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SHORT NOTE

Gypsum plate enhancement of cataclastic fabric in thin section

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Abstract—Individual fine particles in cataclastic zones (gouge) are often extremely difficult to distinguish in thin section in either plane- or cross-polarized light. It is equally difficult, using these techniques, to determine the relationship of fine fragments in gouge zones to one another or to their parent material. Cathodoluminescence can greatly improve such observations, but it too has limitations and requires special equipment. This paper discusses how using a gypsum plate, which causes light retardation, can enhance the interference colors of fine particles in gouge such that they are more clearly distinguishable. In addition, if cataclastic deformation within the gouge is not extreme, flow paths and origins for fine particles can be observed by using the gypsum plate, thus providing an easily available, inexpensive tool for the structural petrologist studying finely comminuted material.

INTRODUCTION

Cataclastic flow is a bulk strain process and, at all scales, involves the rigid body rotation and/or translation of intact particles with respect to one another. If these particles are sufficiently interlocked so as to prevent rotations or translations, during deformation they become fractured into smaller fragments so that bulk strain can occur by rotation and further comminution of these fragments. At the microscopic scale in sandstone, for example, such fragmentation occurs within sand grains. If the fractures that cause grain fragmentation emanate from isolated stress concentrations at separated grain contacts, and bulk strains are small, fragments remain relatively large, and rotations and translations remain small, so that the cataclastic process can be traced using plane- or cross-polarized light (among others Friedman 1963, 1969, Dunn *et al.* 1973, Engelder 1974). However, if fragmentation of grains is due to fracturing that emanates from multiple point contacts (crushed grains), and strains are high, as in highly deformed porous sandstones or along micro-faults, these petrographic techniques fail to distinguish the extremely small individual fragment outlines and, hence, their relationships to other fragments (Griggs and Handin 1960, Aydin 1978, Jamison 1979).

Cathodoluminescence can overcome some of the constraints that accompany microscopic study of cataclastic zones with plane- or cross-polarized light (Aydin 1977, Lloyd & Knipe 1992). However, as pointed out by Marshall (1988), this technique involves special, expensive equipment, is time consuming and is not accomplished without certain difficulties. Perhaps more importantly, assuming that most grains composing a given sandstone come from the same, or similar, provenances, the cathodoluminescence signature (diagnostic color) will be identical for all sand grains. While this allows individual fragments to be distinguished, there is no way to discern one fragment from another or their relationship to the parent sand grain.

There is another procedure that does not involve extra petrographic equipment, it is simple to use and enhances fine fragments in gouge, namely, the use of the half-wavelength gypsum plate. The interference colors produced by inserting a gypsum plate can improve the microscopic imagery of cataclastic zones, especially in deformed sandstones. While this technique is not necessarily new, its application in experimentally deformed rocks is not fully utilized.

TECHNIQUE AND RESULTS

The gypsum plate retards the wavelength of light passing through the ocular by 550 mμ, thus, increasing the interference colors. The interference color of quartz, for example, can be increased from low first-order colors of pale yellow or gray to brighter, low second-order colors by the insertion of a gypsum plate. This color enhancement not only makes individual, small quartz fragments easier to distinguish, it also permits fragments that are slightly rotated to be related back to the grain from which they originated. The underlying principle is that the interference color of a grain is related to its extinction point. Therefore, the fragments of a broken grain (with little or no undulose extinction) will have the same interference color providing there is not significant rotation. As such, the initial stages of cataclastic flow from initial fracture to primary fragment rotation and translation can be deciphered by using a gypsum plate.

This technique was employed while studying thin sections of experimentally deformed porous sandstones (Fig. 1). Because grain comminution is extensive in the experimentally created cataclastic zones, individual fragments become almost impossible to distinguish in plane light (Fig. 1a) and the results are the same or worse when using cross-polarized light. Individual quartz fragments in the same zone are readily distinguishable using the gypsum plate (Fig. 1b). It is also difficult to determine the amount of slip along the cataclastic zone (Fig. 1a). If the strain in an individual grain is essentially dilation, without much grain shape change, original grain boundaries can be identified by the grouping together of small fragments with the same interference color (Fig. 1b). As a result of using the gypsum plate, the small amount of slip (<1 grain diameter) is much easier to quantify. In this case, it appears that the grains have broken down essentially in place throughout the cataclastic zone. That is, the severe comminution is not produced by spalling of corners as the fragments rotate and translate. When grain strain proceeds to significant grain shape change by, for example, the rotation, translation and further comminution of peripheral fragments, the gypsum plate technique enhances grain fragment outlines and their relationship which would otherwise be difficult to see and determine (Figs. 1c & d).

SUMMARY

While the gypsum plate is primarily used in mineral identification, it can also aid structural petrologists in studying cataclastic zones in naturally, or experimentally, deformed rocks. The major benefits of the technique are two-fold: (1) identifying original grain outlines in crushed grains that have not yet begun to flow in bulk, and (2) observing the incipient flow path taken as grain fragments begin to move producing higher grain distortions. Though the cathodoluminescence technique provides similar results, in some instances, the gypsum plate technique does not require the purchase of special equipment nor is the time investment as great to produce the same results.

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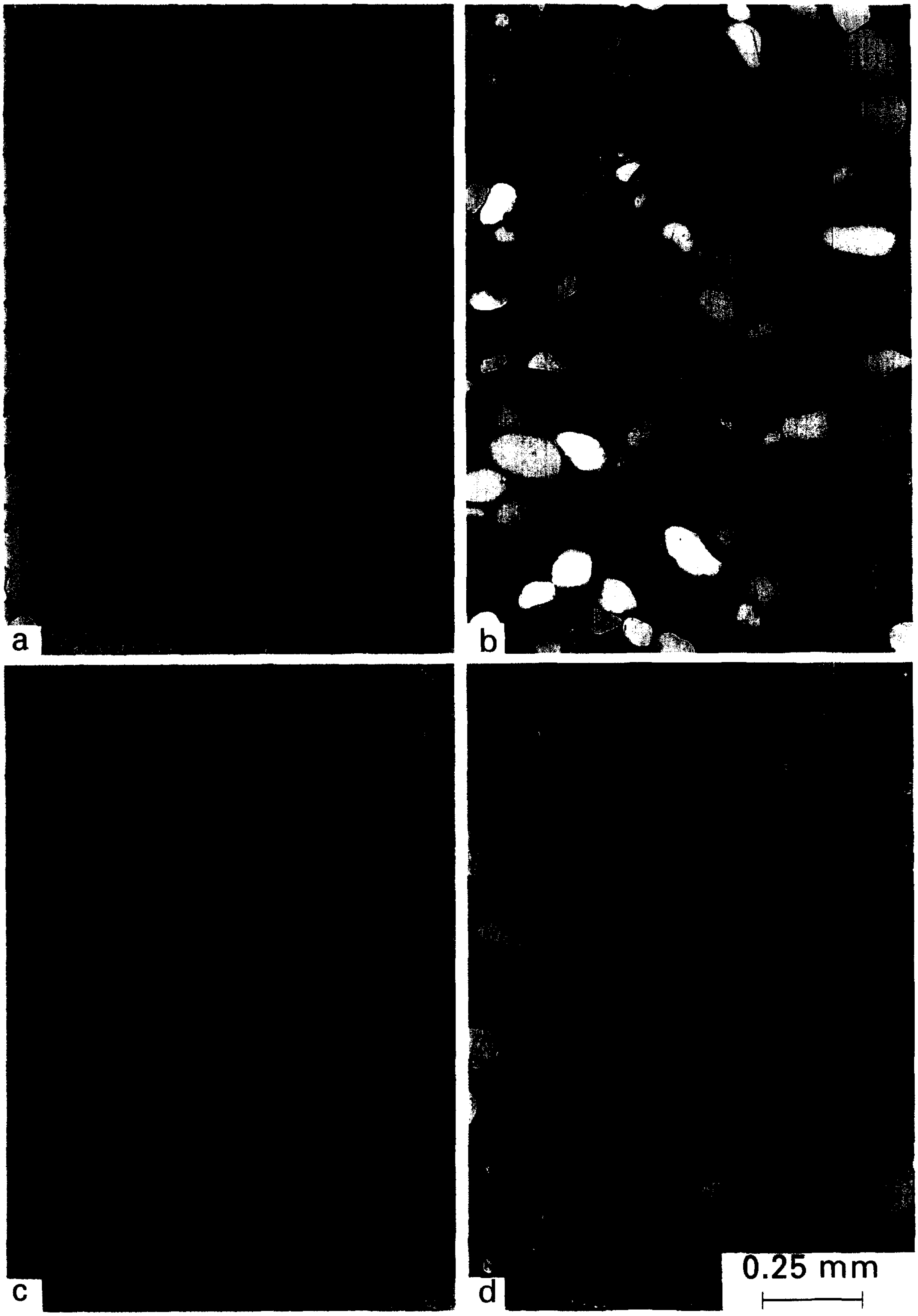

Fig. 1. Photomicrographs of experimentally produced cataclastic zone in a porous sandstone: (a) plane light. The degree of grain comminution is extensive and individual fragments and their relationship to each other and their parent grain are indiscernible. (b) Same location as in (a), but taken using a gypsum plate. Compare the features within the box in (a) to the same region in (b). Artificial enhancement of the interference color of quartz makes individual grain fragments easier to identify and original grain outlines easier to reconstruct. (c) Plane light. It is almost impossible to determine how the particles relate to one another due to the intense comminution. (d) Same location as in (c), but taken using a gypsum plate. Compare the features within the box (a) in (c) to the same region in (d). What appears as a highly disaggregated mass in (c) is actually several grains that have broken down in place. Box (b) illustrates the effect of fragment rotation on interference color. Fragments of the grain in box (b) have started to rotate which produces a gradational change in the interference colors, but it is still possible to see how they relate to each other.