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Opinion

# The Low-Grade Metamorphic Origin of Ancient 'Drusy' Calcite that Simulates Diagenetic Druse

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## Opinion

Calcite is extremely reactive to pressure and is one of the first minerals to respond to low-grade metamorphism. Of the range of metamorphic products generated by calcite, Burkhard [1], for instance, proposed the appearance of calcite twins to be an approximate but rapid and easy-to-use geothermometer in low-temperature metamorphism. While there is a wide range of geological near-surface and surface environments in which calcite occurs with its myriad of crystal structures and forms [2], this article focuses on pore-filling calcite structures that occur interstitially within granular sedimentary carbonate rocks. The occurrence of pore-filling calcite structures within the cavities of quartz-rich, or polylithic sediments, or small-scale microkarst cavities etched into sedimentary rocks is another matter outside the scope of this article. Prior to the development of criteria to recognise pore-filling crystal fabrics [3,4], many inter-granular coarsely crystalline calcite fabrics, in the pre-1950s, would be misinterpreted as to depositional environment and/or to diagenetic history. Thus, Palaeozoic and Mesozoic size-graded drusy calcite had been considered as evidence of crystals filling interstitial pore spaces (and other cavities) and, as such, provided indication that the inter-granular calcite crystals were the result of pore-space precipitation and not recrystallisation of an interstitial fine-grained matrix [5]. However, in the past, to geologists, recrystallised muddy sand-framed limestones and druse-cemented sandy limestones seemed to be indistinguishable as to diagenetic history. Ancient inter-granular pore spaces of winnowed calcarenites filled with size-graded drusy calcite increasing in size toward the interstitial pore centre finally to be succeeded by a blocky equant calcite crystals in the central part of the pore were interpreted as pore-filling crystal mosaics. This entire apparent pore-filling fabric was viewed as the result of diagenesis.

While neomorphic calcite filling interstitial spaces still remained a problem for interpretation for geologists (of diagenesis, or neomorphism, or low-grade metamorphism), following the works of Bathurst, et al. [3-10], current-winnowed and wave-concentrated calcarenites versus neomorphically-coarsened carbonate-muddy limestones could be petrographically differentiated (albeit in patches). This would be useful to separate diagenetic pore-filling sparry calcite in winnowed calcarenites from neomorphic calcite from (low-grade) metamorphic calcite. Provided here is a model showing that this apparent diagenetic fabric can be produced by low-grade metamorphism. The requirements for this phenomenon are [11-13]: (1) polycrystalline carbonate grains such as pellets, recrystallised ooids, or lithoclasts in a framework array; (2) recrystallised blocky equant calcite or single-crystal blocky calcite filling the former pore; (3) strain in the interior blocky crystal resulting in calcite twinning; (4) later strain release resulting in recrystallisation of the blocky/equant calcite to smaller sized crystals; and (5) growth of the smaller crystals nucleating on the appropriately crystallographically-oriented calcite crystals of the polycrystalline grains framing the pore space and, with space-competing growth, the development of size-graded spar, simulating the appearance of pore-filling druse. The interior to the mosaic of the size-graded 'druse' is either a mosaic of blocky calcite or a single crystal of calcite.

The underlying mechanisms to create this apparent 'pseudo-diagenetic' druse are: calcite situated in the interstitial pore spaces of a carbonate grainstone, and with low grade metamorphism, will recrystallise into a blocky equant crystal aggregate and will accommodate further strain by generating twins, with the stain energy stored in the twin lamellae; secondly, recrystallisation of the strained calcite lattice can result in growth of smaller non-strained calcite crystals which will preferentially nucleate on the peripheral polycrystalline carbonate grains that frame the periphery of interstitial area; and thirdly, growth of calcite crystals from the pore periphery into the stained blocky crystal lattice will be space-competitive and will result in a size-graded druse-like mosaic simulating a diagenetic fabric. This style of crystallisation and arrangements of crystals is illustrated in Figures 9.15 & 9.19 in Scoffin [14]. The principles of calcite crystal growth in relation to pore space and the variability of pore-space substrates (e.g., coarse crystals such as echinoderm grains versus fine-grained substrates such as micrite grains) is complex with crystallisation, and potentially many cycles of recrystallisation. In effect, low-grade metamorphic calcite crystallisation is evident in interstitial pores with crystallisation and recrystallisation driven by strain energy underpinned by twin lamellae. A simplified illustration of 'pore-lining calcite' driven by strain energy is shown in Figure 1.

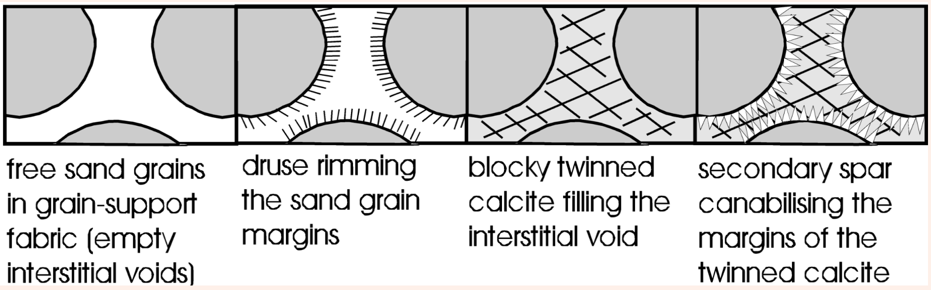


**Figure 1:** From left to right: (a) grain-support sandy calcareous sediment (the grains are fine-grained carbonate); (b) cemented carbonate sand with druse rimming the sand grains; (c) interstitial pores filled with (coarse) blocky calcite that itself is twinned; (d) coarse interstitial calcite that is growing by cannibalising the twinned blocky interstitial calcite.

## References


1. Burkhard M (1993) Calcite twins, their geometry, appearance and significance as stress-strain markers and indicators of tectonic regime: A review. Journal of Structural Geology 15(3-5): 351-368.
2. Brocx M, Semeniuk V (2010) The geoheritage significance of crystals. Geology Today 26(6): 216-225.
3. Bathurst RGC (1958) Diagenetic fabrics in some British Dinantian limestones. Liverpool and Manchester Geological Journal 2: 11-23.
4. Bathurst RGC (1959) Diagenesis in Mississippian calcilutites and pseudobreccias. Journal of Sedimentary Research 29(3): 365-376.
5. Bathurst RGC (1975) Carbonate sediments and their diagenesis. Developments in Sedimentology 12: Elsevier, Amsterdam, Netherlands.
6. Folk RL (1959) Practical petrographic classification of limestones. American Association of Petroleum Geologists Bulletin 43(1): 1-38.
7. Dunham RJ (1962) Classification of carbonate rocks according to depositional texture. In: Ham WE (Ed.), Classification of carbonate rocks. American Association of Petroleum Geologists Memoir 1: 108-121.
8. Flugel E (2006) Microfacies of carbonate rocks: analysis, interpretation and application. Springer, Amsterdam, Netherlands.
9. Boggs S (2009) Diagenesis of carbonate rocks. Petrology of Sedimentary Rocks.
10. Scholle P, Ulmer-Scholle D (2005) A color guide to the petrography of carbonate rocks: grains, textures, porosity, diagenesis. American Association of Petroleum Geologists Memoir 77: 1-486.
11. Rast N (1965) Nucleation and growth of metamorphic minerals. Geological Journal Special Issue 1: 73-102.
12. Hobbs BE, Means WD, Williams PF (1976) An outline of structural geology. John Wiley &Sons, New York, USA.
13. Suk M (1983) Petrology of metamorphic rocks. Developments in Petrology 9, Elsevier Scientific Publishing Co, Amstersdam, Netherlands.
14. Scoffin TP (1987) An introduction to carbonate sediments and rocks. Blackie & Sons, Glascow, Scotland.