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CALCITE-DOLOMITE INTERGROWTHS IN HIGH-TEMPERATURE CARBONATE ROCKS

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INTRODUCTION

Graphic, sub-graphic and lamellar intergrowths of calcite and dolomite in high temperature carbonate rocks have been reported occasionally in the literature. Among such papers with illustrations of these textures in high grade marbles are Coomaraswamy (1902), Joplin (1935), Russell, Hiemstra and Groeneveld (1955), Goldsmith *et al.* (1955), and Long and Agrell (1965). Similar intergrowths have been described from the Søve and Panda Hill carbonatites by van der Veen (1963). The experimental work of Graf and Goldsmith (1955), Harker and Tuttle (1955) and Goldsmith and Heard (1961) has stimulated increased interest in high temperature calcite-dolomite occurrences because it may now be possible to obtain quantitative data on the thermal history of these rocks. It is the purpose of this paper to describe some calcite-dolomite textures in high temperature rocks, which are studied in polished sections. In this study an improved method is applied.

METHODS

The specimens, which were examined during this investigation, are from the Søve carbonatite (Norway) which has been described by Bjørlykke (1955), Seather (1957) and Bjørlykke and Svinndal (1960), the Panda Hill carbonatite (Mbeya, Tanganyika) which has been studied by Fawley and James (1955), Fick and van der Heyde (1959) and van der Veen (1963), and the Loolekop carbonatite (Palabora Mines, Phalaborwa, Transvaal, Republic of South Africa) which has been described by Russell *et al.* (1955). Additional specimens from the periclase marble at Crestmore, California, which has been studied by Burnham (1959) and Carpenter (1963), were also examined.

Many methods have already been developed for distinguishing calcite and dolomite in hand specimens, thin sections and polished sections. Of all the staining methods reported in the literature and summarized by Friedman (1958), the alizarine red S method described by Knauer (1957) proved to be the most satisfactory for use with hand specimens and thin sections.

However, it was soon apparent that the best way to study and photograph carbonate textures was through the use of polished sections. The major factors which control the observation and the photography of very fine-grained textures in thin sections are:

a. The resolving power of the microscope;
b. The thickness of the thin section and mineral grains;
c. The quality of the stain.

Through the use of polished sections one eliminates the difficulties which are inherent in observing and photographing a three dimensional object with a lens of very limited focal depth. In addition, the distinction between calcite and dolomite is facilitated and improved through the use of an acetic acid etch solution (Schneiderhöhn, 1922; Ramdohr, 1960). Immersion of the polished section in 0.25% acetic acid (calcite is etched) for about five seconds provide optimum results for microscopic study and photographic purposes.

Results of the Investigation and Genetic Interpretation of the Textures

According to Brett (1964) exsolution may produce mutual boundary, veining and replacement textures. Therefore, such textures appear to be unreliable data for the determination of mineral paragenesis when phases showing solid solution are involved. This is especially true in the case of such "mobile" minerals as calcite and dolomite which might exsolve from each other and become so completely segregated that there would be little evidence for their having existed as a single phase. The genetic interpretation of the observed textures, given beside the results of this textural study and illustrated in several photographs, are therefore most tentative.

Figures 1 and 2 illustrate subgraphic textures in rocks of very different origin (metamorphic and carbonatitic). Rods of dolomite occur in a field of calcite. The outlines of the dolomite are more easily seen in reflected light (Fig. 2) than in transmitted light (Fig. 1). This texture may be the result of the exsolution of dolomite from calcite.

Figure 3 shows an emulsion texture which is commonly observed in the carbonatite rocks of Panda Hill (van der Veen, 1963, phot. 7–28). Dolomite is present as inclusions in the calcite and as small masses along calcite grain boundaries. This type of texture may be interpreted as an exsolution texture which has nearly been destroyed by the segregation of exsolved dolomite to the borders of the calcite grains. Note the tiny dolomite inclusions in the calcite field. The fine structures of these delicate structures can be studied much more easily in polished section than in thin section.

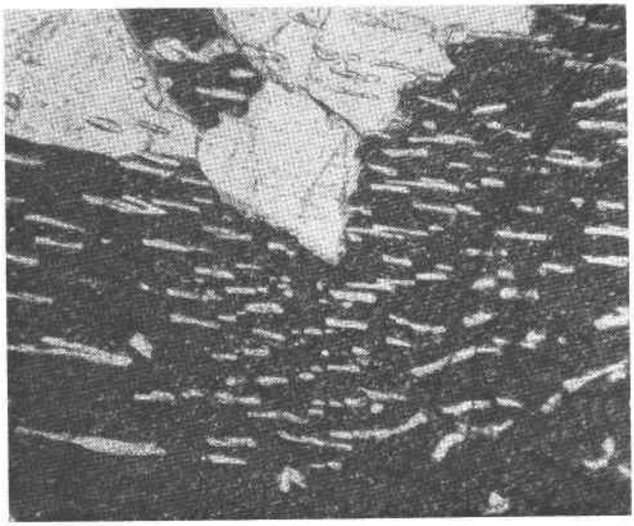

FIG. 1. Sub-graphic texture. Rods of dolomite elongated parallel to the *c* axis in calcite (at extinction). Chino limestone, Crestmore, California. Unstained thin section, ×46, photograph by Dr. Alden B. Carpenter.

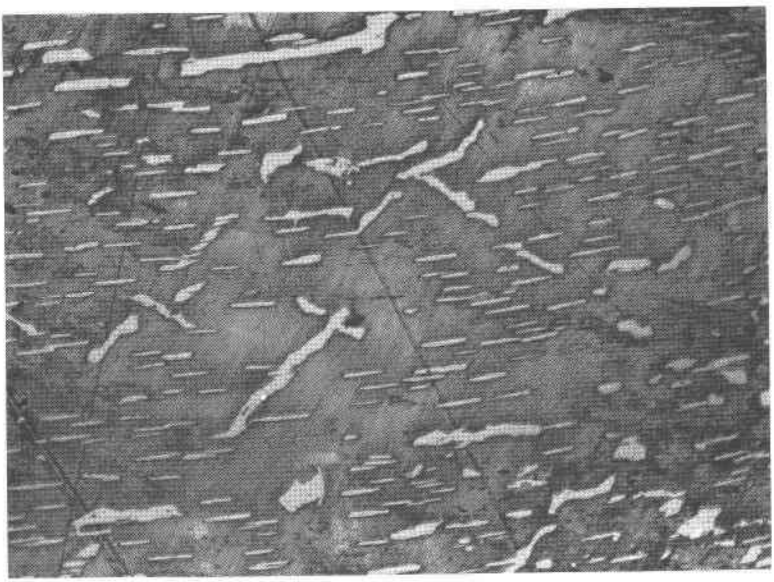

FIG. 2. Sub-graphic texture. Rods of dolomite in calcite. Younger banded carbonatite, Loolekop carbonatite (Palabora mines), Phalaborwa, Transvaal, Republic of South Africa. Polished section etched with diluted acetic acid, ×66.

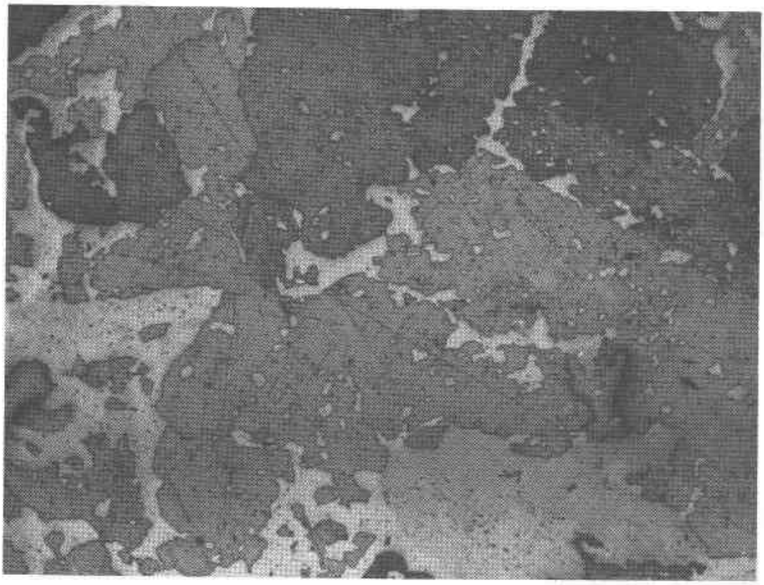

FIG. 3. Emulsion texture. Blebs and grains of dolomite (light gray, unetched) in calcite (darker gray, etched). Museum zone, Panda Hill carbonatite, Mbeya, Tanganyika. Polished section etched with diluted acetic acid. ×62.

Figure 4 illustrates a "replacement" texture. Dolomite occurs as blebs and as a "replacement" of calcite along cleavages and grain boundaries. Note the ultrafine dolomite "veinlets," sometimes less than 3 μ wide. Such "veinlets" could not be distinguished in calcite fields of stained thin sections.

Figure 5 shows a lamellar texture, which at first glance, appears to be an exsolution texture. Close inspection reveals, however, that this texture occurs only in the neighbourhood of periclase crystals which have been more or less altered to brucite. The calcite seems to have been partially replaced along polysynthetic twin planes by dolomite which appears to have come from dolomite coronas around the brucite grains and from dolomite veinlets in the rock. This process produces textures such as those illustrated in Figs. 4 and 5 which occur side by side in the same polished section. Again it should be noted that these features which are easily seen in polished section generally cannot be observed in stained thin sections.

Figure 6 also shows a "replacement" texture but in contrast to Figure 4 the calcite "veinlets" occur in dolomite. The majority of the calcite "veinlets" appear to follow the grain boundaries and cleavage planes of the dolomite. The width of the "veinlets" is very small (often less than 3 μ). The study of such ultrafine calcite textures in dolomite using stained thin

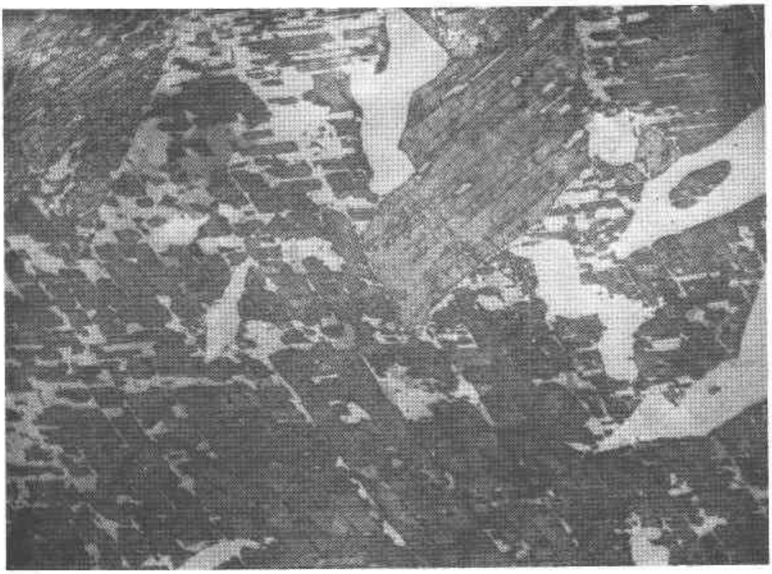

FIG. 4. Graphic to lamellae-layered texture. Dolomite grains and "veinlets" (light gray unetched) in calcite (darker gray, etched by diluted acetic acid). Chino limestone, Crestmore, California. Polished section, ×168.

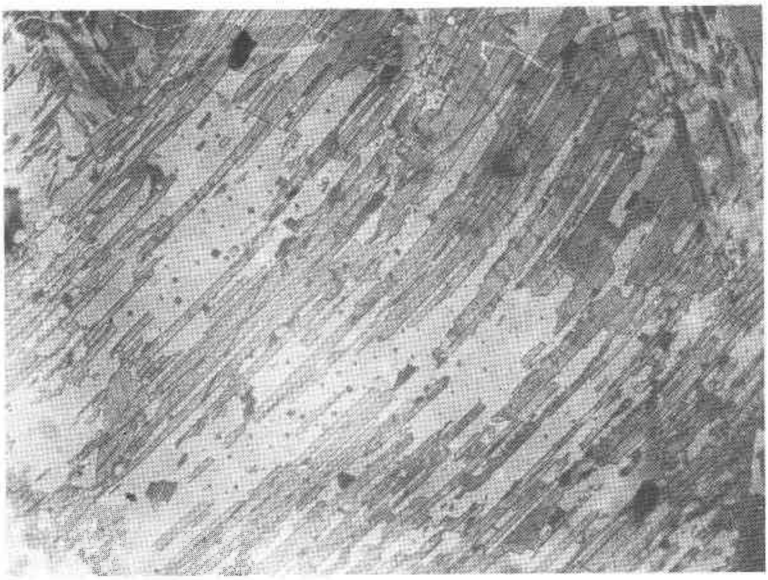

FIG. 5. Lamellar texture. Dolomite lamellae (light gray, unetched) in calcite (gray, etched). Chino limestone, Crestmore, California. Polished section etched with diluted acetic acid. ×168. Light gray halos due to internal reflection are visible locally.

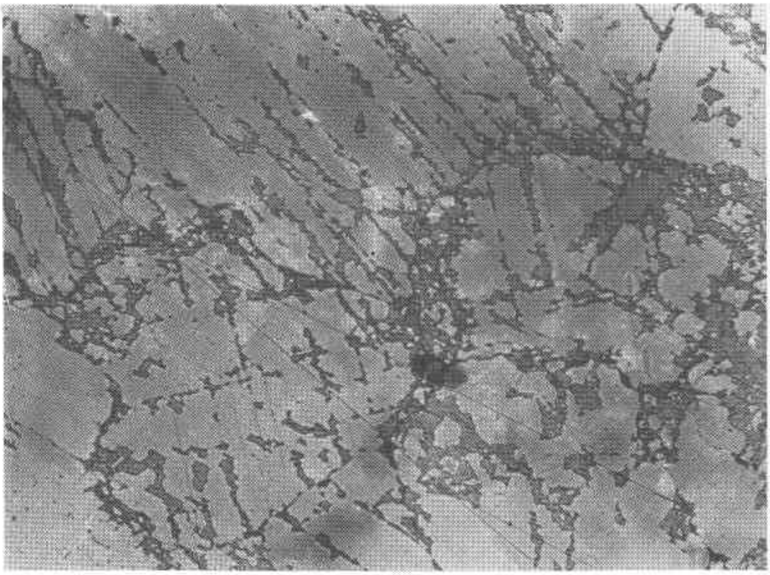

FIG. 6. Graphic to lamellae-layered texture. Grains and "veinlets" of calcite (gray, etched) in dolomite (light gray, unetched), Søvite, Ulefoss mine, Hydro deposit, Søve, Fen area, Norway. Polished section, ×169.

sections is often difficult although it becomes relatively easy when polished sections are used.

CONCLUSIONS

Emulsion, graphic, sub-graphic and lamellar textures of calcite and dolomite in high temperature carbonate rocks have been studied and illustrated. They resemble "replacement" and "exsolution" textures. The best method to study them is in reflected light using polished sections etched with acetic acid. This method is particularly suited to the study of the textural relationships between calcite and dolomite at high magnification. The method described above may also be of value in the experimental study of phase equilibria and textures in systems involving both calcite and dolomite.

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DTA AND QUENCHING METHODS IN THE SYSTEM CaO-CO_2-H_2O[1]

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INTRODUCTION

Harker (1964) recently described a simple technique for differential thermal analysis in closed systems containing volatile components under pressure, which promises to be of great utility. He contrasted the reaction temperatures recorded in his preliminary studies with those reported in the same systems by quenching techniques, and he noted some rather large temperature discrepancies. This led him to conclude that the accuracy of the quenching technique in systems where the liquid phase cannot be quenched to a glass "is often somewhat low and sometimes quite misleading." However, if the melting temperature of portlandite recorded by Wyllie and Tuttle (1960) is corrected as shown by Gittins and Tuttle (1964), the results obtained by DTA and quenching techniques are almost identical, and Harker's concern for the validity of the quenching technique becomes unnecessary, in this system at any rate. This note contains revised values for melting reactions in the system CaO-CO_2-H_2O measured by one of us (EJR) using the quench technique, and a discussion of this technique and DTA by the other (PJW).

REVISION OF THE SYSTEM CaO-CO_2-H_2O (QUENCH TECHNIQUE)

Univariant curves for the reactions plotted in Fig. 1 were published originally by Wyllie and Tuttle (1960, Fig. 15). For a pressure of 1 kilobar, 685° C. was reported as the binary eutectic temperature between portlandite and calcite, and 675° C. for the same reaction in the presence of a vapor phase composed of almost pure H_2O. It was later discovered

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