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TRANSITION FROM FLUVIATILE TO TIDAL-MARINE SEDIMENTS IN THE UPPER DEVONIAN OF SEVEN HEADS PENINSULA (SOUTH COUNTY CORK, IRELAND)

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ABSTRACT

Along the east coast of Seven Heads peninsula (southern Ireland) a more than 1000 m thick north dipping succession of Upper Devonian strata is investigated. The lithology and sedimentary structures of the facies types are described and briefly compared with recent sediments. They indicate a gradual transition from a continental "Old Red Sandstone" facies along a coastal plain facies into overlying (tidal) marine facies.

INTRODUCTION

The southeastern part of Seven Heads peninsula (southern Ireland) consists of relatively fine-grained Upper Devonian strata, forming a broad syncline (see fig. 1a and 1b): The Seven Heads bay syncline (N a y l o r, 1964; N a y l o r et al., 1969). Its southern flank is described in the present paper. The upper part of the strata belonging to the northern flank is dealt with in a separate paper by d e R a a f and B o e r s m a (1971). The beds belonging to the southern flank are almost entirely accessible and form a section comprising more than 1000 m of sediment, cut off near the synclinal axis by a fault of moderate importance (see fig. 1b). As has already been pointed out by Naylor the lower part of this section is of "Old Red Sandstone" facies, whereas the upper part belongs to the lower portion of his marine "Cork beds", namely the Old Head Sandstone Group. It is intended that the relationship between this study and the local litho-stratigraphy as outlined by Naylor (1964, 1969), Mac Carthy et al. (1971, in press) will be dealt with in detail in a subsequent publication. He mentioned furthermore that the top of the Old Head Sandstone Group exposed on the Old Head of Kinsale peninsula is not on outcrop on the east coast of Seven Heads peninsula. Naylor did not examine in detail the lithology and the sedimentary structures in this part of his large area of investigation. The present paper is a preliminary note on a part of a more extensive research work in the South Cork area (d e R a a f, 1970).

LITHOLOGY, SEDIMENTARY STRUCTURES AND PRESUMED ENVIRONMENTS OF DEPOSITION

GENERAL

The upward replacement of the Old Red Sandstone facies b y (tidal) marine beds occurs throughout a transitional unit. Therefore the succession of strata has been subdivided from bottom to top in 3 major facies types (see fig. 1b and fig. 2).

3. "Old Head Sandstone Group" facies (450 m): Upper subdivision.
2. Transitional facies (185 m): Middle subdivision.
1. Upper Old Red Sandstone facies (420 m): Lower subdivision.

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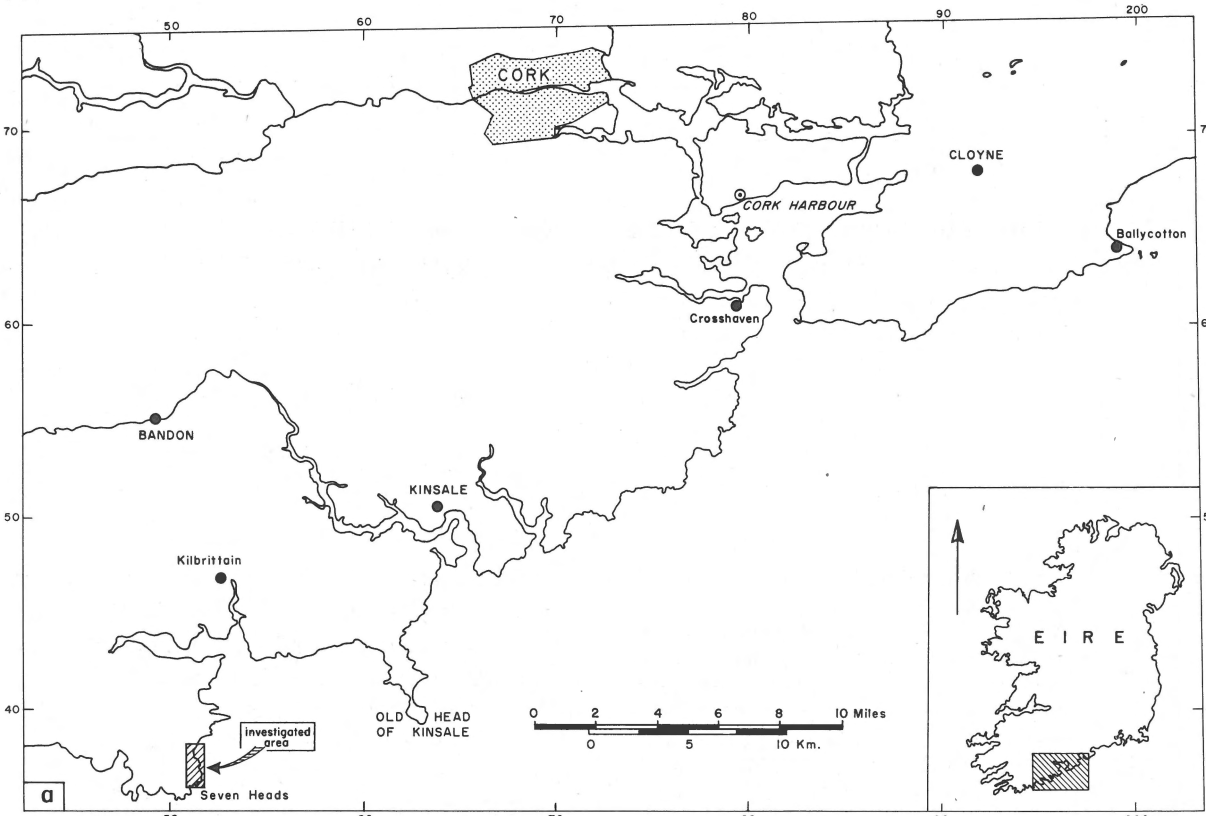

Fig. 1a
Location map.

DESCRIPTION AND ENVIRONMENTAL INTERPRETATION OF THE SUBDIVISIONS

1. *The lower subdivision (Upper Old Sandstone facies), 420 m thick.*

Description

Intensive cleavage usually hampers the analysis of the lithologic and sedimentary features of the lower subdivision, especially in deposits of a fine-grained character. Red shades are predominant; green shades, where present, chiefly occur in the coarser-grained parts.

The bulk of this subdivision consists of reddish

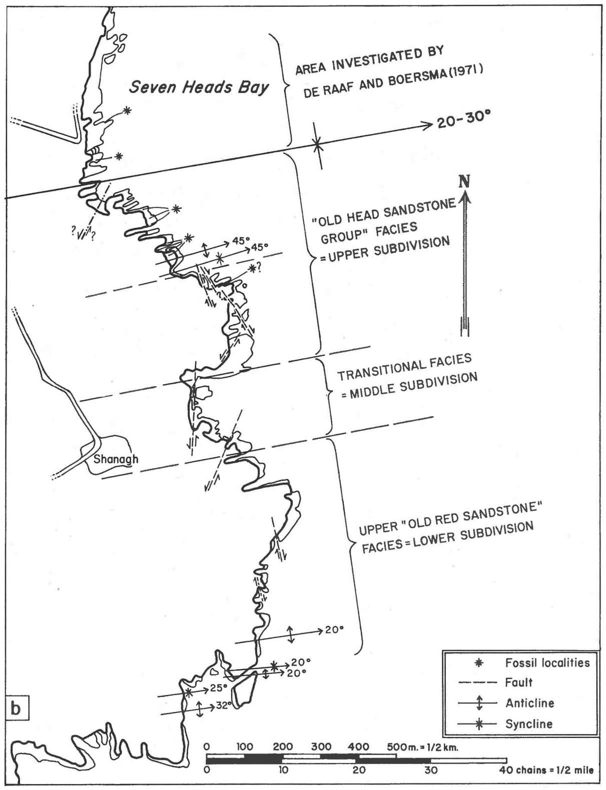

Fig. 1b
Map of the investigated area showing general tectonics and the distribution of main sedimentary complexes (partly after N a y l o r, 1964). Offset along faults do usually not exceed 10 m.

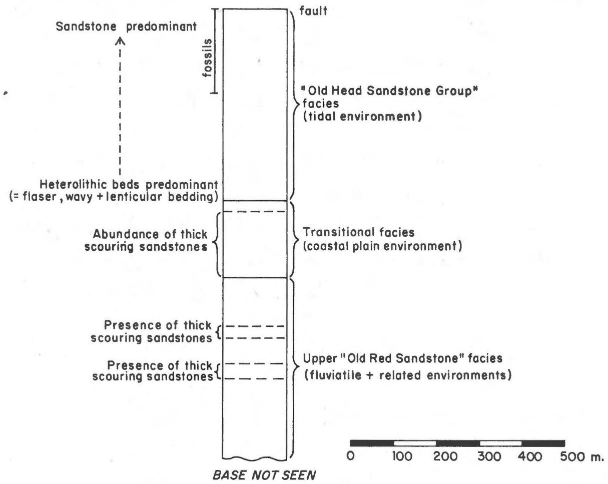

Fig. 2
Diagrammatic picture of the investigated Upper Devonian stratigraphical section.

mudrock (term. Ingram, 1953), which is mostly so strongly bioturbated that often only remnants of the original stratification are preserved (see photo 1). The latter show up as silty to sandy laminae in the mudrock or, exceptionally, as wave-built ripple surfaces.

The next important component consists of sandstones of a generally very fine grain-size, which are regularly intercalated in the mudrock. Their thickness usually varies from a few mm to 40 cm; occasionally beds of more than one metre thick occur. Because of the cleavage the quantitative importance of the thinner intercalations could not be ascertained. The bulk of these very fine-grained sandstones appear to be of a rather sheet-like character. Though their lower boundary is sharp, scouring features and lag deposits are rarely encountered. Generally these sandy units pass upward gradually into the overlying mudrock. Where their internal structures can be observed they show unidirectional, small-scale cross-lamination in places merging laterally and vertically into horizontal lamination. The cross-lamination generally shows a slightly climbing ripple pattern with here and there a preserved ripple stoss-side. Sporadically a single mega cross-stratified set occurs in these fine-grained sandstones.

The coarsest and generally thickest (up to $3\frac{1}{2}$ m) beds of the lower subdivision are represented by fine to medium-grained sandstones, which have been found only in a limited number in two zones (see fig. 2). Their lower boundary scours into the underlying beds. Locally some lag deposits were observed. The sandstones show either a sharp or a gradual upper boundary. In the latter case the fining upward goes with a vertical change in sedimentary structures as follows: In the lower, coarser part the sandstones, if not massive, show horizontal to slightly inclined bedding, which is repeatedly interrupted by irregular cross-stratified intervals connected with erosional truncation and scour and fill (Coleman and Gagliano, 1965). Cross-stratification due to ripple-migration is rare. The overlying fine-grained sandstones show horizontal lamination and especially towards the top unimodal small-scale cross-lamination, usually of a slightly climbing pattern. Here and there scouring sandstones are structurally more complex and show a repetition of the structural intervals mentioned above. The scouring sandstones are sometimes wedging out, which appears in some cases to be due to original depositional conditions, in other cases to tectonics.

Environmental interpretation

The scouring sandstone bodies are structurally and sequentionally very closely comparable to channel sediments of modern fluviatile streams as described by several authors (Allen, 1970a, p. 311). The predominance of even bedding over cross-stratified units built up by migrating ripples pleads for deposition in low-sinuosity streams (Allen, 1970a).

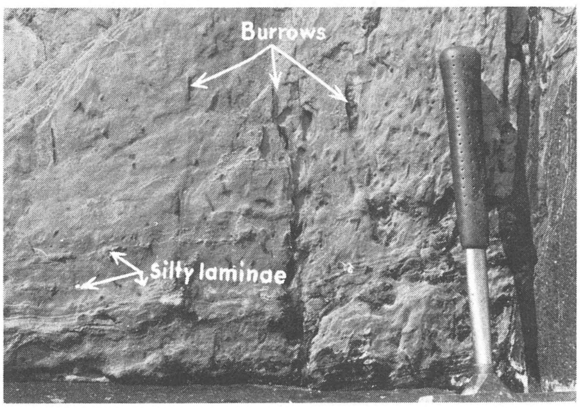

Photo 1
Red burrowed mud with remnants of the original stratification. Photo taken a few metres above the first scouring sandstone in the lower subdivision (see fig. 2), looking north.

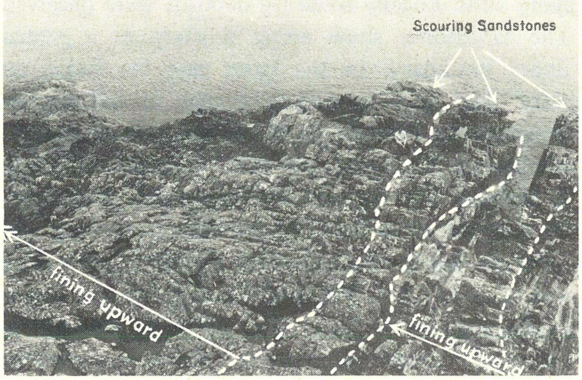

Photo 2
Thick scouring sandstones with a fining upward tendency. Photo taken of a section situated a few metres above the base of the upper subdivision, looking east.

As to the mudrock, when directly overlying the scouring sandstone units it may correspond with deposits present in alluvial floodplains (Allen, 1970a). However, the mudrock units of excessive thickness (more than 60 m, see fig. 2) suggest deposits in a more permanent and extensive alluvial basin. It is thought that these alluvial basins – and floodplains – are generally unimpeded, because of the regular occurrence of usually sheet-like sandstones, which probably are sudden influxes of coarser material in the mudrock.

2. *The middle subdivision (transitional facies), 185 m thick.*

Description

The lower boundary is taken at the occurrence of the first of a large number of scouring sandstones (see fig. 2). The top is formed by the base of the first bed showing "herringbone structures" (van Straaten, 1951); current ripples remain unidirectional in character throughout the middle subdivision.

Green and grey shades are here present in all types of lithology, whereas red and pale-purple shades only occur in strongly bioturbated mudrock in the lower part of this subdivision; the uppermost red bed was observed 50 m above its base and the uppermost pale-purple bed 70 m below its top.

The lithology is characterized by thick sandstones with scouring bases (see photo 2), which are on the whole slightly predominant in quantity compared with the mudrock. The granulometric, structural and sequentional aspects of these scouring sandstones are closely comparable to those of the scouring sandstones present in the lower subdivision: The only difference is their greater individual thickness (up to 12 m). Compared with the lower subdivision these scouring sandstones usually pass upward more gradually, and along silt-laminated sand with small scale cross-laminated intercalations, into mudrock with sandy and silty laminae, which locally display erosional truncations (see photo 3). Towards the top of the subdivision the sandy laminae are here and there replaced by sand lenticles with internal unidirectional cross-lamination. The mudrock is generally slightly bioturbated; however, minor intervals are churned especially where red and pale-purple shades are found.

Compared to the lower subdivision fewer minor sandstone bodies are intercalated in the fine-grained deposits; they comprise beds of a channel as well as of a sheet-like character. The lithologic aspect of this subdivision changes from bottom to top in the following way:

a. A gradual increase of the sand admixture in the mudrock takes place. This is manifested by a transition from mudrock with scattered intercalations of silty to sandy laminae to mudrock with regular intercalations of sandy laminae and sand lenticles.
b. A decreasing bioturbation was observed, which shows up as a gradual replacement of almost homogenized mudrock by less burrowed fine-grained deposits.
c. A gradual replacement from red to green, and from green to grey rocks takes place.
d. A relative decrease in thickness, number and scouring features of the sandstones characterizes the uppermost part of this subdivision.
e. Vertical and lateral transitions between rock types become more common towards the top layers of the middle subdivision.

Environmental interpretation

The scouring sandstones in this subdivision are similar to the scouring sandstones in the Upper Old Red Sandstone facies and are accordingly again interpreted as beds deposited by fluviatile streams of presumed low-sinuosity character. The thickness of some of the fining upward scouring sandstones points to distributaries with an important discharge, characteristic for the lower reaches of a fluvial system.

The finer grained deposits with occasionally intercalations of thin sandstone bodies are interpreted as stream topstrata, generally incorporating levees. The gradual upward change of the character of the sandstones, the mudrock, and the rock colours point to a modification in the depositional conditions similar to the Old Red Sandstone facies and suggest already the approach of a marine (tidal) environment (see upper subdivision), as will be shown in more detail in a later publication. On these considerations a coastal plain environment is assumed for this subdivision.

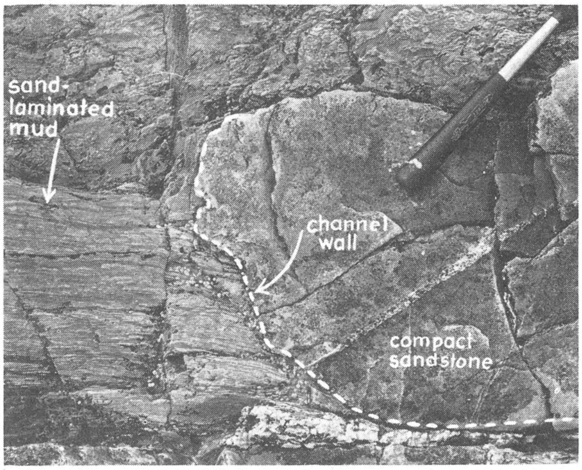

Photo 4
Detail of steep side of a small channelling sandstone lense. Photo taken just above the base of the upper subdivision, looking north.

3. *The upper subdivision (= Old Head Sandstone Group facies), 450 m thick.*

Description

As already mentioned by N a y l o r (1964; et al. 1969) the lower 270 m of this upper subdivision are closely comparable in lithology and sedimentary structures to the Breamrock formation of the Old Head of Kinsale (see fig. 1), which has been dealt with briefly in a previous paper by the author (K u i j p e r s, 1971). The upper 180 m correspond to Naylor's Holeopen formation, (highest formation in the Old Head Sandstone Group), which, as remarked previously, is not entirely exposed.

Photo 3
Sand/mud interlaminations displaying erosional truncations as locally present in this type of lithology. Photo taken in the top layers of the middle subdivision, looking north.

The bulk of the lower 270 m contains lenticular bedding, especially in the lower part associated with sand-laminated mudrock, wavy and flaser bedding (R e i n e c k & W u n d e r l i c h, 1968). These bedding types occur in alternation and form complexes of a varying sand/mud ratio, having the same charac ter as in the Breamrock formation on the Old Head of Kinsale (lithologic type 2 of K u i j p e r s, 1971). In these "heterolithic" beds current-ripple structures – usually of herringbone type – are a common feature; wave-built ripples were rarely observed. Locally thin-bedded sandstone intercalations – commonly horizontally laminated – occur. Minor intervals of fine-grained material are occasionally completely bioturbated especially in the lowest part of this subdivision.

Fine to medium-grained sandstones having a sharp base with little scouring or even none (lithologic type 1 of K u i j p e r s, 1971 are in places intercalated in the lower 270 m of this subdivision. Their upward junction to the mud-containing sediments is frequently sharp. In these sandstones horizontal lamination with slight bedding-plane divergencies is characteristic; also small-scale cross-lamination, usually of herringbone type, is common and is generally found more towards the top of these sandstones. To a less extent irregular cross-stratified intervals connected with erosional truncation and scour and fill were observed.

Throughout the lower 270 m of this succession small as well as large-scale occasionally strongly downcutting channels occur generally with a fine-grained infill. A few small channelling sandstone lenses with a steep side or even an overhanging one were observed near the base of this subdivision (see photo 4). Other structures present include slump structures, convolutions and load casts.

Poorly preserved casts of marine fossils (usually concentrated in wash-outs) are fairly common in the uppermost 180 m of the studied section. Together with the appearance of these fossils a few lithologic and structural changes were observed (see de Raaf and Boersma, 1971):

a. The series show a gradual increasing amount of sandstones (see fig. 2); here and there some of these sandstones are completely bioturbated. More often than in the lower part of the tidal succession the sandstones show a gradual upward junction to the heterolithic beds, which keep their same particular character; locally the mud-rich heterolithic beds are more common towards the top of a heterolithic sequence, thus yielding a type of fining upward cyclothem. Terwindt (1971) describes a comparable feature in subtidal channels in the southwestern Netherlands, when dealing with his litho-facies II.
b. It was often observed in the uppermost 200 m that the horizontally laminated sandstones with slight bedding-plane divergencies alternate laterally and vertically with mega cross-stratified sandstones with herringbone structures due to oppositely migrating mega-ripples (on an average 15 cm high), thus pointing to a higher streampower of the currents (Allen, 1970a).
c. Wave-built and interference ripples are common; they occur frequently in the top centimetres of sandstone beds internally built up by current-produced structures.

Environmental interpretation

These deposits are interpreted as tidal, just as the Breamrock formation of the Old Head of Kinsale (Kuijpers, 1971). The small channelling sandstone lenses with steep sides may have originated in an intertidal environment; however, real proof for intertidal sedimentation could not be found.

Häntzschel and Reineck (1968) mention that fossil concentrations in washouts as found in the uppermost 180 m of the sequence have so far been found only in shallow water.

Modern areas, as the delta of the Klang and Lancat (Coleman et al., 1970) and the lower deltaic plain of the Niger (Allen, 1970b) show, when going through an intertidal zone seaward into a subtidal zone, amongst other phenomena, an increasing sand content caused by a higher frequency of relatively more powerful tidal streams as well as by increasing wave-action. In this respect comparable features were observed upward in the ancient tidal succession, but differences, which probably are also due to dissimilarities in vegetation, remain between the modern and ancient depositional areas mentioned.

PALEO-CURRENT DIRECTIONS

Paleo-current directions were based on measurements of the foreset slopes of small-scale cross-laminated units. Measurements of the foreset slope of

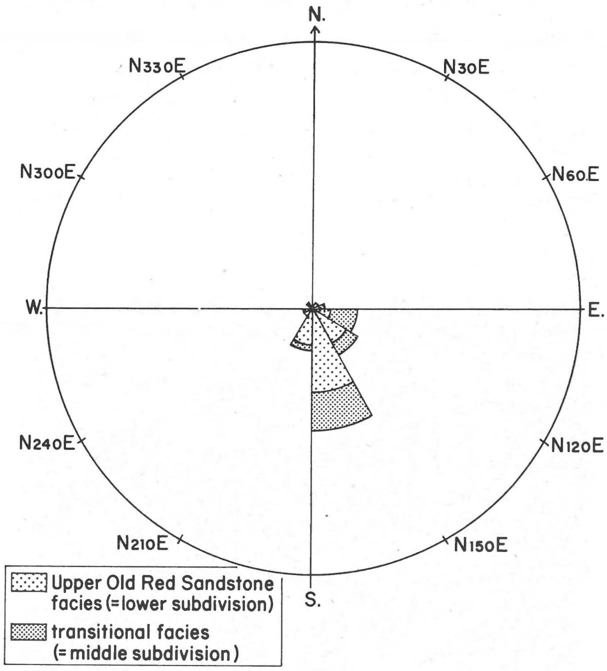

Fig. 3
Current rose based on 52 readings of foreset slopes of small-scale cross-laminated units occurring throughout the upper Old Red Sandstone facies and the transitional facies. Readings are plotted as current directions.

mega-ripple structures were taken too; their quantity, however, is small. The readings were made throughout the succession and, if possible, at regular distances.

The paleo-current directions prevailing in the Old Red Sandstone facies and the transitional facies suggest that the source area for this continental deposits had been situated in the north-northwest (see fig. 3).

Paleo-current directions based on measurements in the tidal facies of the Old Head Sandstone Group clearly show a bimodal current distribution (see fig. 4). North-northwesterly current directions (flood-currents?) and south-southeasterly current-directions (ebb-currents?) are a common feature especially in the lower 300 m of these tidal deposits. In the top of the sequence the current distribution has a more random character.

CONCLUSION

A gradual, vertical transition from strata formed in fluviatile and related environments along coastal-plain deposits to strata formed in a marine tidal environment was observed. The great thickness of these fluviatile, coastal plain and tidal strata occurring in superposition and the slow vertical transition between these environments suggest that the transgression took place in a basin, in which sedimentation almost kept place with subsidence.

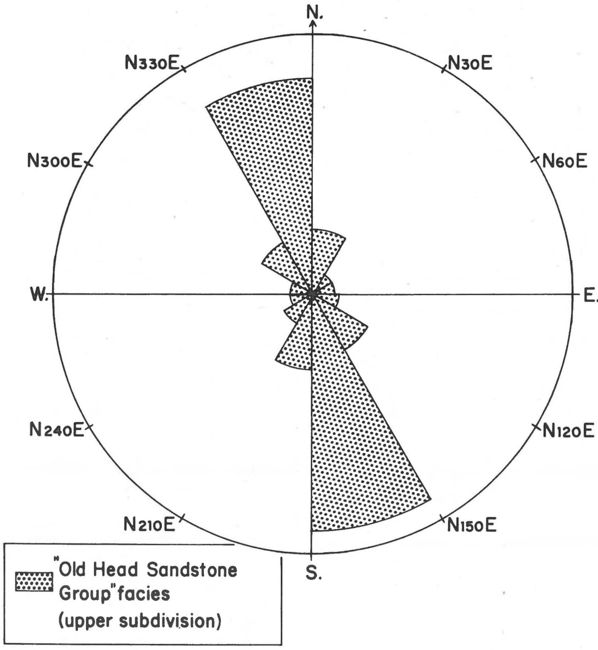

Fig. 4
Current rose based on 133 readings of foreset slopes of small-scale cross-laminated units occurring throughout the tidal facies of the Old Head Sandstone Group. Readings are plotted as current-directions.

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