Clastic Limestone in the Upper Eagle Ford Shale, Dallas County, Texas

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ABSTRACT

Flaggy strata of marine clastic limestone occur in the Eagle Ford shale at a horizon approximately 100 feet below the top of that formation in Dallas County. Anticipating the possible significance of these strata as marker beds useful in correlating the type section of the Eagle Ford here with sections exposed in other areas, a detailed description of them is given.

The limestone is made predominantly (85 to 89 per cent) of angular grains of calcite derived from the prismatic layers of pelecypod shells. In addition there are minor amounts of biotite, collophane, quartz, and lignitic material. These detrital constituents were brought to the site of deposition by submarine currents which moved in directions varying between northeast and northwest, as indicated by the configuration of current ripple marks.

While deposition was in progress the detrital, calcitic substratum was occupied by benthonic animals of unknown identity, whose burrows and trails remain as conspicuous markings on the upper and under surfaces of the beds.

Contacts of the limestone with clayey shales characteristic of the Eagle Ford are sharp but conformable. Field evidence suggests that the flaggy beds represent a level at which a profile of equilibrium was briefly attained but not long maintained along the bottoms of the Eagle Ford seas.

Introduction

During the long drought of 1951 most of the smaller streams of Dallas County disappeared, and the waters of perennial streams dropped to unusually low levels. At the locality which may be reached by following the below given itinerary, a ledge of flaggy limestone within the Eagle Ford shale (Upper Cretaceous) was laid bare as the Trinity River shrank.

Itinerary

<table>
<thead>
<tr>
<th>Miles Between points</th>
<th>Cumulative</th>
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<tbody>
<tr>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>1.1</td>
<td>1.8</td>
</tr>
<tr>
<td>1.0</td>
<td>2.8</td>
</tr>
<tr>
<td>2.0</td>
<td>4.8</td>
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<tr>
<td>0.5</td>
<td>7.0</td>
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<tr>
<td>0.1</td>
<td>7.1</td>
</tr>
</tbody>
</table>

Corner of Daniels and Hillcrest streets, one block west of Fonfren Science Building, Southern Methodist University. Go south on Hillcrest.

Turn right on Mockingbird Lane.

Cross Preston Road; continue on Mockingbird Lane.

Turn left on Inwood Road.

Cross Harry Hines Boulevard, still on Inwood Road.

Cross Irving Boulevard; continue on Inwood Road.

Approaching Inwood Viaduct; turn right on narrow road.

Trinity River levee; turn left on unpaved road.

Turn left towards viaduct.

Stop car; walk to right 125 feet to Trinity River.

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Fig. 1. Geologic map of flaggy limestone bed.
This limestone has long been known to geologists. Moreman included it in the basal portion of his Arcadia Park formation, the uppermost of three units into which he divided the Eagle Ford group (See Adkins, 1932, pp. 425-426). Williamson (1950, p. 11) reported that at the town of Arcadia Park this stratum measures one foot thick and occurs 99 feet below the contact between the Eagle Ford shale and the Austin chalk. Turner (1951, Pl. 1) mapped scatteredcroppings in the area north of Arcadia Park, and Cheatham (1951) traced the unit to near the southern line of Dallas County. At least locally, therefore, this thin but conspicuous unit is useful in stratigraphic and structural studies of the Eagle Ford shale. Conceivably it may connect southward with one of the flaggy beds in the shale of McLennan and Travis counties as described by Adkins & Lozo (1951, p. 112), but this cannot be known until areal studies have been extended southward from Dallas County.

Although frequent reference has been made to the flagstone, it has never been adequately described, nor has the problem of its origin been carefully considered. Probably this neglect has been due in part to the insignificant thickness of the unit, and in part to the fact that it is generally but poorly exposed as cross-sections along the sides of streams and road cuts or as slumped blocks and float along hill slopes. At Inwood Viaduct, however, the stratum not only shows in section but also as freshly washed dip slopes extending 1200 feet along the river (Fig. 1). Here on the bedding

![Diagram](attachment:image1.png)

**Fig. 2.** Columnar section of the Eagle Ford shale with interbedded flaggy limestone. Beds No. 1 & 3, shale; No. 2, limestone; No. 4, alluvium.
surfaces are preserved in exquisite detail many primary structures related to currents of water and to activities of marine organisms that lived on these surfaces when they were the bottoms of Cretaceous seas, more than sixty million years ago. As this remarkable exposure will soon be covered by water and may be destroyed by erosion before the next drought brings it to light again, it is here described in detail.

Fig. 3. Size histogram of particles from the flaggy limestone. Average composition of 6 samples computed from sieving of insoluble residue and micrometer measurements of thin sections.

I wish to thank Professors Claude C. Albritton, Jr., Arthur Richards, and John W. Harrington for time given in discussion of the various problems raised in the course of the investigation, and for assisting with the preparation of the manuscript; and to Marvin Cullum for the excellent photographs.

Composition

The limestone ledge is six to eight inches thick, strikes N 84° E and dips toward the southeast at approximately 20 feet to the mile. The rock is light gray on fresh exposure but weathers brown. Contacts above and below with the blue-black, thinly laminated, and compact shale typical of the Eagle Ford are sharp but conformable. The ledge itself is made of limestone strata between half an inch and two inches thick separated by shale partings ranging from one-
half to three-quarters of an inch thick.

As indicated by the following table the limestone strata are largely of calcite fragments, most of which are prisms derived from the prismatic layers of pelecypod shells. The cement is also largely calcite, although some pyrite and limonite occurs interstitially. With regard to its mineral constituents, the rock is rather uniform; however, the upper one-fifth contains from three to four per cent more calcite with smaller proportional amounts of biotite, pyrite, and limonite. Also lignitic particles ranging from a quarter of an inch to two inches in length occur in the upper portions. The pyrite is present as crystalline stringers and patches which in some places replace fossil materials. When reacting with acid, the rock emits a strong petrol odor.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Occurrence</th>
<th>Shape</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcite</td>
<td>Uni-grained fragments of organic debris</td>
<td>Angular</td>
<td>85-89</td>
</tr>
<tr>
<td>Calcite</td>
<td>Fine crystalline cement</td>
<td></td>
<td>2-3</td>
</tr>
<tr>
<td>Collophone</td>
<td>Remains of fish teeth</td>
<td>Angular</td>
<td>5-9</td>
</tr>
<tr>
<td>Biotite</td>
<td>Flakes</td>
<td>Angular</td>
<td>3-4</td>
</tr>
<tr>
<td>Pyrite</td>
<td>Disseminated aggregates</td>
<td></td>
<td>4-6</td>
</tr>
<tr>
<td>Limonite</td>
<td>Disseminated aggregates</td>
<td></td>
<td>0-1</td>
</tr>
<tr>
<td>Quartz</td>
<td>Uni-grained, crystalline particles</td>
<td>Angular</td>
<td>1-3</td>
</tr>
</tbody>
</table>

Sedimentary particles within the flaggy limestone range in size from less than 1/256 mm. to 4 mm. (Fig. 3). Generally, the lower part of the bed consists of finer materials than the upper, which contains large shell fragments mixed with complete shells.

Primary Structures

The uppermost layer of the limestone is covered by asymmetrical ripple marks with an average wave length of 6.25 inches, amplitude of 0.65 inch, and ripple index of 10 (Figs. 4, 5). The crests trend N 50° E and the steeper sides face toward the northwest. The limestone layer directly underlying this one is also marked by current ripples aligned toward the northeast. In addition, there are local interference markings developed by superposition of a second set of current ripple marks on the prominent set which trends northeast. These two sets intersect at angles up to 90°, so as to form quadrangular patterns where most perfectly developed. The steeper slopes of this second set of ripple

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2Percentages represent the average of 6 samples taken at horizontal intervals of 200 feet, and representing two complete sections of the flaggy limestone bed.
Fig. 4. Ripple marks on limestone; small normal fault in background.

Fig. 5. View showing details of rippled surfaces. Traces of laminae show on gentle side.
marks face toward directions ranging between N 40° E and N 52° E.

Upper surfaces of the limestone also show external molds of fossil molluscs, including impressions of the ammonite *Prionotropis* and the pelecypod *Inoceramus*. Interspersed among these molds are elongate, subcylindrical ridges which are intertwined and superposed so as to make complex patterns, and which presumably represent worm or holothurian castings. Individual castings vary from a half to three inches in length and from a quarter to a half inch in diameter. Along weathered surfaces they can be separated from the matrix with ease. In addition, the upper bedding surfaces contain numerous minute, subcylindrical bodies of calcite sand which range from $\frac{1}{16}$ to $\frac{1}{8}$ inch in diameter, which generally do not exceed a quarter-inch in length and which cross the bedding at angles up to 90 degrees. The origin of these bodies is not known, although it is possible that they represent the fillings of tubular burrows made by some worm-like animal.

A most peculiar assortment of shapes is present on the under surfaces of the flaggy layers (Fig. 6). The most conspicuous are in the form of grooves and ridges. The grooves are essentially "V" shaped, and in the larger examples that measure as much as $\frac{3}{4}$-inch across, they tend to be straight, simple and parallel. Some are partly filled with a coarse sand of delicate shell fragments. It is suggested that these are molds of incomplete oscillation ripples. There are also smaller grooves the size of a pencil line which are variously branched, and for which I can offer no explanation.

Associated with the grooves, both large and small, are ridges which measure from half-an-inch to an inch in diameter and up to two or three inches in length. These are commonly made of finely fragmented shells which in some examples are oriented in subparallel manner. Many show striations paralleling their longer dimensions and have a convoluted internal structure which on a minute scale resembles flow structures as seen in lava. Others, however, are very smooth and show no internal structure. All may very well represent the fillings of animal burrows.
Fig. 6. [above]. Markings along the under surfaces of the limestone; Fig. 7. Fish teeth taken from the limestone bed.
Fossils

In addition to the calcite prisms which form the bulk of the rock, there are larger fragments and occasional whole valves of pelecypods, including *Alectryonia* and other genera. Many of these clearly show the effects of mechanical wear. Pelecypod shells are usually distributed at random but also occur in patches through the upper portions of the bed. Some have convex sides pointing upward, while others have the convex sides downward in what is commonly regarded as an unstable position for such shells. The small but ornate molds of the ammonite *Prionotropis* are common throughout the limestone.

Foraminiferal tests are rare, especially in the upper parts of the bed. Most specimens belong to the presumably planktonic genera *Giumbelina* and *Globigerina*, but occasional specimens of *Planulina* were found. Samples of the Eagle Ford shale both immediately above and below the limestone contain the same genera, but volume for volume have approximately 25 times the number of individuals found in the limestone.

Fish teeth occur locally in numbers sufficient to impart a black speckled appearance to the gray limestone. Like the invertebrate shells, these teeth are randomly distributed through the sediment and are mostly fragments that show evidence of mechanical wear. The predominate types are the sharp cusped, triangular varieties with serrate edges, similar to those which Fowler (1911, p. 22-182) referred to the shark, *Isurus*. Moreover there are larger specimens of teeth of the sort possessed by modern skates and rays. (Fig. 7).

Structure

The flaggy limestone bed is broken by two sets of vertical joints. The principal set strikes N 59° W, while the other strikes at approximately right angles to this. Slumping of joint blocks as they are undermined along the bank of the river accounts for the serrate pattern seen on the map.

Several small normal faults break the limestone bed near the eastern edge of the outcrop area. The strike of these ranges between N 60° W and N 68° W, and the dip between 79° and 85° NE. The throw in all cases is less than a foot,
and by matching of ripple crests and troughs on the adjacent up-thrown and down-thrown blocks, it can be demonstrated that there is no appreciable horizontal component of displacement.

Origin

As indicated by its content of such fossils as ammonites and foraminifera, the flaggy limestone originated as a marine deposit. It is manifestly a clastic deposit and, except for the silt and clay fractions which may have been carried in suspension, its materials presumably were moved along the bottom by the same currents that produced the ripple marks. That the bottom over which these currents moved had only a slight degree of dip is suggested by lateral uniformity of the bed and absence of such features as might be produced on steep surfaces, such as cross-bedding or submarine contortion due to slumping of materials.

The diverse trends of the ripple marks indicate a direction of bottom currents varying between northwest and northeast. Poor sorting of the clastic particles suggests fluctuation in current velocity. Moreover, the presence of interbedded shale suggests that the currents altered sporadically, and that there were times when the bottom was receiving sediment dropped from suspension.

In broader perspective the flaggy limestone was deposited along the bottom of an Upper Cretaceous epeiric sea which
occupied the present Gulf Coastal plain of Texas. There is nothing to indicate the depth of water that obtained in this area during late Eagle Ford time. Ripple marks are frequently cited as indicators of water no deeper than a few hundred feet, although Menard (1952, pp. 3-11) has recently photographed current ripples at depths of 792 feet.

Since the particles are angular, it appears unlikely that they were subjected to long or rigorous transportation (Fig. 7). This reasoning, however, would not necessarily apply to the smaller grade sizes, as the finer particles may have been transported from their sources in suspension.

It is suggested that the flaggy limestone bed marks a level at which a profile of equilibrium was attained during the deposition of the Eagle Ford formation. So long as this profile was maintained, the bottoms became densely populated with shellfish. Waves and currents swept away most of the fine material, leaving an accumulation of organic debris which was reduced to sand-size (partly by abrasion and partly by the work of worms, and probably other burrowing benthonic animals). The teeth of fishes accumulated in great numbers. Subsequently the bottoms subsided and deposition of muds, now lithified to form shale, was resumed.

After the flaggy limestone bed was deposited as a fragmental-textured sediment, precipitation of interstitial calcite bound the particles firmly together, changing the rock into a pseudo-crystalline limestone. Possibly another diagenetic effect is represented in the formation of pyrite as crystalline aggregates some of which replaces calcareous shells.

Compaction also appears to have left its impress upon some of the calcite fragments. The larger particles of *Inoceramus* are irregularly fractured with the disturbed particles remaining together in almost perfect unison so that it is difficult to conceive of such orientation by gravitational settling.

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