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INTERPLAY OF CEMENTATION, MECHANICAL AND CHEMICAL COMPACTION IN EARLY SILURIAN PHACOIDAL (NODULAR) LIMESTONES OF THE PINDAYA RANGE, SOUTHERN SHAN STATE

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Abstract

The phacoidal (nodular) limestones of early Silurian age were studied in three selected areas on the Pindaya Range of Southern Shan State. In Yegyanzin area, the limestones are entirely crinoidal; the Linwe area are red crinoidal limestones, grey ostracoda limestones and lime mudstones; while the Thayetpya area consists of grey ostracoda limestones and lime mudstones. The limestones commonly show evidence of early lithification taken place near the sediment/water interface.

Petrographic observation of both mud and grain-supported facies being rich in crinoids, brachiopods, trilobites, thin-shelled bivalves enabled the reconstruction of the digenetic evolution. Some layers, underwent a phase of early lithification, acquired a rigid framework that prevented deformation and rearrangement of grains during later burial. In the mud-supported facies, the effects of subsequent mechanical and chemical compaction are easily recognizable. Mechanical compaction includes overburden pressure, flattened burrows, fossil breakage, shrinkage pores and transformation from wackestone to packstone fabrics. The response to chemical compaction varied with texture; grain-supported sediments developed fitted fabrics whereas in mud-supported sediments stylolitic seams were generated. As a result of these diagenetic processes, laterally extensive stylolities would have developed in these phacoidal limestones.

Introduction

This paper describes compaction mechanisms in limestones and relationships among cememtation, mechanical compaction, and chemical compaction are considered as the complex diagenetic history of the purple and grey phacoidal (nodular) limestones of the early Silurian age. Petrological observations of both mud-supported facies (Thayetpya area) and grain-supported facies (Yegyanzin and lower parts of Linwe area) which are rich in thin-shelled bivalves, crinoid and brachiopod enabled reconstruction of the diagenetic evolution. Difference in the original composition and texture of sediment certaintly influence the development of burial diagenetic features. To clarify the effects of these differences, I focused on particular lithologies composed mainly of one kind of skeletal grain for an initial comparative study of compacted and uncompacted textures. The location map of the present study area is shown in Figure (1).

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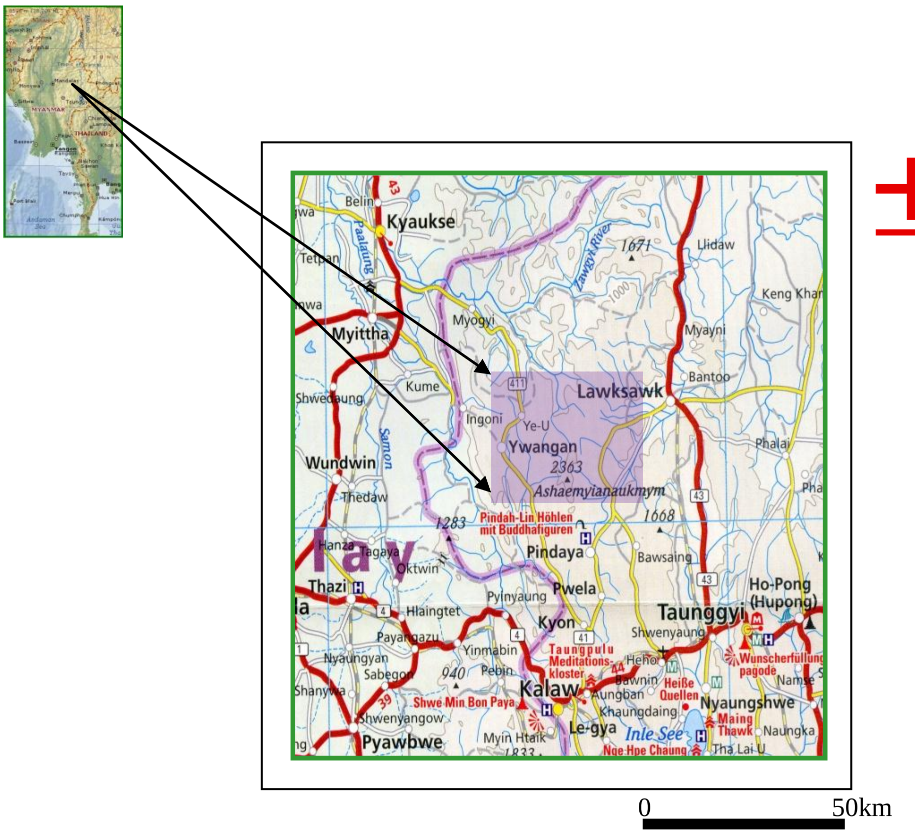


Figure 1 Location map of the study area

Materials and Methods

The petrographic study was based on nearly 90 samples obtained from the three studied areas. In the phacoidal limestone, only indirect method can be used becaused direct measurement of deformation objects of known original size and shape is not possible. Two parameters of carbonate sediments have been used: percentage of clay and percentage of grains which are not modified by diagenesis. On the basic of these considerations, Ricken (1986) mathematically related the percentage of compaction, K, rock porosity, n, carbonate content of the rock, C, and the standardized non carbonate fraction NC_d (i.e., the clay content in the original uncompacted sediments).

Lithofacies Description

Crinoidal Limestones

These crinoidal limestones can be observed in the Yegyanzin area. They are pink to purple, medium-bedded, argillaceous seam in some horizon, thickening-upward sequence (Fig. 3a). They have sand-sized crinoid fragments, with lesser amounts of brachiopods, bryozoans, trilobites, and other allochem. Two types of crinoidal limestones can be distinguished: crinoid-dominated zones, with syntaxial overgrowth cements and rim cements and few pressure solution feature: less crinoid-rich rocks which are lack of substantial cementation. In the first type, syntaxial overgrowths on crinoids are abundance and minor sparry calcite cement is seen on microcrystalline substrates. In the second type, cementation is minor, both crinoidal and other allochem grains are fitted in an interlocking pressure solution mosaic.

Phacoidal Limestones

These phacoidal limestones are encountered in the Linwe area. The limestones are purple colour phacoidal limestone at lower horizon and grey colour phacoidal limestone at upper horizon. Phacoidal limestone (0-25 m thick units) consists of medium-bedded, purple bioclastic wackestone and mudstone with some bioclastic packstone (Fig. 3b). Fossils are very poorly sorted and are highly diverse. The packstone contain 5 to 30 percent fine-grained matrix which reduces visible pore spaces. Cementation on brachiopod fragment mask in matrix indicates early lithification, acquired a rigid framework that prevented deformation and rearrangement of grains during later burial.

Bioclasts-bearing limemudstones

These bioclasts-bearing lime mudstones are observed in the Thayetpya area. The limestones are grey, medium-bedded limestones contains less than 10 percent allochems, most of which are ostracods and large brachiopod and trilobite, slightly phacoidal appearance (Fig. 3c). The bioclasts are sometimes attained their size as large as 1 mm and these fragments are cemented by bladed calcite.

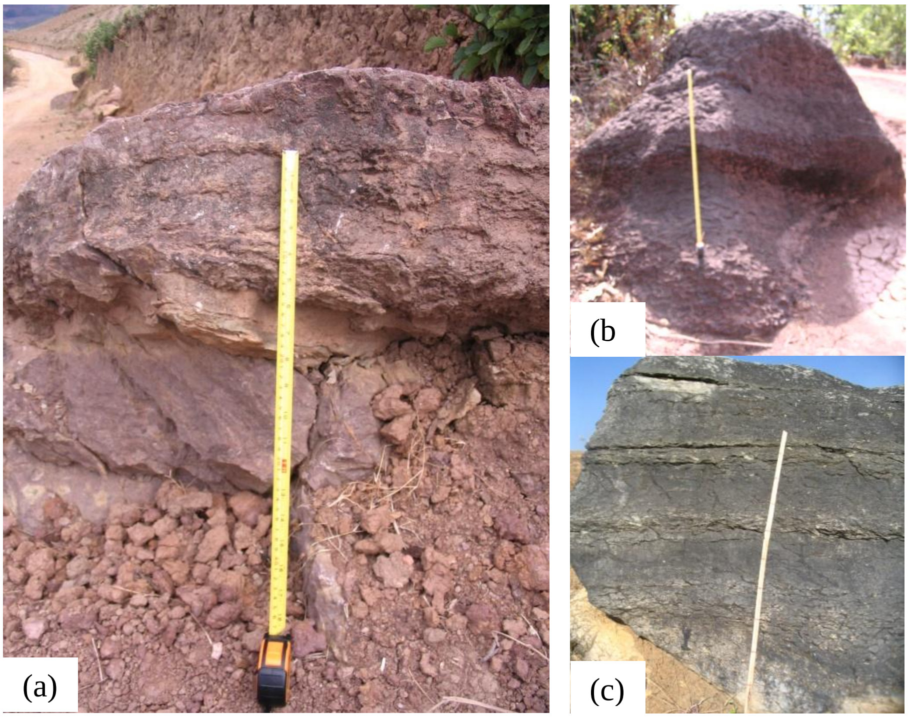


Figure 3 Outcrops of the Silurian limestone from (a) Yegyanzin area (b) Linwe area and (c) Thayetpya area

Discussion

There are three fundamental styles of diagenesis in the phacoidal limestones: cementation, mechanical compaction and chemical compaction.

Cementation

Early cementation affected on bioclastic grains is recognized. The type of cement depends particularly on Mg/Ca ratio and salinity of the solutions. In the crinoidal grainstone, early cements consist of clearly recognizable syntaxial overgrowths and rim cement (Fig. 4). In the phacoidal wackestone and grey bioclastic mudstone, early cements are bladed cement on brachiopod fragments. A growing body of evidence obtained by petrographic study suggests that much of the cement in ancient peritidal, shallow-marine, and platform-margin limestone may also have formed during deep-burial diagenesis (Sam Bogg, 2009). Cementation can take place when pore fluids are supersaturated with respect to the cement phase and there are no kinetic factors inhibiting the precipitation.

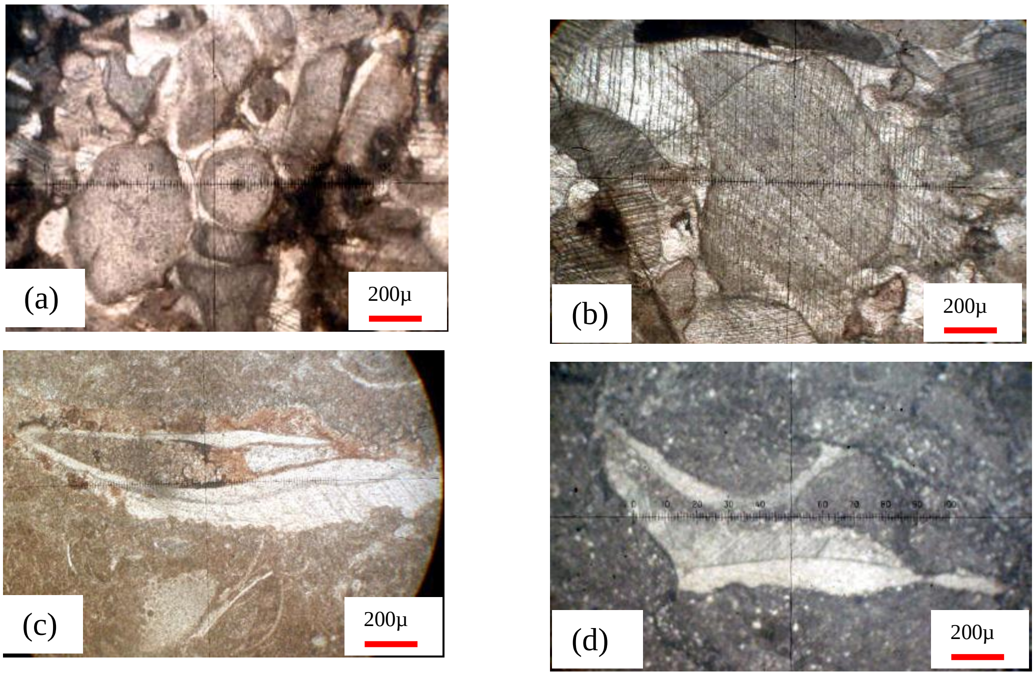


Figure 4 Types of cements (a) rim cement (b) syntaxial overgrowth (c) bladed cement (d) bladed cement within nodule

Effects of Mechanical compaction

Physical compaction may affect loss of porosity and numerous other effects on sediments. Most of the mechanical compaction is fossil breakage and wackestone to packstone. Breakage of the most part is readily apparent and separated by fine sediments (Fig. 5). The extent of porosity loss and thinning of bed and other mechanical compaction effects is related to the degree of early cementation in the sediments. If extensive intergranular cementation takes place in either the seafloor or shallow meteoric diagenetic environments, compaction effects are moderated (Moore, 2001 in Sam Bogg, p.432). It is assumed that sand-size crinoid fragments floating in mud, that is wackestones, have been forced together so that grains are in contact and intergranular spaces filled with mud; a packstone had been produced simply by mechanical compaction (Fig. 5).

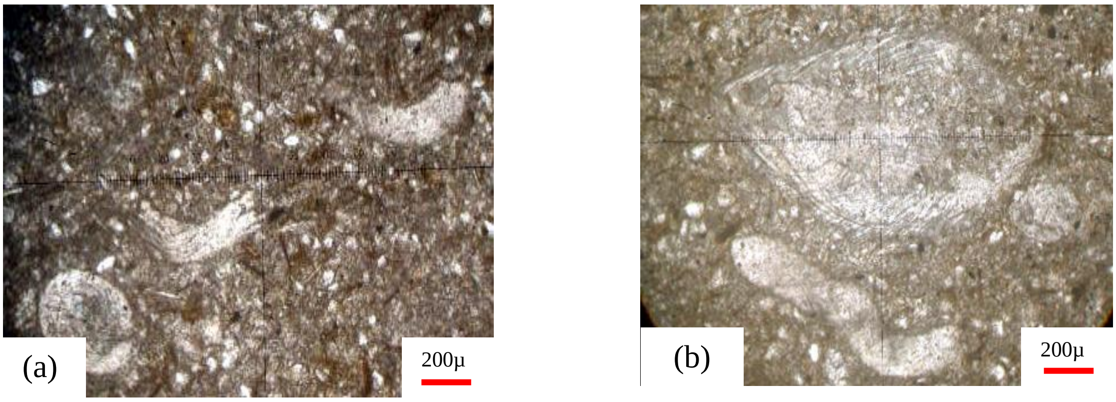


Figure 5 Mechanical compaction (a) fossil breakage (b) fossil twist

Effects of Chemical compaction

The most obvious chemical compaction in the crinoidal limestones of Yegyanzin area is stylolites, solution seams and grain-to-grain solution. Grain-to-grain pressure solution at the contact points of individual grains can result in the formation of interpenetrating or sutured contacts (Fig. 6).

Creation of these features is accompanied by reduction in bulk volume of the rocks and subsequently loss in porosity. Pressure solution begins after mechanical compaction is essentially complete and a stable grain framework has been created. Load or tectonic stress transmitted to grain-to-grain contact points or surfaces causes dissolution at the contact. Solid calcium carbonate is changed to liquid creating a solution film. Calcium and bicarbonate ions released into solution move away from the stressed contact point or surface by solution transfer toward adjacent areas of pore space.

Stylolites are serrated boundaries between units; the boundaries usually have an accumulation of clay, iron oxides, and/or organic matter. In general, solution seams are smooth, undulating boundaries between units, lacking the sutured form of stylolite. They also have an accumulation of clay or other material. These three types of pressure solution features are stylolite, wispy seam and solution seam. Stylolite are sutured surface of interpenetrating colunms that are laterally continuous surface and amplitude ≥ 1cm. Wispy seam is converging and diverging sutured to undulose surfaces that are laterally discontinuous and insoluable residue accumulation along individual surfaces ≤ 1mm. Solution seam is undulose sufaces, laterally continuous and insoluble accumulate.

The important of “fitted fabric” texture as a major category of pressure solution features was recognized by Logan and Semeniuk (1976). Fitted fabric pressure solution differs from pressure solution along stylolites and solution seams in that fitted fabric dissolution occurs pervasively throughout a zone affecting all grains whereas stylolites and solution seams are planar features.

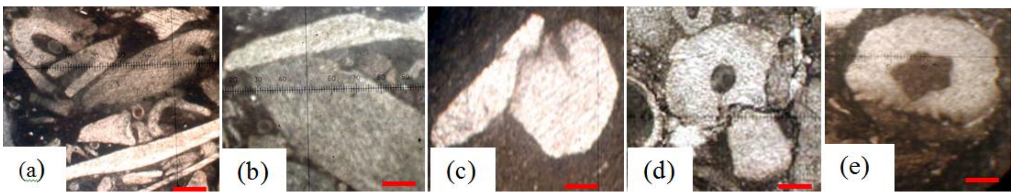


Figure 6 Grain to grain solution (a) point contact (b) line contact (c,d) concavo-convex contact (e) suture contact, scale bar = 100 µm

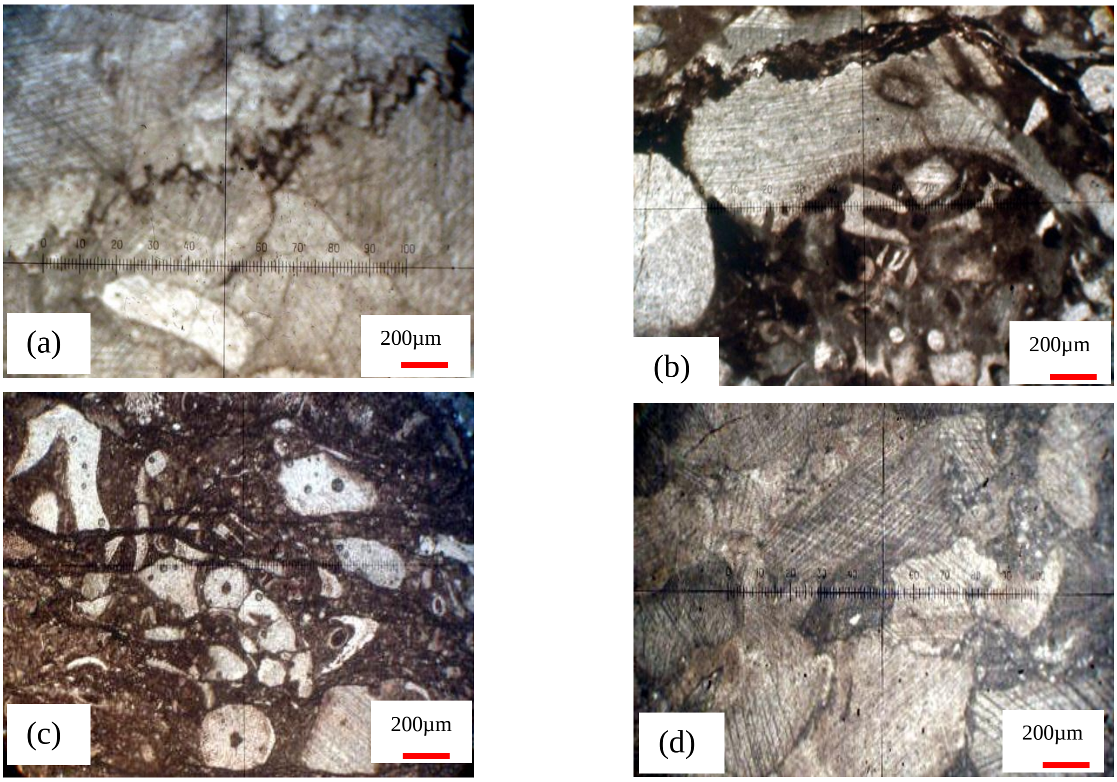


Figure 7 Kinds of pressure solution features (a) stylolite (b) wispy seam (c) solution seam (d) fitted fabric

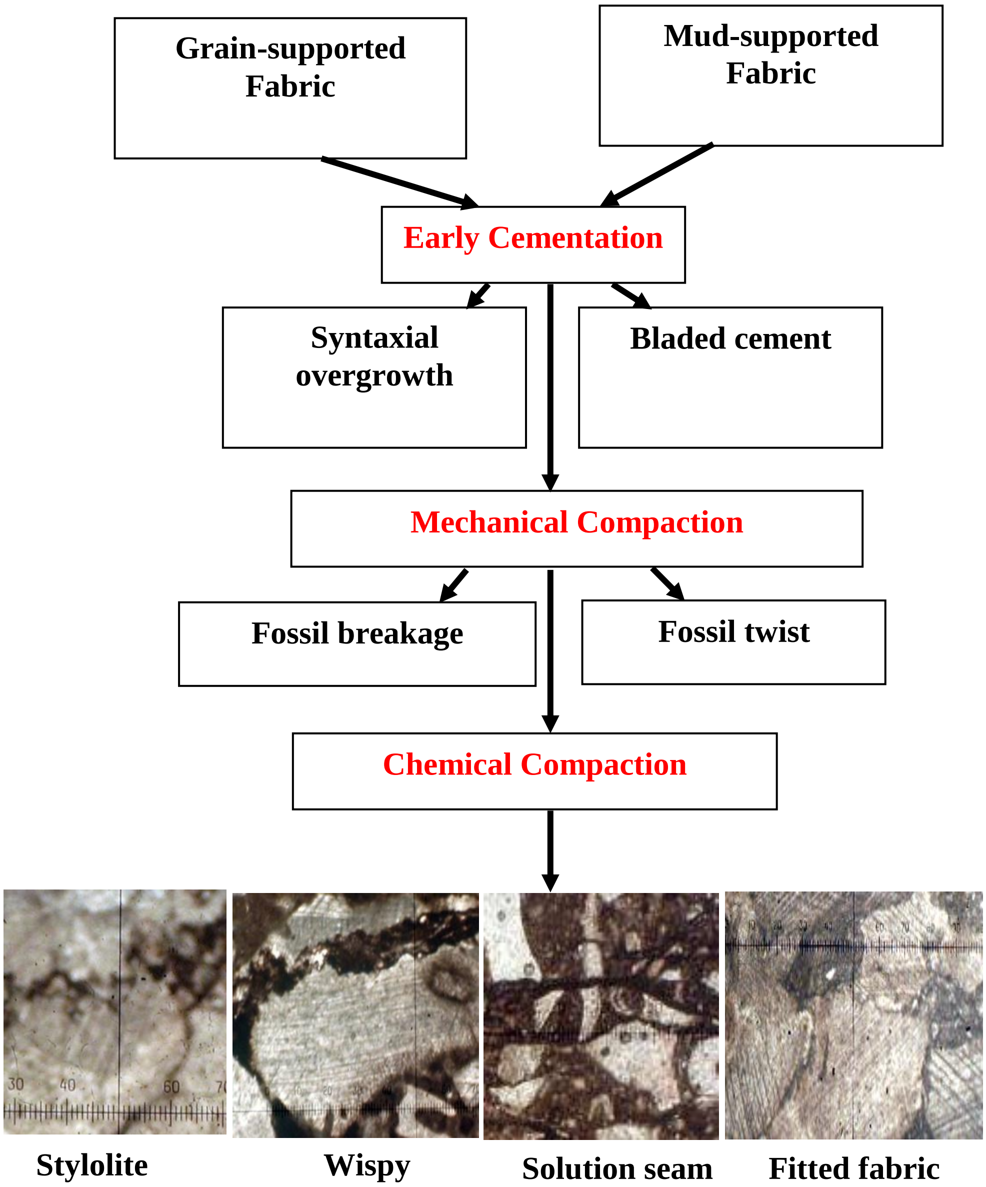
Results

The Interplay among the sedimentation, bioturbation and cementation reached the highest complexity in the phacoidal limestone; burrowing was active and changed in sedimentation style in crinoidal limestones, and sedimentation may have ceased for long enough to allow complete cementation on bioclasts in phacoidal limestones and bioclastic lime mudstone.

Clays disseminated in carbonate mud would not become organized into anastomosing microstylolite-like seams simply by physical compaction. These are a product of pressure dissolution of carbonate. Organic layers resulting from soft-sediment compaction might initiate chemical compaction during and after cementation resulting stylolites. Stylolitization would proceed further with increasing depth of burial.

In the grainstones, early cements consist of clearly recognizable syntaxial overgrowths and rim cement. In the wackestones, early cements are obviously larger bioclastic fragments. Besides, stylolite and fitted fabric are common in crinoidal grainstones whereas wispy seam and solution seam are observed in packstone-wackstone.

Some layers, underwent a phase of early lithification, acquired a rigid framework that prevented deformation and rearrangement of grains during later burial.



Conclusion

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