ported, occasional crystals yielded patterns characteristic of networks (Figs. 1 and 2). If the network lies between the two crystals, the absence of contrast when the imaging plane contains the Burgers vector indicates that the network is composed of three sets of dislocations having Burgers vectors [100], [010], and [110]. The double image parallel to the [110] direction in Fig. 1 indicates a dissociation into partials as follows:

$$[110] \rightarrow [\tfrac{1}{2}\,\tfrac{1}{2}\,0] + [\tfrac{1}{2}\,\tfrac{1}{2}\,0]$$

The narrow ribbon of stacking fault between these two partials corresponds to a region in which the plane of the polyethylene chain in one crystal is twisted approximately 90° with respect to the other crystal. The absence of stacking-fault contrast is to be expected since $b \cdot g$ is integral for all strongly diffracting planes. Possibly the other two dislocations also dissociate into partials, and a complete analysis of the diffraction contrast exhibited by these dislocations should settle this question (*5*).

The observation of dislocation network formation between two folded-chain polyethylene crystals has important significance with regard to the nature of the molecular folds. Although some workers (*6*) suggested a regular molecular folding of the chains, and although the subsequent description of the hollow pyramidal nature (*7*) and the cleavage properties (*8*) support this conclusion, others (*9*) have concluded that a layer of amorphous material occurs on the fold surface of these crystals. We feel that it is very difficult to interpret the careful determination of the crystallographic nature of the fold surface with any model other than that of regular molecular folding. From our observations we conclude that the molecular folds must be sufficiently regular so that the molecular forces across the folds are strong enough to align the two crystals perfectly in some regions and to concentrate any misalignment into a network of dislocations. In other words, the molecular fold surface should be considered as a crystallographic plane which can pack with another similar fold plane and continue the crystal along the direction of the chain axis. Thus not only can a polyethylene molecule crystallize by a regular molecular folding mechanism but also such a chain-folded crystal is not restricted in size along the chain axis by the fold length.

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Dolomitization of the Mid-Pacific Atolls

Abstract. *The origin of the dolomite which occurs beneath the atolls of Funafuti, Kita-daitō-jima, and Eniwetok in the Pacific Ocean can be explained by the reaction of hypersaline brines with transported or buried reef skeletal material. Dolomitization could have taken place at the sediment surface in shallow restricted back-reef lagoons and tidal flats or below the surface by reflux action. Measurements of oxygen isotopes in samples of dolomite can be interpreted as indicating an origin from evaporated, isotopically-heavy sea water.*

Many hypotheses have been offered to explain the origin and distribution of dolomite $CaMg(CO_3)_2$ which occurs beneath the atolls of Funafuti, Kita-daitō-jima, and Eniwetok in the western and southern Pacific Ocean. These hypotheses were summarized and discussed recently by Schlanger (*1*). Interest in the dolomites stems from their uncomplicated geological history and their isolated location far from any source of magnesium-bearing solutions other than sea water. Paleontological studies have shown that the ancient calcareous organisms which have been dolomitized are similar to forms now living on the atolls, so that fossil materials which now consist of dolomite must originally have been made up of calcite and aragonite.

In summarizing the available information and hypotheses of origin, Schlanger (*1*) states:

> Any attempt to explain the formation of dolomite in these atolls must take the following into account:
>
> 1) The vertical distribution of dolomite in all drilled atolls . . . . [It is not a simple function of depth and, therefore, pressure.]
>
> 2) The presence of dolomite as a distinct mineral phase in limestones that contain as little as 2- to 3-percent $MgCO_3$. Leaching of originally magnesium-rich rocks could not account for these traces of dolomite . . . .
>
> 3) The differing susceptibility [from drill hole to drill hole] of any single fossil group to dolomitization . . . .
>
> 4) The apparent lack of effect of primary porosity on dolomitization . . . .
>
> 5) The lack of co-existent dolomite and aragonite . . . . [Only calcite occurs with dolomite.]
>
> 6) The lack of correlation between length of immersion in sea water and intensity of dolomitization suggests that mere prolonged soaking in magnesium-rich water does not by itself cause dolomitization.
>
> 7) The wide variety of secondary textures seen in limestone from these atolls suggest that emplacement of dolomite takes place in several ways with different paragenetic sequence [including massive replacement, layered void filling with interlayers of calcite, and volume-for-volume replacement with preservation of organic structures].
>
> 8) The fact that the dolomite from these atolls is structurally calcium rich [protodolomite of Goldsmith and Graf (*2*)].
>
> 9) The fact that most of the limestone from both atolls and higher islands in the Pacific is not dolomitized. Therefore, one must look at dolomitization as an 'abnormal' rather than as a 'normal' diagenetic effect.
>
> 10) That the three-dimensional distribution of dolomite in the subsurface of any atoll is unknown . . . .

In this report a new hypothesis is outlined which successfully meets all the above requirements.

The formation of dolomite in present day sediments has only recently been demonstrated unequivocally. Radiocarbon dating has shown that dolomite is forming in the coastal region of South Australia (*3*), on the west coast of the Persian Gulf (*4*), on the island of Bonaire in the Netherlands West Indies (*5*), in the Bahama Islands

Table 1. Analyses of the oxygen and carbon isotopes in samples of dolomite from Kita-daitō-jima (KDJ) and from Funafuti (FF). The symbols δO^{18} and δC^{13} refer to the PDB Chicago (Belemnite) standard; $\delta = [(R_{sample}/R_{standard}) - 1]1000$, where R refers to the ratio of heavy to light isotopes of oxygen or carbon [see (*16*)].

δO^{18}		ΔO^{18}	δC^{13}	
Calcite	Dolomite	Dolomite—calcite	Calcite	Dolomite
		Sample KDJ—691		
−2.29	+4.52	+6.81	+2.29	+3.19
		Sample FF—224a		
−2.18	+4.13	+6.31	−2.99	+3.05

and the Florida Keys (*6*), and in Deep Spring Lake, an intermontane playa in east-central California (*7*). Probably, authigenic dolomite also occurs in the surface sediments of Great Salt Lake, Utah (*8, 9*). In all of these occurrences the dolomite is structurally and compositionally a protodolomite (*2*) and is directly associated with solutions much more saline than normal sea water. All marine occurrences are in shallow water areas of restricted circulation such as lagoons or poorly-drained tidal flats, where sea water becomes isolated from the sea and undergoes intensive evaporation. The nonmarine occurrences are in very highly saline lakes. To my knowledge, no irrefutable evidence for the formation of recent dolomite in sea water of normal salinity has yet been demonstrated. Well-ordered stoichiometric dolomite has been shown to be the thermodynamically stable phase (relative to calcite and aragonite) in sea water of average salinity and containing an average ratio of magnesium and calcium (*10*). Therefore, the recent formation of protodolomite only in supersaline environments must be explained by its instability in normal sea water (with the assumption that protodolomite is less stable than stoichiometric, ordered dolomite) or explained by various kinetic mechanisms favored by a high salinity. One such mechanism advanced by Deffeyes, Lucia, and Weyl (*5*) is the increase of the Mg/Ca ratio of evaporated sea water by the removal of Ca to form gypsum. An increased Mg/Ca ratio would favor the conversion of calcite or aragonite to dolomite by the reaction:

$$Mg^{++}_{aq} + 2\,CaCO_3 \rightleftarrows CaMg(CO_3)_{2\,dol} + Ca^{++}_{aq}$$

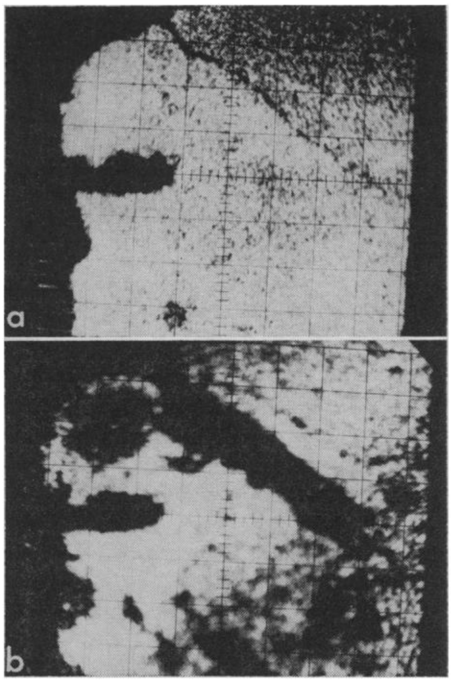

Fig. 1. Photographs of the oscilloscope output produced by scanning dolomitized reef sample FF-224a with an ARL (Applied Research Laboratories) electron microprobe at 15 kv, 0.1 μamp. Each white dot represents a point of fluorescence produced by (*a*) calcium radiation, and (*b*) magnesium radiation. The dark zone shown only in (*b*) represents a vein of secondary calcite, low in magnesium content, crosscutting dolomite. This fissure-filling can be interpreted as evidence for circulating meteoric water (*1, 20*). Scale: one large unit = 0.1 mm.

Based on the conclusions of Schlanger and the natural occurrences of recent dolomite, I suggest that the dolomite found beneath the atolls of Funafuti, Kita-daitō-jima, and Eniwetok was originally formed by the reaction of supersaline evaporated sea water with calcareous skeletal materials transported or buried *in situ* (*11*). This reaction could have taken place within a restricted back-reef lagoon or tidal flat, or in the shallow subsurface by the downward and seaward migration of the overlying brine. The latter process, called reflux, has been proposed to explain the dolomite found in the Permian Reef Complex (*12*) and has been proposed by Adams and Rhodes (*13*) and by Deffeyes, Lucia, and Weyl (*5*).

Dolomitization by brines would help to explain the "abnormal" occurrence of dolomite (restricted lagoons would have been an "abnormal" situation). It also would explain the lack of correlation of dolomitization with depth (that is, pressure), with time of soaking in sea water, or with skeletal texture and mineralogy. The critical factor determining rate would be the chemistry of the dolomitizing solution and not the original mineralogy or time of soaking in sea water. The occurrence of thin interlayers of dolomite and calcite in void fillings can be explained by fluctuations occurring in the chemistry of the water (*1*), this being indicative of a shallow water environment such as a hypersaline lagoon whose salinity fluctuates according to fluctuation in rates of rainfall and evaporation. Fluctuations in water composition would not be expected if the reef material had been simply buried in ordinary sea water. The accompanying absence of aragonite and common presence of features indicating solution (*1*) also suggest formation of dolomite near or above sea level alternating with periods of aragonite solution and secondary calcite formation by circulating meteoric waters. An example of secondary calcite, as a crack filling in dolomite, is shown in Fig. 1, *a* and *b*.

Once buried below the zone of brine reflux, any evaporite minerals that might accompany the dolomite would be expected to redissolve in the surrounding interstitial sea water. That the buried reef materials actually are immersed in normal sea water, which exchanges with the surrounding ocean outside the buried reef mass, is shown by measurements of temperature and tides in bore-holes on Eniwetok and Kita-daitō-jima (*14*).

To provide one possible test of the proposed hypothesis, analyses were made of the oxygen and carbon isotope content of two samples from Funafuti and Kita-daitō-jima. These samples (FF-224a and KDJ-691) have already been examined in detail for their mineralogy and described by Goldsmith and Graf (see *1*). The isotopic compositions of the samples were determined by the mass spectrometric analysis of CO_2 obtained by differential reaction with phosphoric acid (*15*). The acid fractionation-factor was taken as 1.01088 for dolomite and 1.01002 for calcite (*16*).

Results in the form of δO^{18} and δC^{13} values are listed in Table 1. The δO^{18} of dolomite in both samples is considerably higher than that of the co-existing calcite. There are two possible explanations of these results. (i) The δO^{18} of calcite and dolomite in each sample represents isotopic equilibrium with sea water of normal salinity and oxygen-isotope composition. According to the calcium carbonate isotopic temperature scale (*17*) the calcite in both samples would be in equilibrium with standard mean ocean water at 27°C. Extrapolated values for the difference in equilibrium δO^{18} between well-ordered stoichiometric dolomite and calcite are estimated to be 6 to 10 per mil (*18*) and 4 to 7 per mil (*19*). (ii) Alternatively, the δO^{18} of dolomite represents nonequilibrium formation from calcium carbonate in hypersaline brine, whereas the δO^{18} of calcite represents original skeletal material plus recrystallization or isotopic exchange with meteoric waters, brines, or sea water of normal salinity. If the original sedimentary protodolomite-water isotopic fractionation was close to that of calcite-water at the same temperature, then the high O^{18} composition of the dolomite would represent formation in water of high δO^{18} owing to evaporation. Similar nonequilibrium formation of dolomite in standard mean ocean water would necessitate an unreasonably low surface temperature (*17*).

Recent work suggests that the second explanation is more nearly correct. Isotopic analysis of co-existing calcite and dolomite in modern sediments (*18*) has shown that the two actually are of very similar oxygen isotopic composition and do not represent the expected equilibrium ΔO^{18} of about 6 per mil. This similarity was interpreted to mean that dolomite forms by the solid state replacement of Ca in $CaCO_3$ by Mg. However, the occurrence of banded dolomite as concentric crusts in voids (*1*) and as rhombohedra with compositional zoning strongly supports an origin by crystal growth from solution and not by diffusion replacement in the solid state.

The dolomite, once formed, would not be expected to exchange oxygen with meteoric waters or subsurface fluids nearly as readily as calcite (*15*). In this way the original isotopic composition of dolomite would be preserved, whereas that of calcite could approach equilibrium with the surrounding water by exchange or recrystallization (*20*) (see Fig. 1).

Confirmatory evidence for a hypersaline origin of the dolomite beneath the mid-Pacific atolls must await further, more reliable tests for original hypersalinity. Weber (*21*) in a recent paper states that three samples of Funafuti reef dolomite were found to contain an unusually high concentration of chloride ion and this finding can be interpreted as additional possible evidence for hypersalinity.

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Lens Fiber Differentiation and Gamma Crystallins: Immunofluorescent Study of Wolffian Regeneration

Abstract. *From the adult lens of* Triturus viridescens, *a fraction of proteins was isolated which corresponds to γ-crystallins of higher vertebrates. Tests by immunoelectrophoresis indicate that the antiserum against this fraction reacts with γ-crystallins, but not with α- or β-crystallins. With this antiserum, an immunofluorescent reagent has been prepared for detection of γ-crystallins from newts. In the normal lens of the adult newt, these crystallins are detected in fiber cells and fiber material, but not in the epithelial cells. During transformation of the iris into the lens after lens removal, the staining reaction is negative in the regenerating tissue up to the time the prospective primary fiber cells begin to elongate. Subsequently, without exception those cells in fiber differentiation indicate a γ-crystallin reaction. When the secondary fiber cells are produced at the equatorial zone of the regenerating lens, they also begin to show a γ-crystallin reaction. Thus, γ-crystallins characterize fiber differentiation.*

A number of cellular events are closely connected with the control mechanism of γ-crystallin synthesis. When the lens is removed from the eye of adult newts belonging to the family Salamandridae, a part of the iris is transformed into the lens (*1*). This type of regeneration, called Wolffian lens regeneration, has been the subject of a series of cytochemical and immunochemical investigations (*2*), and the acquisition of tissue specificity by such regenerating tissue is the subject of this report.

In our earlier study (*3*), lens specific antigens became detectable in this system, by immunofluorescence, after the lens vesicle showed the first sign of lens fiber differentiation (lens regeneration stage IV after Sato, *4*).