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Application of a modified peel-section technique to the study of siliciclastic rocks

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Abstract

The acetate peel section technique has been successfully used to the study of carbonate rocks. It also appears as a very helpful tool to the study of well-cemented siliciclastics: fine internal sedimentary features and paleocurrent data have been revealed from a series previously considered as monotonous and poor in sedimentary structures.

Introduction

The Grés de Vireux Formation crops out in the Dinant synclinorium of the Ardenne Massif along the Meuse River (Beugnies et al. 1970). Its age is Lower Emsian, Lower Devonian. A study of the Vireux quarry has been undertaken in order to reconstruct the paleogeographical sedimentary conditions. This series constitutes sandstone – siltstone – claystone alternations and has been considered for a long time as very monotonous. A few sedimentary structures can be seen in the field but a very large number only appears after application of the peel-section technique. The formation is well cemented, well compacted and many of the beds are dark. There are not many grain size variations and detrital mica flakes are not abundant enough in the sediment to emphasize sedimentary structures. Under these conditions it is not possible to measure paleocurrents.

The acetate peel-section technique has been used here to try, show and record the textural details and associated sedimentary features. It has been prooved to be a very useful technique for the study of the paleocurrents on oriented samples as well. Although this technique has been commonly applied to limestones and dolomites, the aim of this paper is to present its application to the study of well cemented and well compacted siliciclastic rocks.

Description of the technique

A detailed description of the technique applied to the study of limestones and dolomites is given by McCrone (1965). To make that technique suitable for the study of well-cemented siliciclastic rocks it had to be modified. Especially the 2 minute hydrofluoric acid (HF) etching of polished surfaces destroyed the delicate textural details and had to be abandoned. Instead, excellent results can be obtained by repeated peeling as follows:

After well polishing rock sections, carefully rinsing and drying them, an acetate film is applied on the acetone-wetted polished surface. After one to two hours the film is taken off the polished surface. A very thin rock film is printed on the acetate film reproducing a faithful picture of the rock textures.

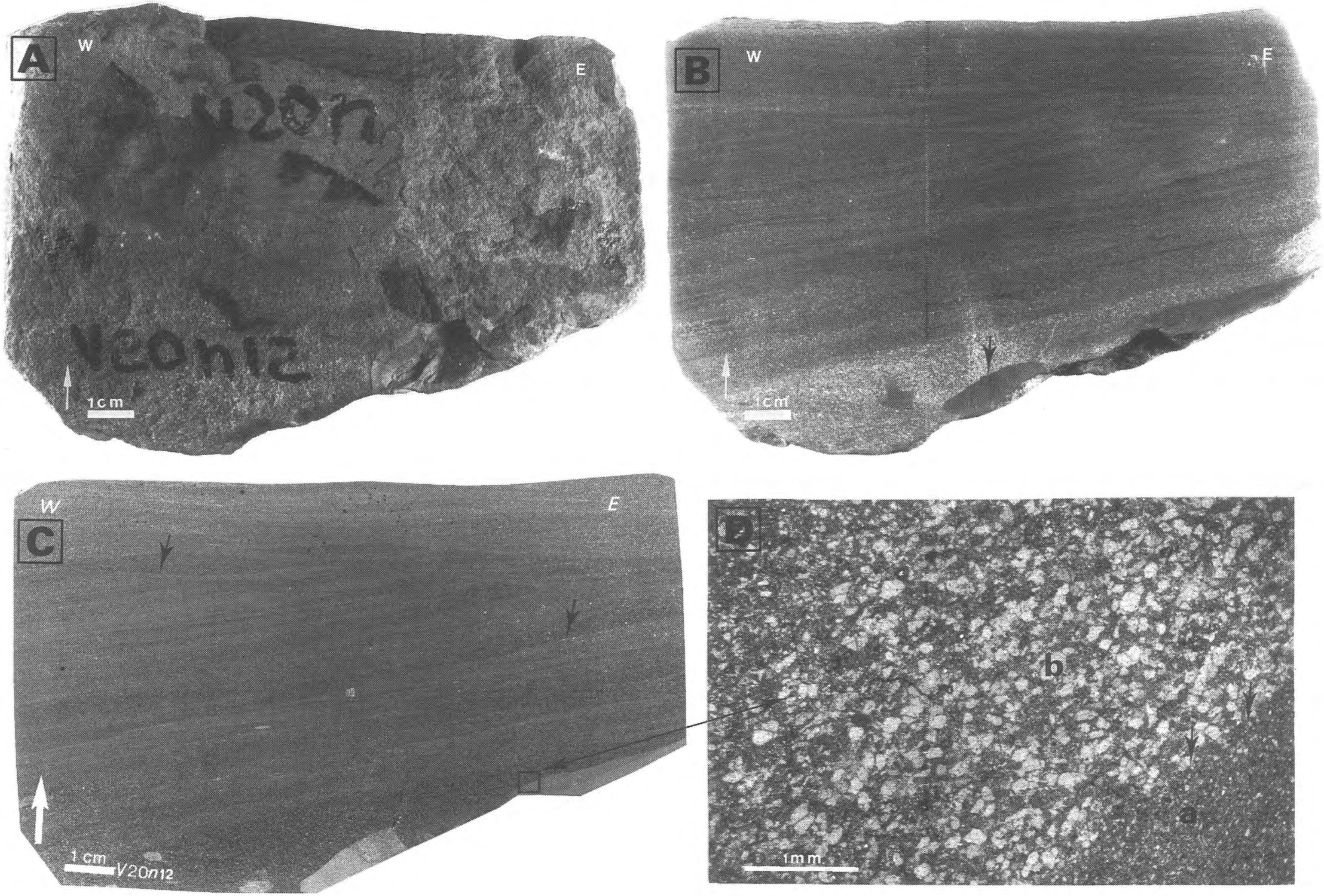

Fig. 1. Three stages of the technique used. Photo A shows an oriented hand specimen of the Grès de Vireux Formation as collected in the field. It represents a black medium sandstone with hardly distinguishable laminations. Photo B represents the same rock sample now cut and polished. Fine laminations, mud clasts (black arrow) and fining-upward of grains can be seen. The photo negative of a peel-print (photo C) shows delicate textural details of the sample. The fining-upward sequence is disturbed by erosional surfaces (black arrows). Fine laminations are always parallel to those surfaces. It may be part of hummocky cross-stratification on a larger scale. Photo D shows a microscopic view of the peel. Siltstone layer (a) is cut by the erosional surface (black arrow); graded, well-sorted, fining-upward sandstone grains (b) are deposited on top. White arrows show the normal vertical field orientation of the samples.

Removing the first film peels slight relief irregularities off the polished surface, which improves the effects of polishing. All subsequent peels reveal more delicate textural details although some contrast is lost. This loss can be overcome by mounting the peels between two glass plates to make a photo negative. Contrast is enhanced by making positive prints on high contrast paper. They are very useful in the microscopic studies for petrologic and textural investigations. The examples shown in this paper are obtained from the negative peel-prints. Sandstone layers, which are light in reality, appear dark on the illustrations, whereas clay layers, which are dark in reality, appear light.

Figure 1 records all stages of the technique. Photo A shows an orientated and numbered hand sample as taken in the field: very little information can be obtained from it; a slight fining-upward of grains as well as a vague lamination are seen. Photo B shows the rock section after polishing: a mud clast (black arrow), fining-upward of grains and occurence of fine cross-laminated sets are seen on this polished section. The negative peel-print (photo C) reveals all textural details. The general fining-upward of grains is not continuous. It is made up of elementary fining upward sets superimposed on each other with an upward increasingly finer material, thus giving a graded character. The top of each set is generaly sharp and sometimes erosive (black arrows). Fine laminae are parallel to those erosive surfaces. At a larger scale they are part of a hummocky cross stratification within a graded bed, a good indicator of storm events.

Peel sections can also be used for the study of sedimentary petrography and textural investigations under the microscope (photo D).

Application of the technique to the study of a lithological section

The peel-section thechnique was applied to the study of the 'Grès de Vireux' Formation of the Lower Emsian, Lower Devonian of Ardennes in the Vireux quarry section (Fig. 2A). It comprises sandstone – siltstone – claystone alternations which are poor, in the field, in visible sedimentary structures. Because of that, it has been considered for a long time as a very monotonous series. A recent study (Godefroid & Stainier 1988) has come to the same conclusion. In Fig. 2A the lithological log of the section is shown along with the sedimentary structures revealed by the peels. Fig. 2B shows the same lithological section published by Godefroid & Stainier (1988). The two logs are represented here at the same scale. Our aim in comparing them is to show the valuable improvements that can be obtained by applying the peel-section technique (left column).

The numbered beds of the log B were identified in the field and so a bed-by-bed correlation of the two logs has been possible. The thick sandstone beds are considered as massive and no sedimentary features are given in the log B. Peels reveal a parallel lamination in these light medium to coarse grained sandstone beds. They form either progradational prisms or swash cross-stratification, which have large dimensions (tens of metres) and are well exposed in the field.

The fine sandstones and siltstones are darker and rich in fine sedimentary structures. They show cross-laminations which are only rarely observed in the field as shown in the log B. In peel-sections we can see all textural details such as wave ripples or current ripples (Fig. 3e, g, i). Three dimensional precise measurements of current directions and ripple indices can be done on peels and so their wave or current origin can be determined.

Sandstone – claystone alternations in wavy beds or in flaser beds can be seen only in peel-sections (Fig. 3a, e, g). In the field they are very difficult to see because they show a homogeneous massive aspect without any structure.

More difficult to observe in the field are siltstone and claystone beds. They are very dark and do not show any sedimentary structure as seen in the log B (beds number 2, 16, 51, 58, 75 etc). These structures are revealed in peel-sections only. In these beds we find storm graded layers (SGL) (Fig. 3b) and clays with fine laminations, rich in bioturbation (condensed sections) (Fig. 3d). The furrows are filled with siltstones in micro hummocky cross-stratifications (HCS). In other places mud cracks are observed (Fig. 3c). Again, they are not shown in the log B because it is very difficult, even impossible, to see them in the field. They are, however, abundant in the log A as revealed by peels.

Examples of lithological and sedimentary structures of the Vireux section

Figure 3a shows sandstones and clays in continuously alternating layers forming slight wavy beds (after Reineck & Singh 1980). The clay layers are heavily bioturbated as indicated by horizontal burrows (black arrows).

Graded beds are often observed (Fig. 3b) made up generally of fining-upward layers, about 1 to 3 cm thick. They are constituted of horizontal plane parallele laminations (a) at the base and of current riples (b) at their top. Sharp and erosive surfaces (black arrows) cut off these graded layers and give them a discontinuous character. They are the result of the addition of successive increments of material each of which containing one less coarse grade (Reineck & Singh 1980). They are interpreted as storm generated events (Guillocheau & Hoffert 1988).

Figure 3c shows a section of mud crack structures. Thin mud laminae are dried and have curved concave upward sections (black arrows). In plan view they form a network of polygons. The space between polygons is filled with sandy material. Sometimes fine laminated clay layers are disturbed by vertical (Fig. 3d, black arrow) or horizontal burrows.

In other parts of the geological section wavy and flaser beds are observed. Mud and sand layers alternate and form continuous layers (Fig. 3e, g). Sandy layers show wave-related cross-lamination; they can sometimes be identified as subcritical to critical cross-laminations of climbing ripples (c). Two opposing paleocurrent directions can be identified. The mud layers follow the concavity and the convexity of the underlying ripple surface (b). In contrast to sandy layers which are deposited during current and-or wave action, mud layers require slack water conditions. They are highly bioturbated and exhibit horizontal burrows (d).

Mud clasts within a graded bedding texture (Fig. 3f) and a sharp erosional top surface (black arrows) showing evidence of storm deposits are alternated with wavy and flaser beds. Mud clasts and mud pebbles (Fig. 3h) are seen at the bottom of a channel. Underlying beds consist of fine cross laminated sandstones (Fig. 3i).

Discussion

The acetate peeling technique has proved to be very useful in the study of the sedimentary features and the determination of paleocurrent directions of siliciclastic series. Without this technique the study would have been either impossible or much more expensive. Furthermore it has been possible to reveal the finest textural details in studied samples.

The technique has been applied to samples with alternating lithologies (e.g. clay and sandstone) (photos a, c, e, f, g, h, Fig. 3) as well as to lithologically uniform samples (photos b, d, i, Fig. 3). In the first case the lithological contrast puts fine tex-

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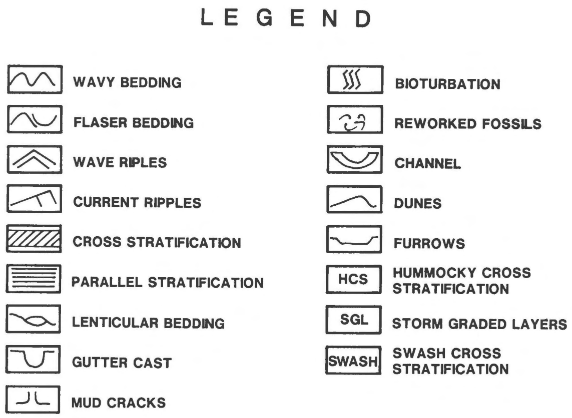
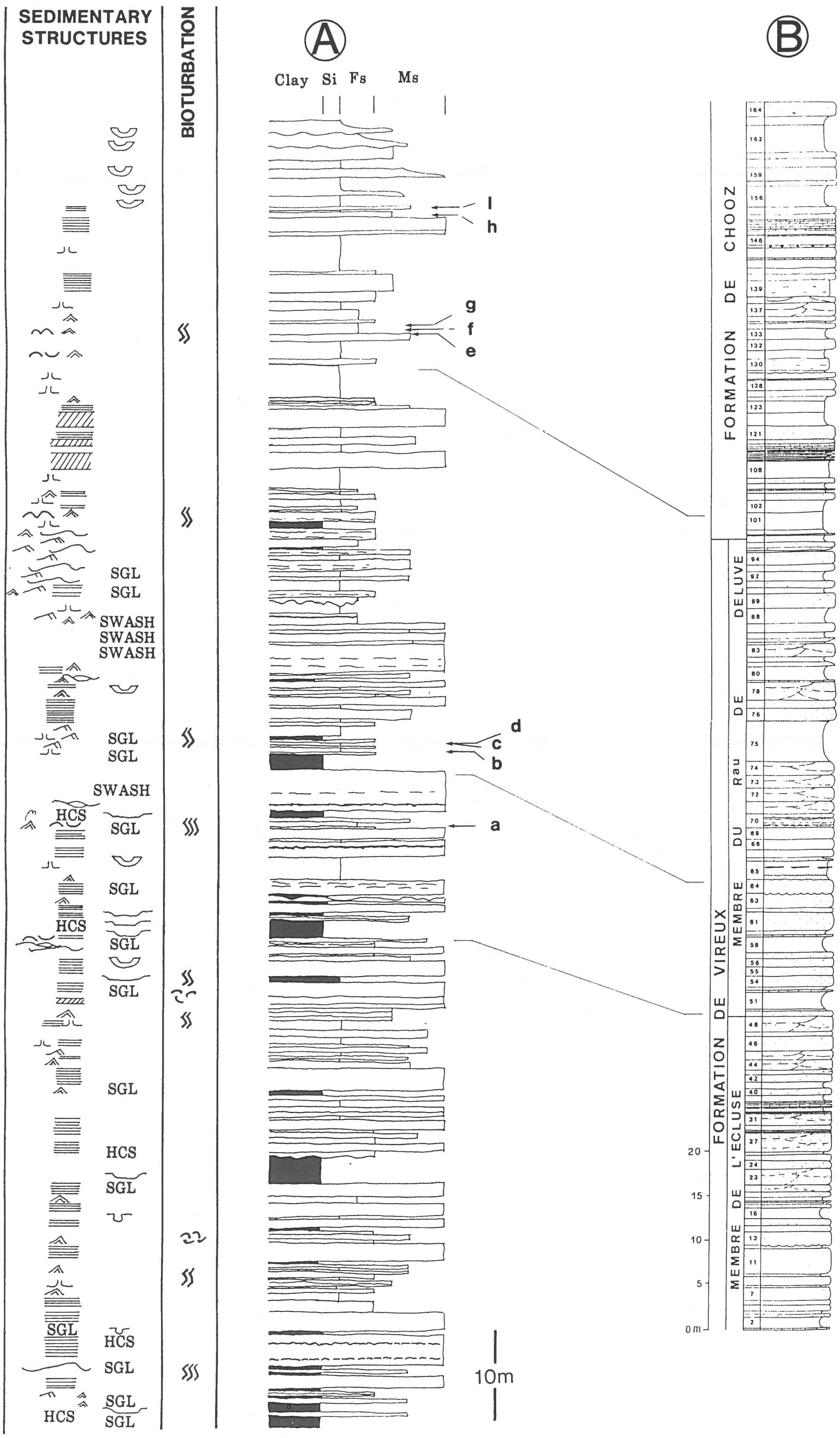
Fig. 2. A – The lithological log of the studied geological section in the Vireux quarry. The position of oriented hand specimens collected in the field is shown by arrows. Letters correspond to photographs of Fig. 3. It has been possible to complete the final log after application of the peeling technique on the field samples in the laboratory. B – The same geological section studied by Godefroid & Stainier (1988). The two logs are correlated in the field. The quantity of sedimentological information in the log A is greater than that of the log B thanks to the application of the peel-section technique. Abreviations used: Si – siltstone, Fs – fine sandstone, Ms – medium sandstone.

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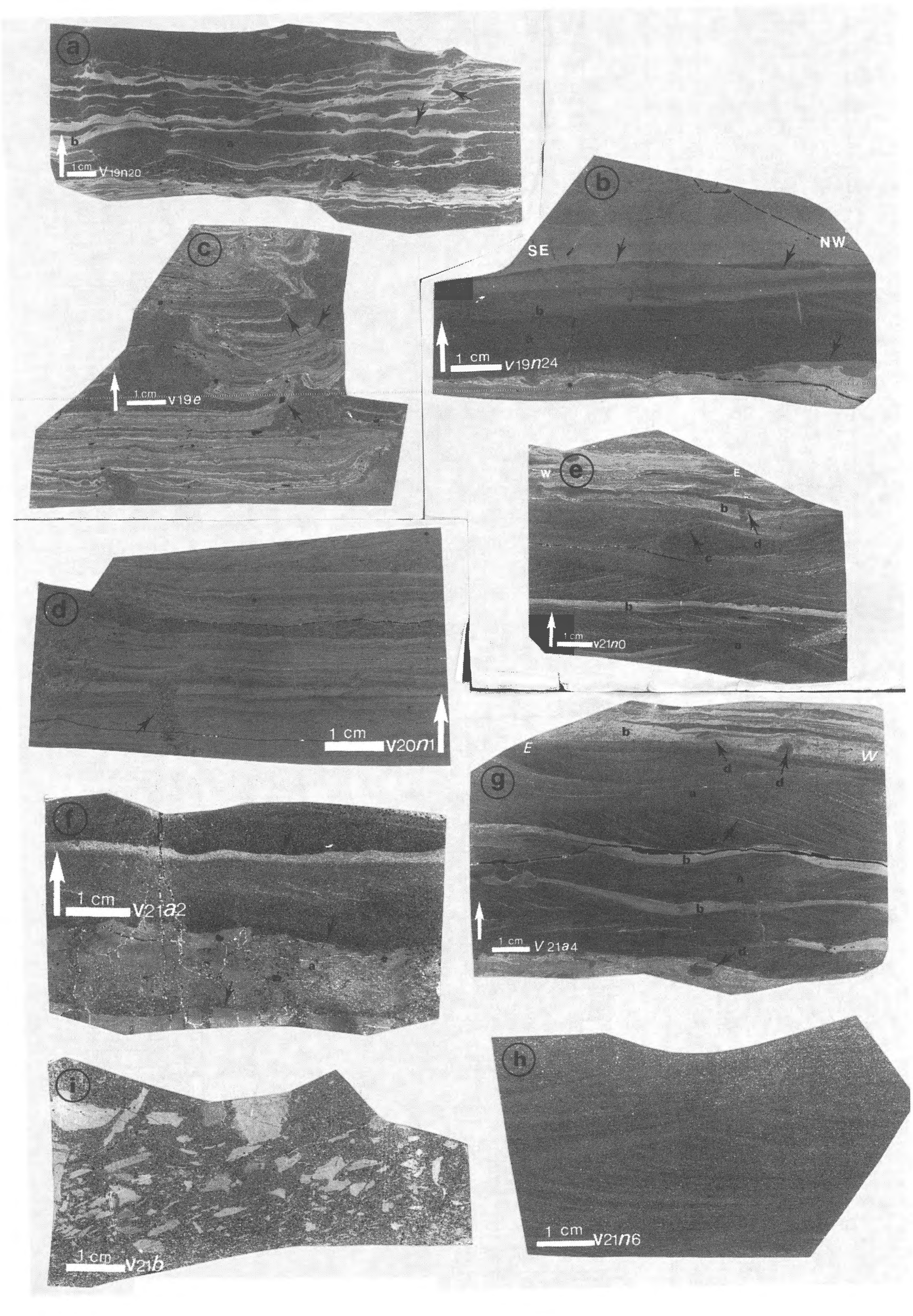
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tural features in evidence. Lithologically uniform samples are also of uniform grain size, so their internal structure can be observed only thanks to different mineralogical constituents of the rock (e.g. quartz grains and rock fragments) in the case of sandstones and parallel orientation of argillaceous minerals in claystones. The results obtained are good enough in the case of lithologically uniform samples as well as in the case of lithologically heterogeneous samples.

The peel-section technique has been applied also on metamorphic and igneous rocks and the results are very encouraging.

Conclusion

A modified acetate peeling technique appears to be a very useful method for studying ancient siliciclastic deposits. Well cemented and poorly exposed deposits have revealed their internal delicate textural details in the laboratory thanks to this technique. The results obtained are independent of grain size and the lithological variation puts fine textural details in evidence. Furthermore, the technique is very useful to draw out paleocurrent data. Peel-sections are used for petrological studies under the microscope.

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Fig. 3. Photo negatives of peel-prints. Examples are chosen to represent the lithological and sedimentary strucural variability of the geological section (Fig. 2A). Black encircled letters in the top left hand side of the photographs correspond to the position of samples on the log, as shown by arrows in Fig. 2 A. White arrows show the normal vertical field orientation of the samples.

a Sandy layers (a) alternating with clays (b) are arranged in wavy beds indicating alternating high energy and slack water periods. Clay layers are rich in horizontal burrows (black arrows).

b Storm graded layers with erosive surfaces (black arrows).

c Mud-cracks in section. Mud layers are concave upward (black arrows).

d Clay layers with fine laminations and a vertical burrow (black arrow).

e, g Sandstone (a) and clay (b) layers organised in wavy beds. Wave-induced cross laminated sandstones sometimes show a climbing ripple structure (c). Clay layes are rich in horizontal burrows (d).

f Mud clasts (a), erosive surfaces (arrows) and a graded texture characterize this sample.

i Mud clasts at the channel base.

h Cross laminated sandstone in evidence of a high energy depositional environment.

Lithologically homogeneous and heterogeneous samples show the same resolving power with the technique (see discussion in the text).