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FOREWORD

Mineral processing is an art of treating raw ores in order to separate valuable minerals from the waste rock as well as preparing mineral products for specific needs. It is the first process that most ores undergo after mining in order to provide concentrated material for the downstream metallurgical processes. The primary operations are comminution and concentration, but there are other important operations in a modern mineral processing plant, including sampling and analysis and dewatering. In mineral processing, a number of unit operations are required to prepare and classify ores before the valuable constituents can be separated or concentrated and then forwarded on for use or further treatment. Mineral processing education at the Istanbul Technical University has started as a division of the "Mining Engineering Department" which was founded as a part of the Mining Faculty in 1953. The division was re-organized as a Mineral Processing Engineering Department of the same faculty in 2007, in order to meet the requirements of engineering education. It is the first and only one in Turkey.

The first Balkan Mineral Processing Congress was held in Varna, Bulgaria in 1973. The “XVIIth Balkan Mineral Processing Congress – BMPC 2017” is organized by ITU Mineral Processing Engineering Department and the Turkish Mining Development Foundation between November 1 and 3, 2017, in Antalya-Turkey. “BMPC 2017” will bring together a large number of academicians from Turkey and many other countries as well as the authorities from the companies that are operating in the mining, mineral processing, and extractive metallurgy industries in order to create an opportunity to evaluate the future of the sector. In this context, BMPC represents a technical platform for the safe and sustainable future of the mining and mineral processing industries in Balkan Countries. We are inviting you to become a part of this global challenge by attending our congress through participation, presentation, exhibition and supporting our activities. In this respect, Antalya with its dynamism and diversity presents a unique opportunity for the attendees. We assure you that we will provide all means to make you enjoy and benefit from this extraordinary event.

The Congress will gather over one hundred professionals and academics from all over the world to exchange knowledge and experience, to present the results of scientific research and to discuss innovations in the mineral processing industry. Universities specializing in mineral processing, a number of important mining companies, major leading providers of services and technologies will participate in the Congress.

We are very pleased to welcome you to attend and we are sure you will enjoy the Congress from both scientific and social points of view. Looking forward to meeting you in Antalya!

Prof. Dr. Fatma Arslan | Prof. Dr. Ayhan Ali Sirkeci

FOUNDATION'S FOREWORD

As Turkish Mining Development Foundation, we are happy to be organizer of 17. Balkan Mineral Processing Congress. I would like to express my sincere thanks to the Balkan Scientific Committee, Turkish Organization Committee, to the Sponsors, exhibitors and all the attendees. Our special gradidute to Istanbul Technical University, Mining Faculty and Mineral Processing Department.

We wish successful and fruitful congress and sunny days in Antalya.

With kind regards,

Prof. Dr. Güven Önal

President of Turkish Mining Development Foundation

Balkan Scientific Committee Member

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INVESTIGATION OF THE EFFECTS OF CLAY IMPURITIES ON CERAMIC TILES AND NOVEL METHODS FOR IMPROVEMENTS

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ABSTRACT

Kaolin and clays form the basis of classical ceramics due to their plastic shaping properties. Clays usually occur under certain conditions, from the dissociation of feldspars or the dissolution of volcanic rocks. Besides the clay minerals formed by the collapse of the rocks, there are feldspar, quartz, mica, iron minerals (pyrite, hematite, goethite, etc.), carbonate minerals (Siderite - calcite) and rock deposits such as anatase. Minor minerals in the clays form raw material-induced defects on the surface of the tile. Due to the necessity of using the sources of regional raw materials, the minor minerals in the clays must be identified, reduced to a size that does not cause a defect, or completely removed. Especially the mica minerals cause breaks on the surface of the fired tile.

Clays and kaolin are used in floor and wall tile production recipes between 30-40%. 80-85% of the clays used in recipes are Regional clays (Şile - Konya - Söğüt) and 15-20% of them are Ukrainian clays.
In this study, the effects of clays originated Şile Region that are used at 30% on the glaze porcelain recipe were examined and the separation methods of impurities were sought. The clay sample used in production was subjected to sieve analysis in the laboratory and sieve residue was defined 150, 90, 64, 45 and 32 micron. Optical microscope and SEM images were taken. Optical microscope, chemical analysis and XRD analysis were also performed on the sieve residue given above. The type of impurities and their effects on the creation of defects in products have been diversified. It has been found that defect caused by impurities of raw materials is characteristic and vital on the product quality.
Along this finding; the possibility of reducing the effects of impurities through grinding the coarse sized impurities to finer size were studied. Also a new method for separating the impurities was suggested. A design of new separation system was developed in Kaleseramik production line in Can location of Turkey.

Key words: Clay, impurities

1. INTRODUCTION

Ceramic bodies used for floor and wall tiles fabrication are normally composed of a complex mixture of different raw materials (1). The ceramic raw materials can be grouped in two classes: plastic and nonplastic. The plastic raw materials are essentially the clays and the kaolin that have, as their main function, to supply plasticity and to provide adequate mechanical strength for both, the green and dried body pieces. Among the non-plastic raw materials, feldspars, calcite, dolomite and quartz are the most used.

For preparing body recipes, raw materials are ground and sieved in wet system together then granulated in the spray driers. Granulated powders are sent to the shaping, glazing and sintering processes. Finally sintered tiles are elected by quality control department. Clays provide a basis of traditional ceramics by the reason of the plastic properties for shaping tiles. 30-40% amount of clays are used in both floor and wall tile body recipes. In Turkey, 80-85% of regional (İstanbul, Söğüt, Konya) and 15-20% of Ukraine clays are applied to the ceramic bodies. In 2015, 2.048.000 tons of clay was used for ceramic tile production (Seramik Türkiye, 2016). Clayey raw materials for ceramic production have been widely surveyed, especially in the areas of industrial ceramic application (Vieira et al., 2008; Celik, 2010; Dondi et al., 2014).

Generally clays are comprised of feldspar decomposition and volcanic rock dissolve under specific conditions. Clay is a fine-grained natural rock or soil material that combines one or more clay minerals and contain feldspar, quartz, mica, iron compounds(siderit-hematit- goethite) , titanium compounds(anatas –rutil), carbonate minerals and organic content partially. Clays are plastic due to the water and organic content and become hard, brittle and non–plastic on drying or firing. Organic content of the clays enhance plasticity and shaping property in connection with the extended surface area (Malkawi et al., 1999). Clay and trace minerals affect plasticity, physical, mechanical and sintering properties of the raw material (Mandour M.A. 1989, Önal M. 2009). Trace minerals such siderite, calcite, hematite may cause raw material based defects on the tile surface. It is important to identify and remove such trace minerals due to the necessity of using regional clays in the ceramic bodies because of the economic conditions.

2. MATERIALS AND METHODS

2.1. Material Characterization

In this research İstanbul Şile region clays was used for the experimental study. XRF and XRD analysis were done in order to characterize the material. The chemical composition of clays was obtained by XRF that was illustrated in Table 1.The material was also analyzed by X-Ray diffraction to describe the mineralogical structures. Figure 1 shows the X-Ray diffraction patterns of İstanbul Şile region clays which give the peaks of quartz, illite, kaolinite and anatase. Impurite minerals of İstanbul Şile Region clays showed anatas, siderit, feldpars, hematite.

Table 1**.** Chemical Composition of Clays

	*LOI	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Na_2O	K_2O
Clay A	7.67	58.55	23.61	1.10	4.68	0.27	0.88	0.17	2.92
Clay B	8,16	60,82	22,94	1,21	2,87	0,56	0,97	0,20	2,11
Clay D	8,48	59,27	24,50	1,42	3,32	0,21	0,71	0,09	1,87

*LOI: loss of ignition

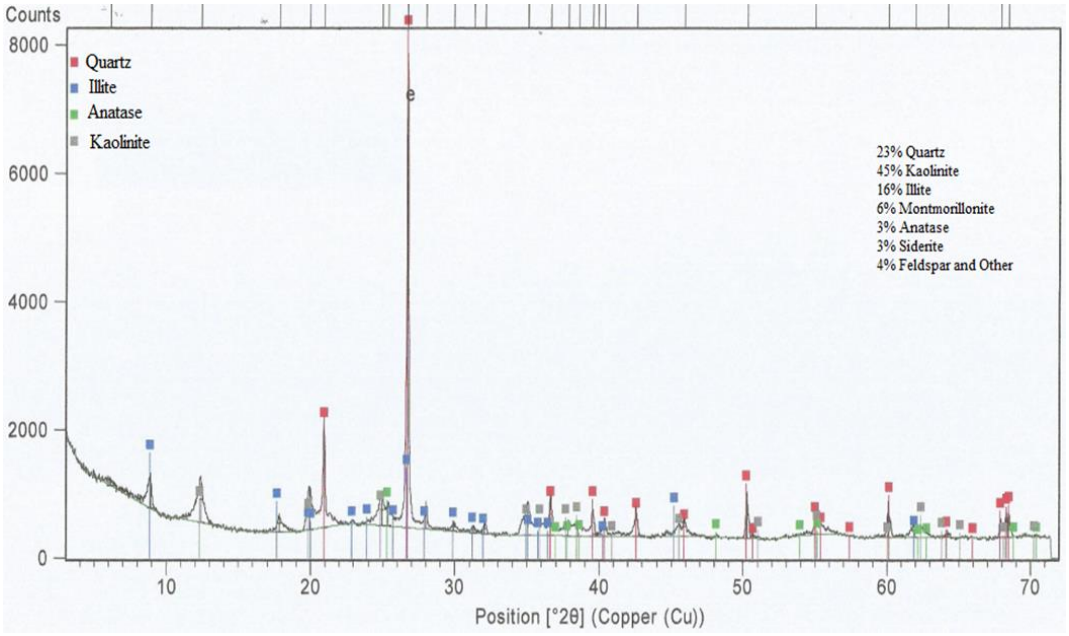


Figure 1. shows optical microscope images for +125, -125+90, -90+63, -63+45 µm size fractions at CLAY A.

Siderite, hematite, mica minerals, feldspar, quartz and organic materials are found for each size fractions. It can be seen that organic materials densified at +125 µm but are seen other size fractions too. Quartz and feldspar increases while coloring minerals decreases for -63+45 µm fraction.

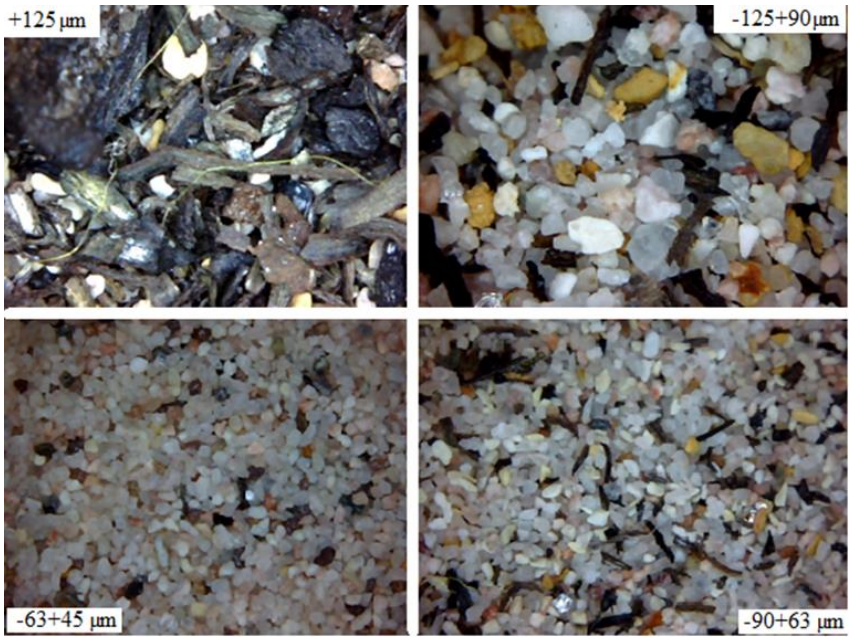


Figure 2. Optical Microscope Images for Size Fractions- CLAY A

Figure 3 shows optical microscope images for +125, -125+90, -90+63, -63+45 µm size fractions at CLAY B. Siderite, hematite, feldspar and quartz are found for each size fractions. It can be seen that iron materials

densified at -125+90 µm but are seen other size fractions too. Figure 4 shows optical microscope images at CLAY C.

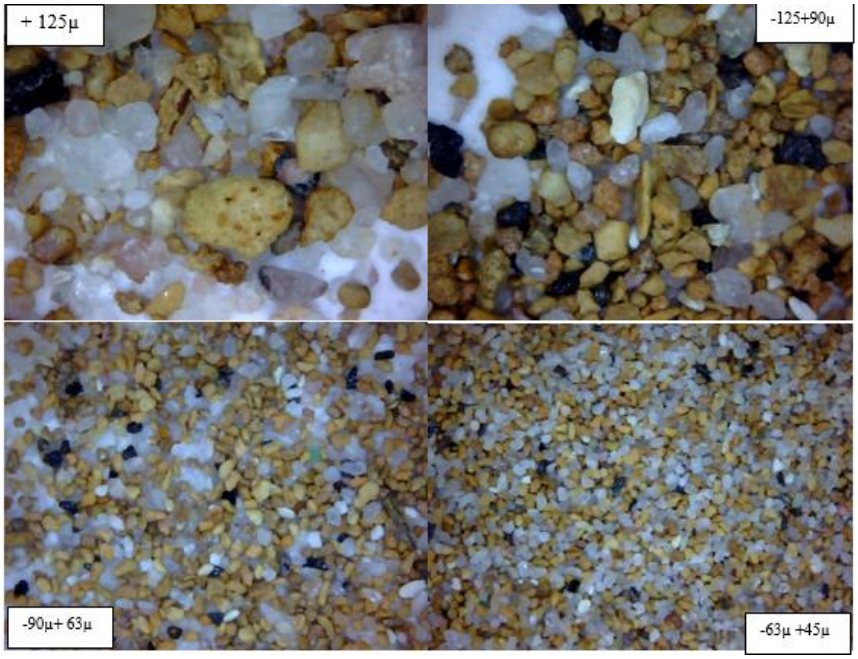


Figure 3. Optical Microscope Images for Size Fractions- CLAY B

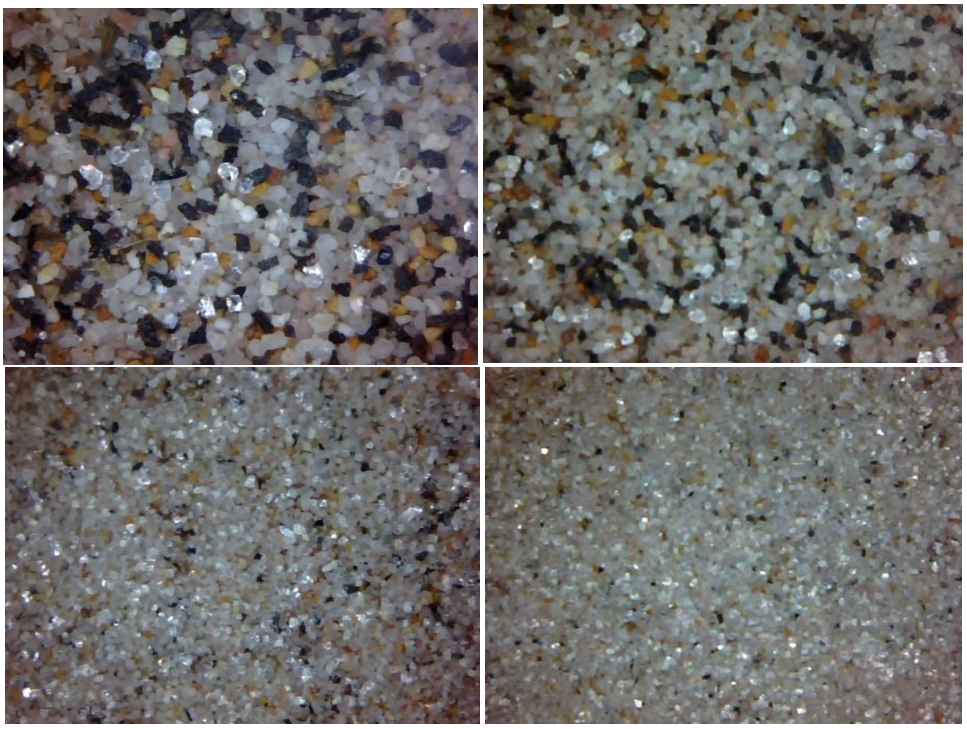


Figure 4. Optical Microscope Images for Size Fractions- CLAY C

2.2. Tile Defects, SEM Images and EDX Analysis

Tile defects were taken from the industrial production lines. Defective region of the tile was cut diamond cutting saw then the source of the defect was displayed by Scanning Electron Microscopy (SEM) and analyzed by Energy Dispersive X-Ray Analysis (EDX).

Figure 5 shows the big sized quartz particle and effect on the tile quality defect. The defect was shown with SEM image and EDX analysis. EDX analysis gave 25.5% Si, 58.9% O and 15.6% C in atomic percentage.

Figure 6 shows the sintered iron mineral and effect on the tile quality defect. The defect was shown with SEM image and EDX analysis. EDX analysis gave 38.2% Fe, 43.8% O and 14.7% C in atomic percentage.

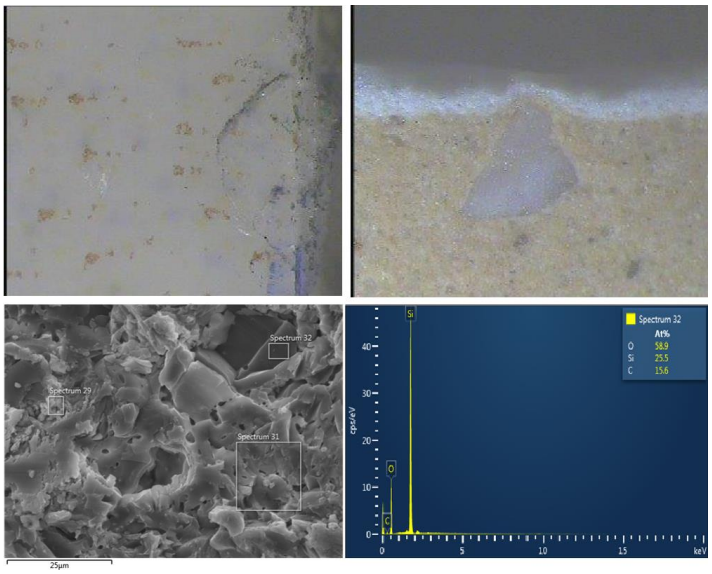


Figure 5. Quartz Defect on the Sintered Tile

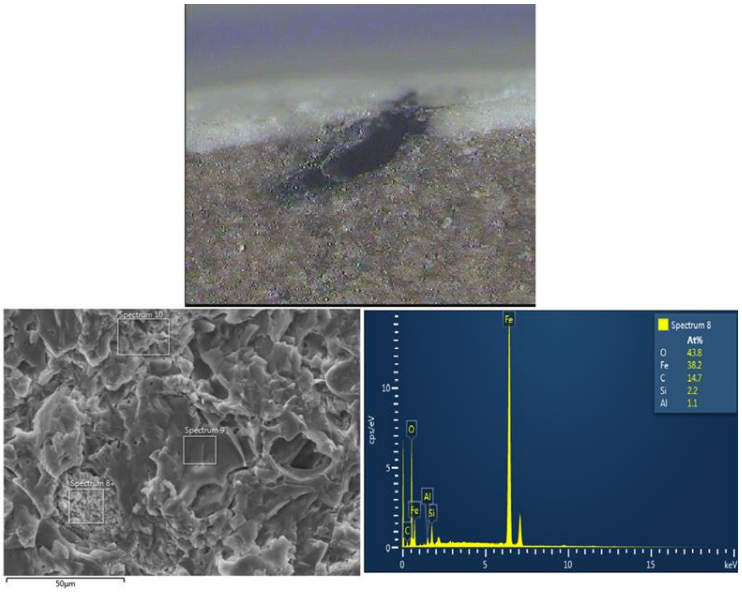


Figure 6. Iron Mineral Defect on the Sintered Tile

Figure 7 shows the sintered organic matter and effect on the tile quality defect as blackcore. The defect was shown with SEM image and EDX analysis. EDX analysis gave 43.2% C and 45.6% O in atomic percentage.

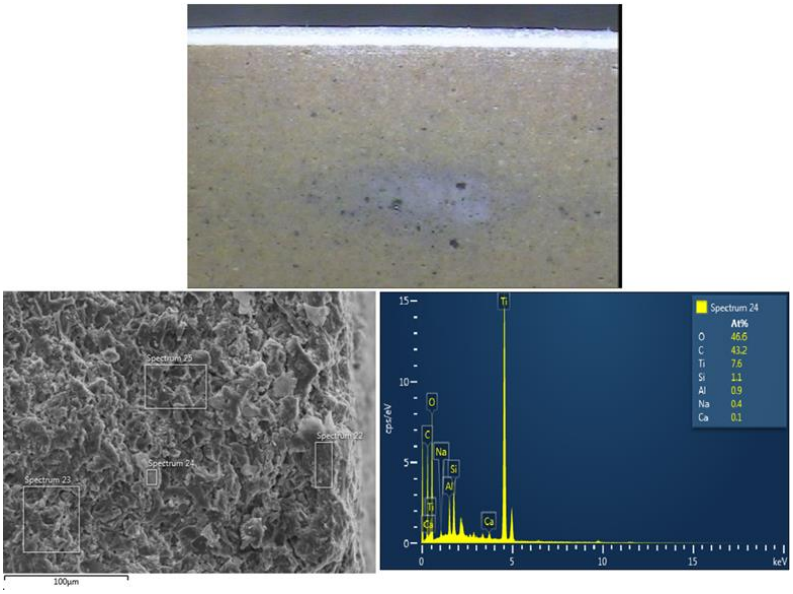


Figure 7. Organic Matter Defect on the Sintered Tile

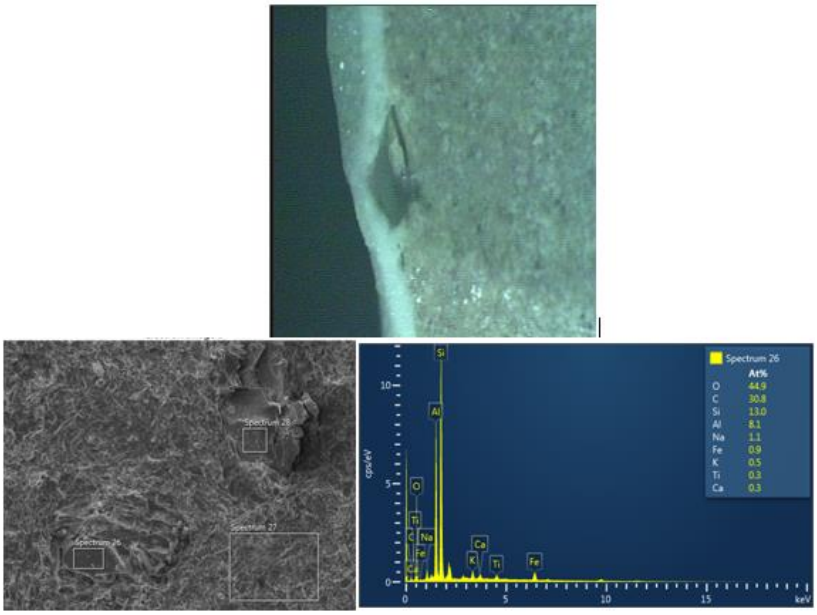


Figure 8. Mica Defect on the Sintered Tile

3. RESULTS AND DISCUSSION

As a ceramic raw material clay consists of organic materials, quartz, iron minerals etc. in terms of impurities. Clay was defined as -4 µm grain sized sedimentary minerals and plastic material. Therefore, clays are used by mixing with blungers and following sized by screens in the ceramic processing technology. Most of the impurities are eliminated by screening process but the rest causes quality defects on the tile surface.

There are some solutions to remove such problems but these solutions must be applicable with the current process because of the economic reasons. In present ceramic body preparation process, plastic materials like clay is used by mixing and non-plastic materials like feldspar is used by grinding in the mills. Size reduction is a way of eliminating quartz defects by means of an auxiliary operation to include it into sintering process.

Additionally, density difference may be used to separate low density organic matters with the high density minerals like clay, quartz and iron minerals. Even more magnetic minerals like ferrous minerals can be distracted by magnetic separation techniques to the degree of the magnetism properties of the minerals and magnetic separators can be used according to the properties of the minerals inside the clay.

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