6562 Å) in the spectrum of the scattered sunlight; this comes at a point where the red emission is nearly at its peak of intensity.

This work is being carried out under contract *AF* 61(052)–379, through the United States Air Force Cambridge Research Laboratories. We are grateful to the British Museum (Natural History) for the loan of the meteorites.

C. J. Derham
J. E. Geake

Department of Physics,
Manchester College of Science and Technology.

[1] Derham, C. J., and Geake, J. E., *Tech. Note No. 2, Contract AF* 61(052)–379.
[2] Geake, J. E., and Lumb, M. D., *Tech. Note No. 1, Contract AF* 61(052)–379.
[3] Prior, G. T., *Catalogue of Meteorites* (1953).

GEOCHEMISTRY

Carbon and Oxygen Isotope Ratios as Environmental Indicators: Anomalous Results from Carbonate Shells from Beach Sediments of Lake Managua, Nicaragua

The value of carbon and oxygen isotope ratios in determining the nature of the depositional environment for various types of carbonate rocks has been pointed out by a number of workers[1–3], who showed that freshwater limestones are enriched in carbon-12 and oxygen-16 relative to the marine varieties. Moreover, detailed variations in $^{12}C/^{13}C$ ratios were found to be preserved in the Vanport limestone of Pennsylvanian age[4]; the ratios increase regularly toward the shoreline of the estuarine–deltaic basin complex and presumably indirectly reflect variations in salinity concurrent with the mixing of carbon-12 enriched continental bicarbonate of the distributary with carbon-13 enriched bicarbonate of the ocean.

Isotopic criteria are not infallible, however, and a number of mechanisms by which anomalous isotope ratios may be effected were discussed by Keith and Weber[3]. Most of the samples with divergent $^{12}C/^{13}C$ ratios may be detected before analysis by signs of diagenetic alteration, by deposition in strongly reducing environments, or by the presence of organisms known to precipitate calcium carbonate out of isotopic equilibrium with their external environment.

Table 1. Isotopic Composition of Mollusc Shells from Recent Sediments of Lake Managua

	$\delta^{13}C$*	$\delta^{18}O$*
Anadara, cf. *A. lienosa*		
Average of 18 specimens	− 4·11	− 3·42
Standard deviation	1·97	0·38
Planorbina sp.	− 9·56	− 7·78
Fossaria sp.	− 5·21	− 2·59
Thais sp.	+ 0·54	− 2·36
Conus sp.	+ 1·29	− 2·09

* Relative to the Chicago PDB standard, in per mil.

An interesting example of recent sedimentation which would provide anomalous environmental evidence on the basis of both fossils and carbon isotopic composition has been found in beach sediments of Lake Managua, near the capital city of Nicaragua. Small, freshwater lacustrine gastropods, *Fossaria*, *Planorbina*, and *Physa*, and one species of land snail, *Succinea*, are found in small numbers in the upper layers of beach sands. The isotopic composition of the freshwater shells (Table 1) is well within the range of freshwater carbonates ($\delta^{13}C$ less than − 2 per mil, relative to the PDB standard). In greater abundance, however, occur shells of *Anadara*, a food clam collected in brackish water environments in the river mouths along the Pacific coast, and later transported into the area and discarded in the lake after extraction of the soft parts. Specimens of *Anadara*, distributed by wave and current action are found along with the lacustrine species, and the isotopic composition of *Anadara* shells suggests growth in brackish water environments. Specimens of *Thais* and *Conus*, with $^{12}C/^{13}C$ ratios typical of the marine carbonates, are also found in the beach sediments and have been derived from the erosion of nearby Tertiary marine sedimentary rocks.

Because of their fragility, the freshwater molluscs are rapidly comminuted by wave action and dissolved by the waters of Lake Managua. The brackish water *Anadara*, and the marine fossils, however, are buried in the beach sands, and under suitable conditions would presumably be entombed as fossils, or would diagenetically redissolve and form carbonate cement. In any case, both fossil and isotopic criteria, if applied some time in the future, would suggest brackish water to marine depositional conditions for a sequence of sediments having originated in a freshwater lacustrine environment.

In some areas, transportation of mollusc shells by animals, or the redeposition of fossil shells derived from nearby sediments undergoing erosion, may not be uncommon, and in such cases, both fossil and isotopic environmental indicators may be wholly in error. The search for new environmental indicators should be continued.

Jon N. Weber

College of Mineral Industries,
Pennsylvania State University,
University Park.

[1] Clayton, R. N., and Degens, E. T., *Bull. Amer. Assoc. Petrol. Geol.*, **43**, 890 (1959).
[2] Weber, J. N., and Keith, M. L., *Geol. Soc. Amer. Ann. Meeting*, 159, A (1962).
[3] Keith, M. L., and Weber, J. N., *Bull. Amer. Assoc. Petrol. Geol.* (in the press).
[4] Weber, J. N., Bergenback, R. E., Williams, E. G., and Keith, M. L., *Bull. Amer. Assoc. Petrol. Geol.* (in the press).

CRYSTALLOGRAPHY

X-ray Diffraction by a Layer Silicate containing Stacking Faults

In cronstedtite, as in many layer-type silicates, structural faults occur during the growth of the crystals which consist of displacements of the layers from their correct positions. Since the direction of the displacements is parallel to the layers, their effect is to destroy the regularity of the structure in the direction perpendicular to the layers, considered here to be the direction of the c^*-axis of the reciprocal lattice, and the reciprocal lattice points become smeared along this axis. On an X-ray diffraction photograph, spots on a row of constant h and k and varying l are linked by a streak which varies in intensity from a maximum at the positions of the spots to a lower value between them. The extent of the streaking depends on the frequency of the faults, and varies from one crystal to another.

Recently, eight polymorphs of cronstedtite have been discovered[1,2], and crystals of nearly all of them can be found which show this disorder streaking very well. Two features of it are very noticeable. The first is that it always takes one of two forms, and the second is that each of these forms appears invariably with a certain group of polymorphs.

In one form, the streaking varies in intensity in the way described here, and the observed variation is in qualitative agreement with the results of the calculations carried out by Wilson[3]. In the other form, the streak itself appears to be of almost uniform intensity throughout its length, and on it are spots which are as sharp as those from a perfect structure.

The first form is found in polymorphs with space groups $P31m$ and $P6_3cm$, and possibly Cm, and the second, more unusual, form in polymorphs with space groups $P6_3$ and $P3_1$, and possibly $R3$. (The space groups alone are given, since they are sufficient to identify the structures, which are described in detail elsewhere[1,2].) This association of a particular form of streaking with a certain