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2 March 1964

Geometry of Bermuda Calcareous Dune Cross-Bedding

Abstract. *Bermuda wind-blown limesands are lobate-shaped bodies composed internally of leeward foreset strata which dip at 30 to 35 degrees and windward strata which dip at 10 to 15 degrees in an opposite direction. The foreset beds are convex upward. This convex upward cross-stratification is preserved because of the early stabilization of the eolian calcareous sand due to surface cementation by percolating rain water.*

The geometry of cross-stratified sedimentation units has received considerable attention during the past 10 years (*1*). It is now accepted, perhaps unintentionally, that for all practical purposes, the geometry of cross-stratified calcareous and siliceous rock units is the same. The geometry of the Bermuda wind-blown limesands suggests that early stabilization of calcareous skeletal particles produces distinctive cross-stratification.

The stratigraphy of the Bermuda land rocks has been discussed by various writers (*2*). About 95 percent of the exposed land of Bermuda is composed of calcareous dune formations of presumed Pleistocene age. The individual dunes appear to be predominantly lobate sand bodies which have coalesced to form irregularly defined transverse dune ridges. Figure 1 shows various aspects of bedding within the lobate sand bodies. In Fig. 2 an idealized lobate unit is illustrated.

Internally, the lobate unit is composed of leeward foreset strata which dip at 30 to 35 deg and windward strata which dip at 10 to 15 deg in an opposite direction when undisturbed. The configuration of the base of the unit depends on the topography over which the sand body was deposited.

The foreset cross-beds are slightly convex upward and usually abut sharply against underlying surfaces, but may continue leeward into the windward strata of another unit. Some cross-beds are tangent to the base. The cross-stratification surfaces are convex downwind. The foreset beds pass windward into strata which dip 10 to 15 degrees in an opposite direction or are truncated by younger beds. Repeated truncation of the cross-bedding in a leeward direction by successively younger beds with slightly divergent dips is common.

The leeward cross-strata may be as thin as 2 mm or as thick as several centimeters. They are commonly ripple-marked or broken by root casts. The individual cross-beds range from 0.5 to 25 meters in length. Thickness of the cross-stratified lobate units varies from 0.3 to about 20 meters. The sand bodies are up to 100 meters in the longest dimension. Brecciation of the bedding occurs within or between the units.

The windward strata are commonly very irregular and complexly bedded. Blowouts filled with sediment are found in the windward beds. Irregularities in the windward strata have thus far prevented better definition. The convex upward cross-strata and the curved cross-bedding, which is convex downwind, suggest that the lobate unit is a true parabolic or U-shaped dune form.

The leeward cross-beds which are convex upward apparently represent periods of aggradation of the lobate

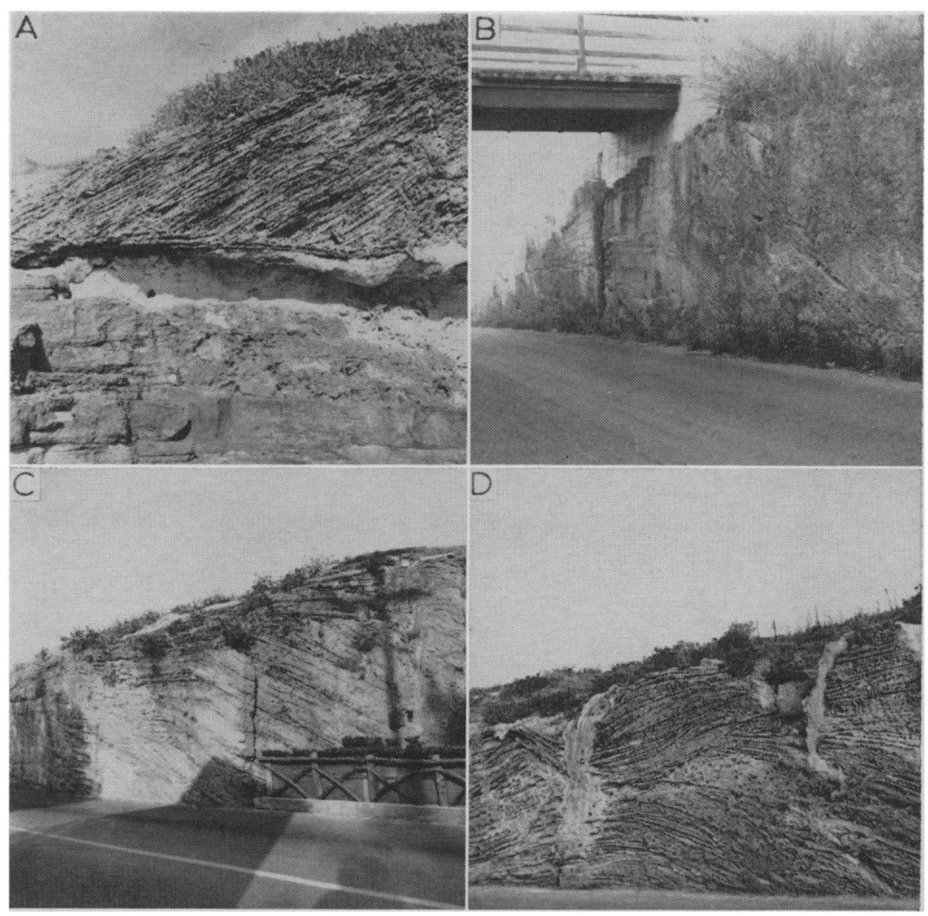

Fig. 1. Aspects of bedding within lobate sand bodies. *A*, Cross-bedding, convex upward portion of cross-bedding is eroded (see Fig. 2, *1*). *B*, Roll-over of windward strata into convex upward leeward cross-beds (see Fig. 2, *2*). *C*, Truncation of older strata by younger in a leeward direction (see Fig. 2, *3*). *D*, Irregular bedding in windward beds of eolian sand body (see Fig. 2, *4*).

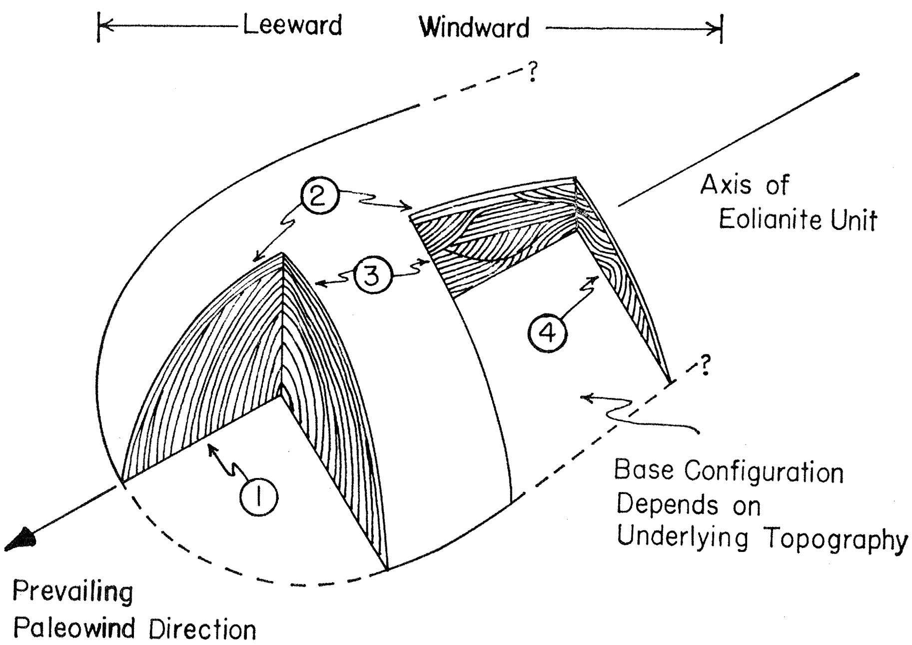

Fig. 2. Generalized geometry of a Bermuda, wind-blown, lobate sand body.

sand body as it built forward. This convex upward cross-bedding is preserved because of the relatively rapid stabilization of wind-blown, calcareous sand due to surface cementation by percolating rain water. Intraformational breccias are a result of this early surface cementation and later reworking. If stabilization was slow, the cross-strata were eroded and appear in some sections like planar or festoon cross-bedding.

Convex upward cross-stratification characterizes the Bermuda calcareous dunes. I have also observed it in the Bahamian eolian limesands. Its occurrence as a predominant type in siliceous sandstones has not been reported.

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Contraction Hypothesis Consistent with the Kennedy-Thorndike Experiment

Abstract. *A Lorentz-Fitzgerald contraction augmented by an equal isotropic contraction gives a null result for all interferometric ether-drift experiments.*

Grünbaum (*1*) has pointed out that an ether theory amended by the Lorentz-Fitzgerald contraction and the time-dilation hypotheses is consonant with the null result of the Kennedy-Thorndike (*2*) experiment, so that a rejection of the doubly amended ether theory in favor of special relativity rests upon philosophical grounds.

As an addendum to Grünbaum's paper, it may be observed that the situation is further complicated by the fact that there also exists a singly amended ether theory which does the same thing with Newtonian concepts only.

To find the amendment, consider an interferometer arm *OP* and require the transit time of light for the round-trip *OPO* to be independent of both the orientation and speed of *OP* relative to the ether. Suppose the interferometer arm *OP* to be of unit length and directed along the x-axis; a pulse of light goes from O to P, where a mirror reflects it back to O. With O and P fixed in the ether the time for the round trip is $2/c$, where c is the velocity of light relative to the ether. Now suppose the ether to flow along the negative x-axis with speed u; if the time $1/(c-u) + 1/(c+u)$ is to remain the same as before, *OP* must shrink by the amount u^2/c^2. Next, suppose the ether to flow along the negative y-axis with speed v. The ray of light which makes the round trip *OPO* is inclined at an angle whose sine is v/c to the x-axis so that the x-component of velocity is $(1-v^2/c^2)^{\frac{1}{2}}$. To keep the time the same as before, *OP* must contract by this factor. When both components of drift exist, the total contraction is the sum of the separate ones to the second order in the drift components, so that the contraction of *OP* is $(u^2/c^2+v^2/2c^2)$.

If the drift velocity $\mathbf{V}$ makes an angle θ with the x-axis, $u = V \cos \theta$, $v = V \sin \theta$ and the contraction is $(V^2/c^2)\ (1-\frac{1}{2} \sin^2 \theta)$.

The contraction is V^2/c^2 for $\theta = 0$ and $\frac{1}{2} V^2/c^2$ for $\theta = 90°$. A sphere which has unit radius for $V = 0$ shrinks into an oblate spheroid altogether inside the original sphere, with the minor axis in the direction of $\mathbf{V}$. The total contraction can be resolved into an isotropic contraction, $\frac{1}{2} V^2/c^2$, and a superimposed Lorentz-Fitzgerald contraction of $\frac{1}{2} V^2/c^2$ along the direction of motion.

For observations lasting only a small fraction of a day, such as the Michelson-Morley or the Trouton-Noble experiments, only the Lorentz-Fitzgerald part of the contraction applies, since the isotropic contraction will presumably already have taken place and will not change appreciably during the experiment. The hypothesis is therefore equivalent to the Lorentz-Fitzgerald contraction for short-term experiments.

It is apparent that such a contraction suffices to yield null results for any interferometric ether-drift experiment, for if fringes are once established, no changes in speed or orientation can alter them.

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