

CONTINENTAL AND COASTAL PLAIN DEPOSITS OF THE UPPERMOST OLD RED SANDSTONE COMPLEX OF SOUTHERN IRELAND

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ABSTRACT

A description is given of an Old Red Sandstone sequence of Upper Devonian age occurring along the southcoast of Ireland. This sequence shows a gradual transition from continental deposits to overlying tidal marine sediments via a transition zone. The most characteristic changes occurring upward in the transition-zone between the underlying continental (interior alluvial plain) deposits and the marine tidal sediments are:

- 1) The increasing mineralogical maturity of the sandstones.
- 2) The appearance of "heterolithic beds".
- 3) The increasing frequency of occurrence of thick fluvialite sandstones.
- 4) The change in rock colours from reddish via greenish to greyish hues.

INTRODUCTION

A 605 metre thick succession of strata of the uppermost series of the Old Red Sandstone complex is exposed along the southern part of the east coast of Seven Heads peninsula in the south of Ireland (see fig. 1); deeper strata are not exposed here (see fig. 2). Stratigraphically this steeply dipping succession becomes gradually and uninterruptedly younger to the north (see fig. 2); accessibility is good.

To this series an Upper Devonian age is ascribed, based upon the determinations of a miospore assemblage (PL-zone, Clayton, et al., 1974) occurring 490 m above the starting point of the investigated section (see fig. 2).

In previous papers Naylor (1964, 1969) already briefly described these Old Red strata of the Seven Heads peninsula. The present author (1971) advocated that deposition of the lower part of the succession (Lower Subdivision of Kuipers, 1971) took place in fluvialite and lacustrine environments, and that of the upper part (Middle Subdivision of Kuipers, 1971) in a coastal plain environment. Furthermore he showed that the latter is conformably overlain by

tidal deposits, viz. beds characterized by diametrically opposed current-directions (Upper Subdivision of Kuipers, 1971).

The present paper pays particular attention to changes in rocktypes, sedimentary structures, and textural features, connected with the transition from continental to tidal deposition.

CLASSIFICATION OF ROCKTYPES

The present subdivision is based largely upon Leflef's classification (1973a table II, 1973b table II). The Old Red Sandstone succession studied by Leflef occurs 30 km ENE of the Seven Heads sequence (see fig. 1). Only three rockfacies, however, have been distinguished along the shore of the Seven Heads peninsula: Sandstone facies: S, Heterolithic facies: H, and Mudstone facies: M. The climbing-ripple cross-lamination structures of the Intermediate facies of Leflef (1973a, b) are not present here.²⁾

The subdivision of the three facies into rocktypes is based primarily on structural variations. The characteristic narrow relationship between sedimentary structures and grainsize of Leflef's (1973a) Churchbay and Templebreedy members is lacking.

The rocktypes described in the next paragraph will be indicated by standardized symbols as shown in figure 3.

Sandstone facies: S

Apart from compact sandstones without recognizable sedimentary structures, the sandstone facies is subdivided into four rocktypes (see fig. 3). These rocktypes vary in grainsize from medium-to very fine-grained sand. No rocks coarser than medium-grained sandstones are present in any appreciable amount, a phenomenon typical of the Old Red Sandstone deposits of South Co. Cork (presumably due to absence of coarser grains in the source area).

Rocktype S_{mg.cr.} (observed in medium-grained sands): Sandstones showing mega cross-stratification probably due to ripple-migration. Height of sets does not exceed 35 cm.

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²⁾ the present paper shows a restricted lateral extension of the Old Red Sandstone series described by Leflef (1973 a, b)

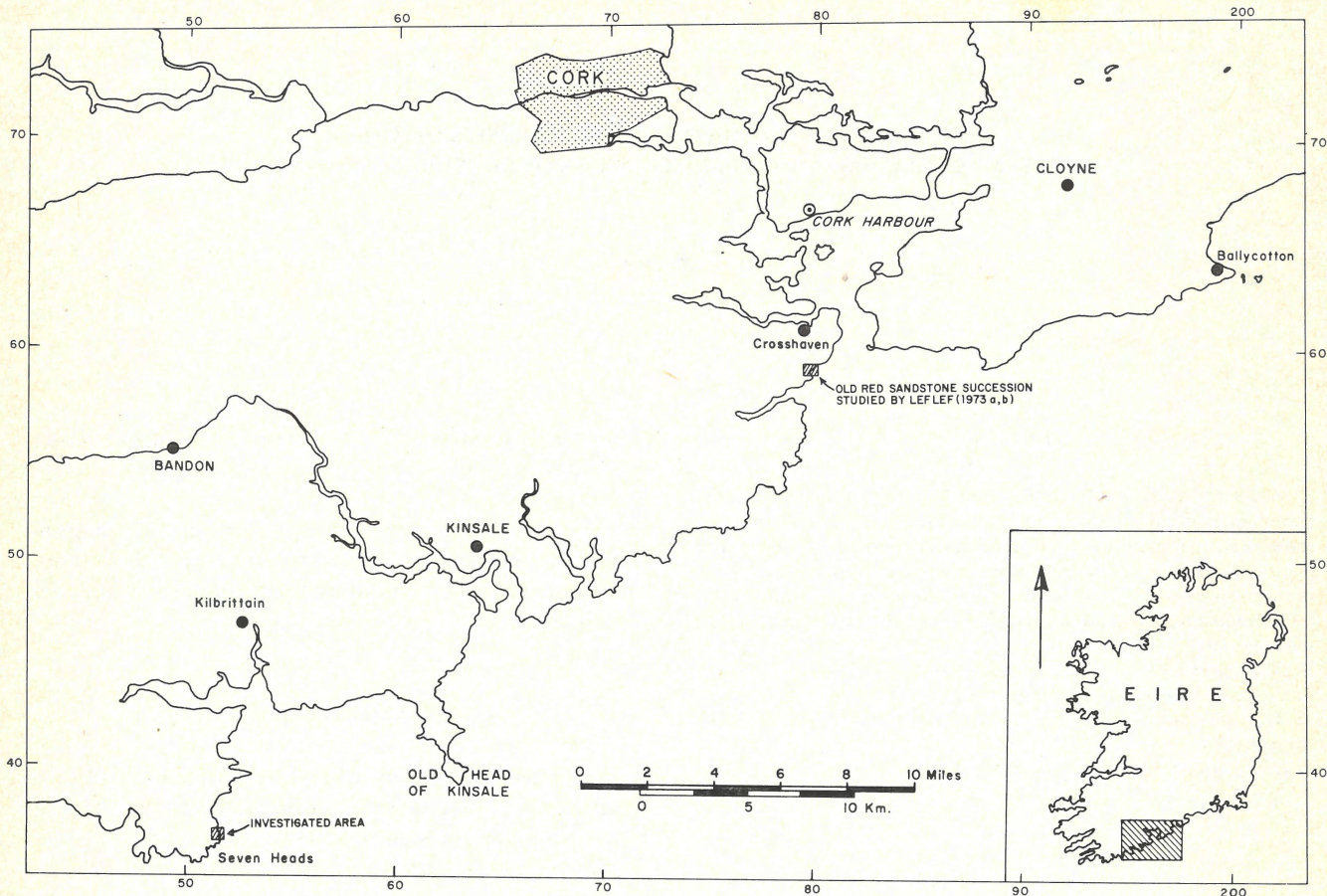


Fig. 1
Location map of Seven Heads peninsula (southern Ireland).

Cross-stratified sets consist at times of laminae dipping at a very low angle and thus merge into horizontal lamination. Corresponding features are described in detail by L e f l e f (1973a, photo 6 and 7).

Rocktype S.h. (observed in medium-grained, fine-, and very fine-grained sands): Horizontally laminated sandstones. The energy level prevailing during the deposition of the sand particles is in many cases uncertain. Information is obtained at some localities by means of grainsize determinations and also by means of the structural association between the horizontally laminated sandstone and the different types of cross-stratified sandstones.

Rocktype S.wa.cr. (observed in fine- and very fine-grained sands): Sandstones with wavering cross-lamination. L e f l e f (1973a, photo 8 and 9) describes this rocktype in detail. It represents a transitional rocktype occasionally formed during a passage from horizontal lamination to small-scale cross-lamination, which is presumably connected with a decrease in current strength.

Rocktype S.rip.cr. (observed in fine- and very fine-grained sands; infrequently in medium-grained sands): Sandstones showing small-scale cross-lamination caused by migrating ripple-sets, which are generally non-climbing or only slightly climbing (less than 5°). This cross-lamination maintains a unimodal character within individual sandstone beds; a SSE current-direction prevails throughout the succession (K u i j - p e r s, 1971).

Juxta- and superimposition of S.mg.cr. and S.h. occur throughout the investigated strata; the same holds true (see photo 1) for S.rip.cr. and S.h. (with or without a transitional S.wa.cr. structure).

In addition to the above four sandy rocktypes one composite rocktype (Sand/Mud) has been distinguished (see fig. 3) viz.:

Rocktype S.MI.: Sandstone (fine- and very fine-grained) with occasional mudstone laminae in the form of intercalations; the sandstones may show horizontal lamination, and wavering or small-scale cross-lamination. Rocktype S.MI.

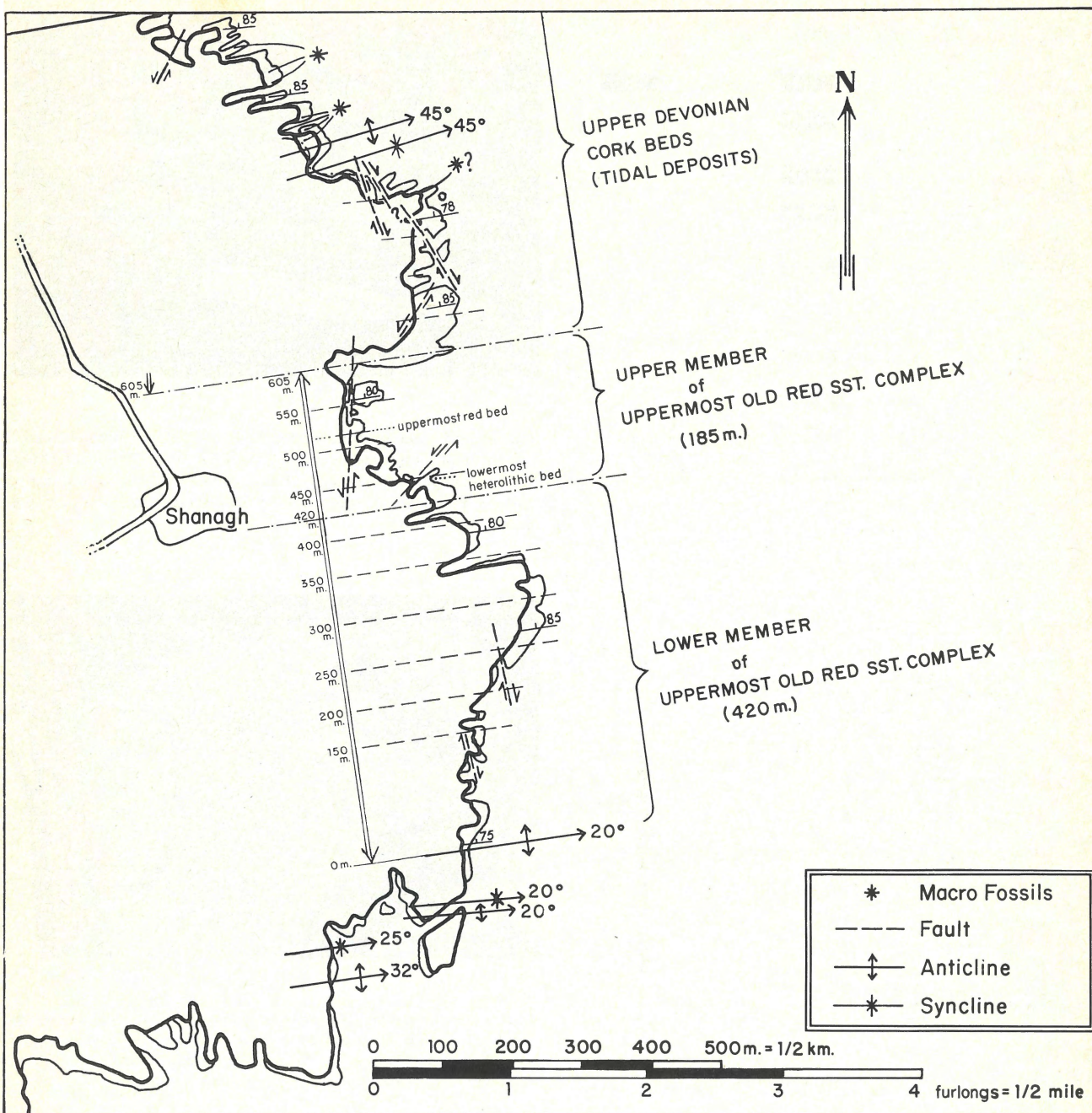


Fig. 2
Map of the investigated area showing stratigraphical metrage of beds (to facilitate location of photographs, figures, etc.) and general tectonics (partly after Naylor, 1964); displacement along faults less than 10 m.

occurs only in the upper part of the succession, and may pass into the heterolithic facies.

Heterolithic facies: H

The heterolithic facies is characterized by beds showing rapid alternations of mud and sand laminae (the latter are

here less than 1 cm thick); the mud-fraction dominates in the strata in question. Low-angular erosional contacts between groups of laminae are typical (K u i j p e r s, 1971, photo 3).

Two rocktypes can be distinguished from the shape of the sandy laminae:

Rocktype H.len.bed.: The sandy laminae have a locally

ROCK-FACIES	Rocktype (Abbr.)	SYMBOL of ROCKTYPE
MUDSTONE FACIES	M. non. lam.	with bioturbation
	M. lam.	
HETEROLITHIC FACIES	H. sand.lam.	
	H. len. bed	
COMPOSITE SANDST./MUDST. FACIES	S.M I.	
SANDSTONE FACIES	S.rip.cr.	
	S.wa.cr.	
	S.h.	
	S.mg.cr.	LOW-ANGULAR CROSS-STRAT.
	Structureless Sandstones	

Fig. 3 Classification of rocktypes (partly after Leflef, 1973a, b).

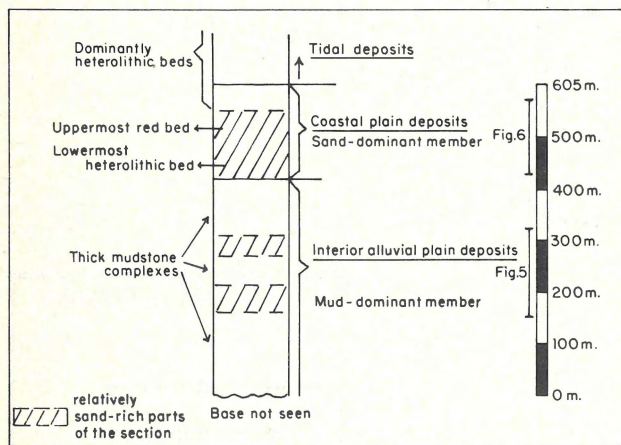


Fig. 4 Stratigraphic section showing main lithological features.

rippled surface with, when recognizable, current-generated internal foresetting in the ripples; unimodal foresetting alone is observed here (oppositely directed foresetting is used as a criterion of distinction between these beds and the overlying tidal deposits). H.len.bed. corresponds to one of the types of lenticular bedding of Reineck and Wunderlich (1968). It occurs only in the topmost 60 m of the investigated succession.

Rocktype H.sand.lam.: These sandy laminae occur as thin plates in mudstone (see photo 2). Rocks of this type are found in the uppermost 160 m of the succession.

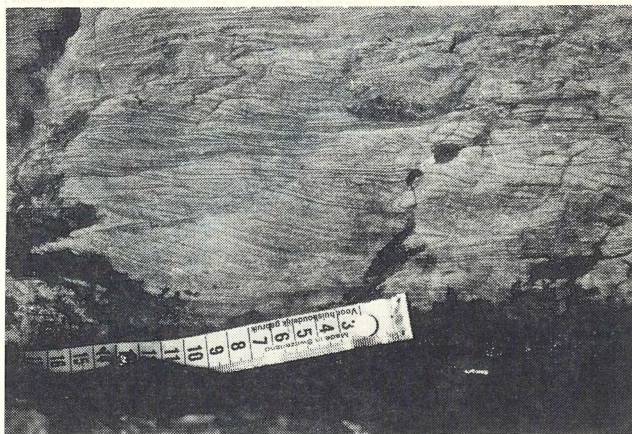


Photo 1 Fine-grained sand showing frequent juxta- and superimposition of current-ripples (here locally strongly climbing, an exceptional feature) and horizontal lamination without any recognizable systematic pattern. Photo taken from top Unit A of photo 3 at 170 m, looking north. Scale in cm.

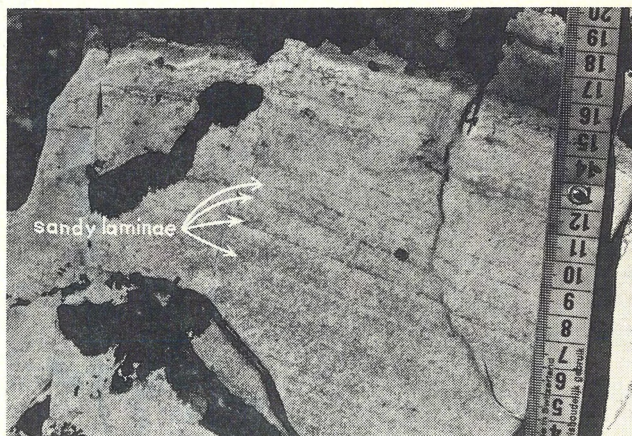


Photo 2 A two-dimensional view of sand-laminated mud. Perpendicular view is similar apart for disturbances due to cleavage. Preserved miospore assemblages are found in this rocktype. Photo taken at 490 m, looking north. Scale in cm.

Mudstone facies: M

The term “mudstone” is used for rocks consisting of clay- and siltgrade material. The mudstone complexes in our succession generally have a reddish colour; above level 420 m, however, green and (infrequently) grey mudstone occurs as well as reddish coloured varieties.

Two types of mudstone are distinguished:

Rocktype M.non.lam.: Unstratified mudstone with frequent traces of bioturbation. Fe-concretions occur occasionally.

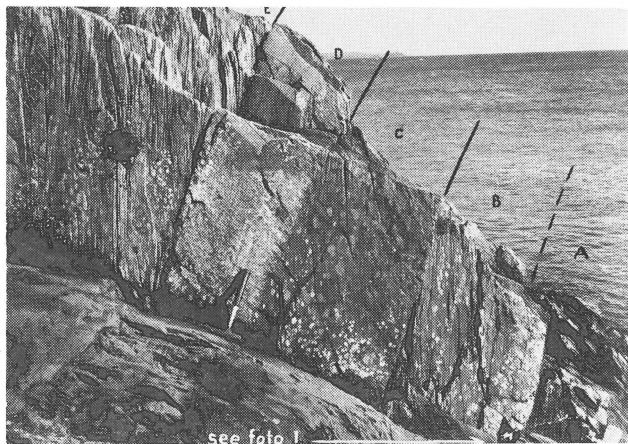


Photo 3
Rock sequence shown becomes younger to the left. The uppermost part of a thick scouring sandstone (A) which grades into mudstone (B) appears at the right side of the photo. Two sandstone intercalations (C and D) overly this mudstone bed. The sandstone indicated by C shows clearly a gradual upward curving of the cleavage planes, what is due to a gradual decrease in grain size. The overlying sandstone D has sharp lower as well as upper boundaries. Latter sandstone is overlain by a mudstone unit (E) with pronounced cleavage. Photo of rock interval 169-173 m looking east.

Rocktype M.lam.: Mudstone characterized by the occurrence of silty laminae (K u i j p e r s, 1971, photo 1). An increasing bioturbation in lateral and vertical directions destroys the laminae; the remaining rock shows up as a bioturbated mudstone with pockets of irregular lamination. This rocktype corresponds to L e f l e f 's E.hor. (1973a), and M₁-h (1973b), but not to his H₃.Si.lam. (1973b) which is not bioturbated.

LITHOLOGICAL DESCRIPTION OF THE SUCCESSION

The succession, which belongs to the uppermost Old Red Sandstone complex, has been subdivided into two units (see fig. 2 and fig. 4): a mud-dominant Lower Member (0-420 m = Lower Subdivision of K u i j p e r s, 1971) overlain by a sand-dominant Upper Member (420-605 m = Middle Subdivision of K u i j p e r s, 1971). Apart from the sand-content other important differences between these members are: that heterolithic beds are found only in the Upper Member, and that a gradual change from red-coloured rocks to greyish ones takes place, this again in the Upper Member.

The boundary between both members – which is gradational in character – is taken at the lowermost of a series of thick scouring sandstones, an easy marker in the field (K u i j p e r s, 1971). Heterolithic beds – the base of G a r d i n e r and H o r n e 's (1972) Coomhola formation – are first seen 25 m above this horizon; the uppermost red bed in the sequence appears 100 m above the base of the sandy Member (see fig. 2).

Representative parts of the mud-dominant and sand-dominant Members are shown in two logs (see fig. 5 and 6).

Mud-dominant Member (0-420 m)

Unstratified and generally bioturbated mudstone complexes of red colour strongly predominate; the thickness of such a complex can attain more than 100 m. Primary stratification (locally connected with wave-ripples) is rarely preserved in these mudstones.

Thin sandstone beds (generally less than 40 cm thick) occur as occasional intercalations in the mudstones. These sandstones have a sheet-like character. Their lower boundary is generally sharp without any appreciable scouring. They often pass gradually upward into finer-grained material; a gradual deflection of the cleavage planes locally betrays the FU-character of such beds. (Fining Upwards). The structure of these sandstones is S.rip.cr. occasionally merging into S.h.; S.mg.cr. (at level 365 m developing laterally from S.rip.cr.) occurs in exceptional cases at their base. Some of the sandstones are completely churned up.

Sandstone intercalations of comparable structure and texture, though often thicker, tend to be frequent in mudstone units occurring directly above the fine-grained top of a thick scouring sandstone (see photo 3, C and D); they are here locally associated with channelling (lenseform) sandstones (see fig. 5, 193-196 m).

Thick scouring sandstones of up to 3,5 m are present only in two separate and particular zones of the mud-dominant Member (see fig. 4) and here only in subordinant amounts (see fig. 5). An occasional mudstone band may occur within some of these sandstones. The log shown in figure 5 demonstrates the usual FU-character of the scouring sandstones (see photo 3, A and B) and also their sedimentary structures, – mainly S.h. which frequently passes into S.mg.cr. at the base of the sandstones, and into S.rip.cr. at their top.

The scouring sandstones and the thin zones of mudstone occurring at their base are often greenish. A similar phenomenon is described by F r i e n d (1966) from other occurrences of Old Red Sandstone complexes.

Sand-dominant Member (420-605 m)

Thick sandstone bodies with scouring bases form a major sequential feature particularly in the lowermost 150 m of this member. These sandstones are often of greater thicknesses (up to 12 m) than in the underlying member, but they have a comparable sequential and structural character. S.mg.cr. as well as unbedded compact sandstones are, however, more common here. The interesting structural association at level 434 m (see fig. 6) is due to descending tabular sets of mega-ripples forming the front of a giant ripple (sandwave) which is occasionally covered by descending laminae giving rise to a metre-size cross-stratification (latter type of accretion probably occurred during periods of high discharge).

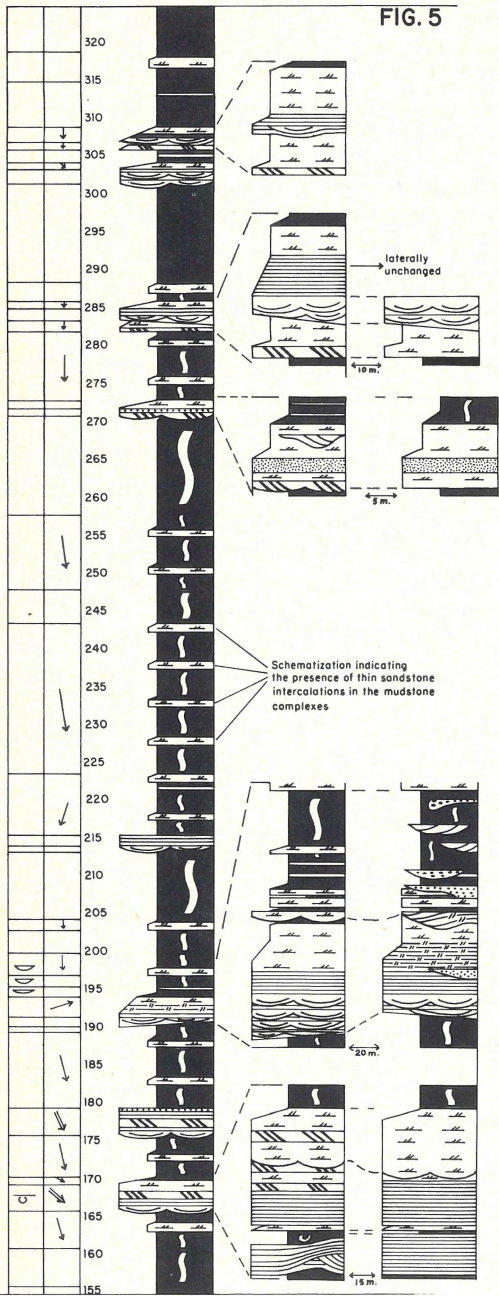


FIG. 5

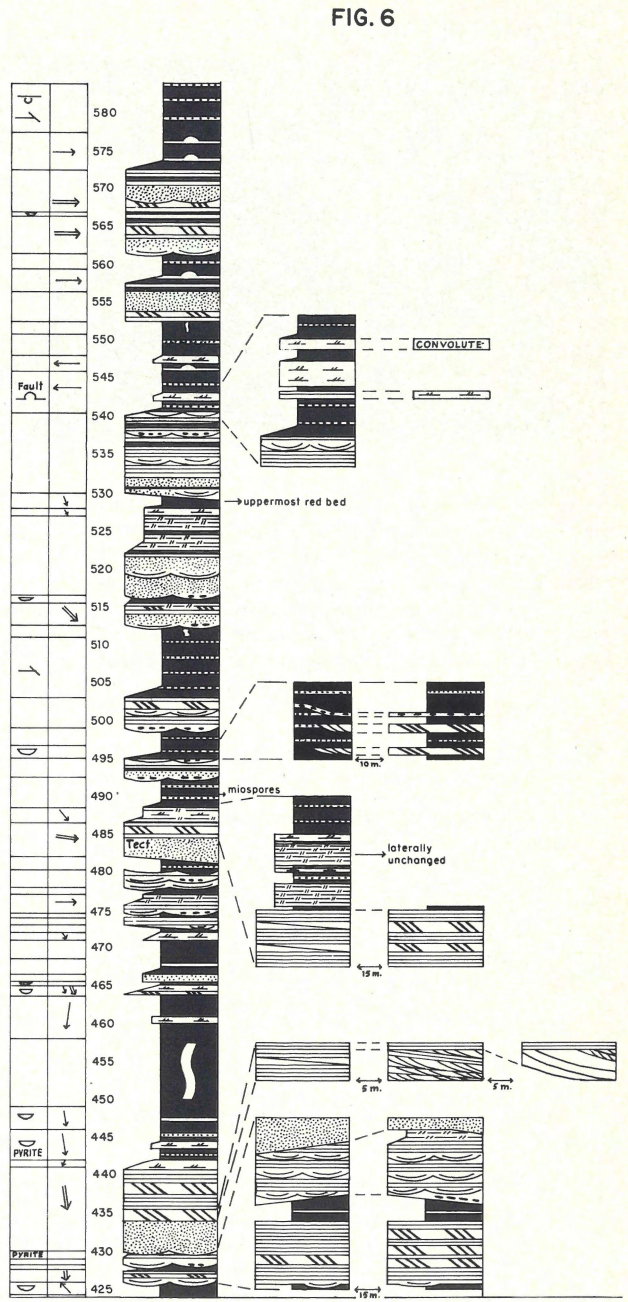


FIG. 6

ADDITIONAL LEGEND TO FIG. 5 AND FIG. 6

- ↓ CURRENT DIRECTIONS measured on small-scale foresets
- ⇓ CURRENT DIRECTIONS measured on large-scale foresets
- ⤿ SCOURING SURFACE

- DOWNCUTTING SURFACE
- - - SHALE FLAKES
- ⤿ SMALL CHANNELING SANDSTONE LENSES.

- ⊖ LOADCASTING / SANDBALL
- ⤿ CONVOLUTION / SLUMPING
- ↗ local EROSIONAL CONTACTS between groups of laminae of the heterolithic facies

Fig. 5
Log of rock interval 155 m-325 m (mud-dominant Member; see fig. 2 and 4 for location).

Fig. 6
Log of rock interval 424 m-584 m (sand-dominant Member; see fig. 2 and 4 for location).

Other characteristic phenomena of these sandstones are: their increasing mineralogical maturity upward through this member, and the repeated occurrence of mudstone bands in the topmost sandstones.

Mudstones become scarce, particularly higher up in the succession; this goes hand in hand with an increasing frequency of heterolithic beds. When comparing the FU-sequences of the Lower and Upper Member (see fig. 5 and 6) it appears that where we find heterolithic beds in the Upper Member, we find mudstone in the Lower. Heterolithic beds are predominant in the topmost 50 m, just as in the overlying tidal deposits (see fig. 4).

Sheet-like thin sandstone bodies and small channelling sandstone lenses occur, just as in the Lower Member, as intercalations in the mudstone; here, however, they occur additionally within heterolithic complexes. The preferential occurrence of these sandstone intercalations directly above the top of a scouring sandstone is more pronounced in the Upper Member. As to the structure of these intercalations, S.rip.cr. still dominates, but S.wa.cr. and S.h. are also frequently encountered. Moreover, a few medium-grained thin sandstone intercalations with S.mg.cr. and lag deposits also occur (see fig. 6, level 495 m).

As for colouring, greyish hues which appeared for the first time at the base of this member, gradually become prevalent upward in the sequence. The uppermost red bed is found 100 m above the base of this sandy unit (see fig. 2 and 4).

DEPOSITIONAL ENVIRONMENTS

Mud-dominant Member

The sedimentation characteristics of this unit clearly point to deposition under continental conditions without coastal influence. The scouring sandstones appear to be typical for deposition in fluvial streambeds (Allen, 1970). The streams in question must have been of small size and depth (max. 3-4 m). The predominance of horizontal lamination suggests that these streams had a low-sinuosity character (Allen, 1970); the frequently intricate occurrences of this horizontal lamination with either large-scale cross-stratification or small-scale cross-lamination points to turbulent, unsteady flow conditions.

Some of the streams might have had levees as suggested by local concentrations of sand influxes in mudstone close to the top of a FU-sequence starting with a scouring sandstone (see fig. 5). However, the frequency of isolated sandstone intercalations throughout the mudstone complexes points to a prevalence of unimpeded floodplain conditions.

Some undifferentiated mudstone complexes attain such a huge thickness (more than 100 m) that they presumably represent deposits formed in a persistent lacustrine interfluvial environment during the subsidence of the alluvial plain.

Sand-dominant Member

The scouring sandstones occurring in this member, though also of fluvial character, are slightly different from those of the Lower Member. The following points are noteworthy in this respect:

- a) The sandstones have a mineralogically mature character. This feature is understandable as having been caused by a more prolonged (downstream) transport.
- b) The fluvial sandstones of the Upper Member are thicker and contain more frequent S.mg.cr.. This suggests that the streams here were larger and deeper, and also that their sinuosity was more pronounced than in streams of the Lower Member.
- c) Sandwaves occur in streams of the Upper Member. This is assumed to indicate that the streams in question were broad and non-dissected (regular tabular sets, therefore presumably few disturbing effects from river walls) with relatively regular flow conditions. This indicates that the streams here had a more pronounced lower-reach character than those of the Lower Member.

Apart from these textural and structural differences between the sandstone bodies of both members, other lithological differences also point to an environmental change:

- a) The more frequent occurrence of sandstone intercalations in fine-grained beds directly above a FU-sequence starting with a thick scouring sandstone. This might suggest that levees play a more important part in the Upper Member than in the Lower Member, a feature which would tally well with conditions prevailing in the lower reaches of a river, where a more regular stream pattern is established.
- b) The first appearance and increasing quantity of heterolithic beds. This points to regular, small fluctuations of stream conditions (current-generated ripples) in the interfluvial areas. These fluctuations might have been caused in this instance by a tidal-induced damming-up of the water in the river stream beds, giving rise to overflow. The repeatedly occurring mudstone bands in the top sandstones of this member are further indications for this assumed damming-up. Convincing evidence for the presence of tidal action is found in the overlying sequence of rocks (Kuijpers, 1971, 1972). The aberrant E-W foreset-direction of current-ripples found in the top part of the Upper Member (see fig. 6) is in accordance with the foreset-directions found in the lower part of the tidal sequence (Kuijpers, 1972).
- c) The change in rock colours from red via green to grey hues. This feature is judged by many authors to be a characteristic phenomenon pointing to transition from continental to marine conditions.

On the strength of the above mentioned considerations the sand-dominant Upper Member is probably a "near-coast" (coastal plain) equivalent of the interior alluvial plain deposits observed in the mud-dominant Lower Member.

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