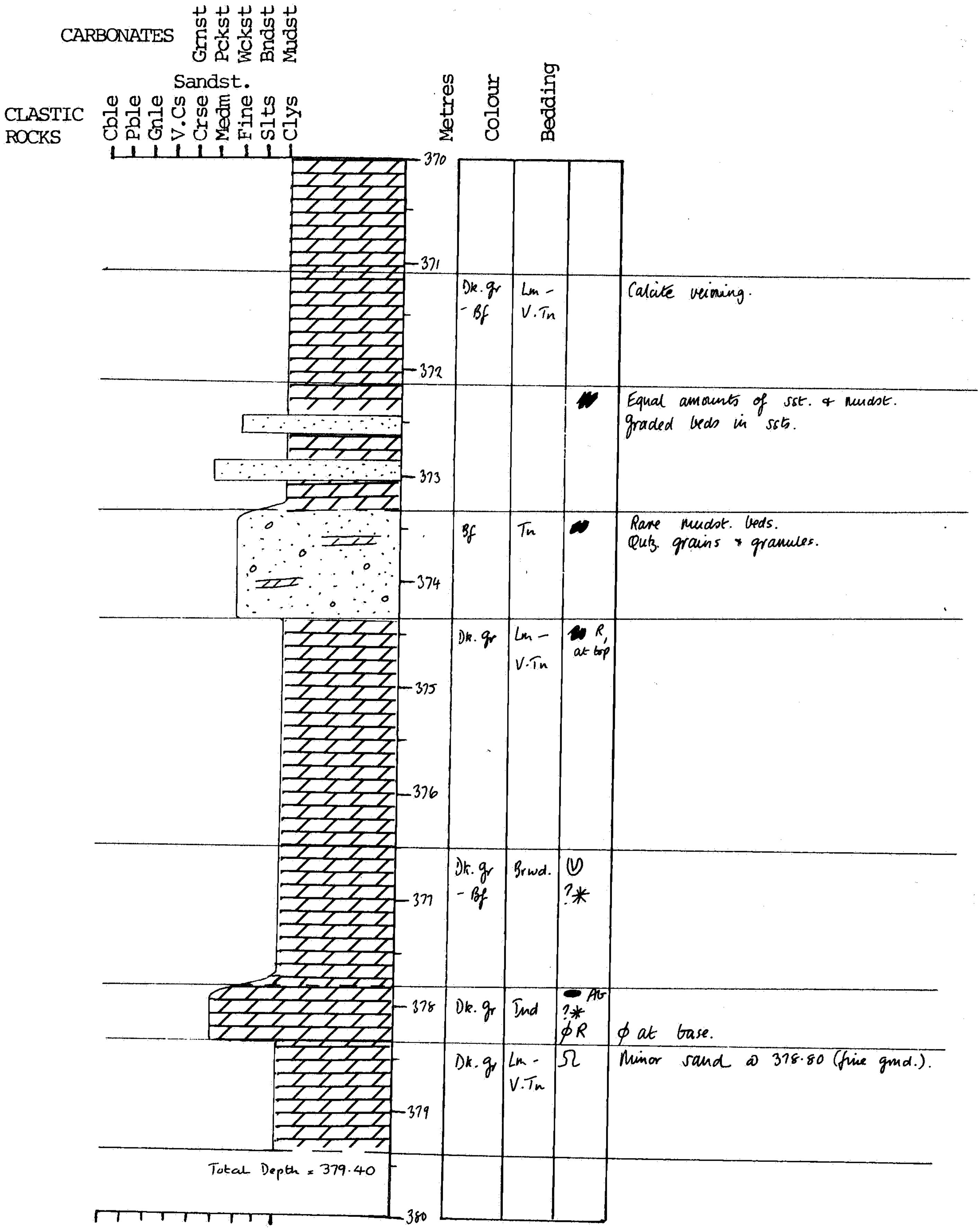

APPENDIX II

Identification of a Mineral at 179.80 m, Marla-1B

By

AMDEL

EXAMINATION OF GREENISH MATERIAL IN BORE CORE

1. INTRODUCTION

A piece of bore core from Marla 1-B (179.80 m) was submitted by Bridget Youngs of the South Australian Department of Mines & Energy. Abundant green-grey fine-grained material of clay-like appearance was to be identified.

2. PROCEDURE

An X-ray powder diffraction photograph was taken, and supplementary evidence was obtained from low-angle X-ray diffractometer traces of the material with and without treatment with glycerol.

3. RESULTS

The green material was found to be a mineral mixture. Dolomite was abundant, and the remainder of the material was a mixture of roughly equal amounts of three phyllosilicates, namely muscovite, chlorite and regularly-interstratified mixed-layer chlorite-montmorillonite.