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Quality Analysis of Limestone for the Raw Material of Cement Making Industry in Tangofa Village, Bungku Pesisir Sub-district, Morowali Regency

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ABSTRACTS

Morowali Regency, Central Sulawesi Province is one of the largest nickel laterite-producing areas in the world, on the other hand, this area also has abundant limestone potential, one of the areas that have limestone potential is the Tangofa Area, Morowali Regency. The absence of information related to the chemical composition of limestone in the area is the basis for this research. The purpose of this study was to determine the elemental and mineral content of limestone and to determine the quality of limestone as cement raw material based on CaO and MgO content. The research method was carried out with several stages, namely: literature study, field data collection, and laboratory analysis (Petrography, XRD, and XRF). From the results of petrographic analysis, it can be seen that the constituent minerals of limestone in the research area are calcite and quartz minerals, as well as the results of XRD analysis, show the presence of calcite minerals that dominate the entire sample with a percentage reaching 100%. The results of analysis with the XRF method can be known oxide compounds constituent limestone in the study area are: CaO, MgO, K_2O, PbO, Nb_2O_5, CuO, Sb_2O_3, RuO_4, SnO_2, and In_2O_3. Rh_2O_3, TiO_2, PdO, and Ag_2O. The CaO content of the three samples has a percentage of >48%, while the average MgO content does not exceed 6%, so it can be concluded that the limestone in the study area has good quality for cement raw materials.

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INTRODUCTION

Indonesia is one of the most populous countries in the world. In connection with this, infrastructure development continues to increase along with population growth. In the current era of development, the need for cement is always increasing by the pace of development throughout Indonesia (Sukandarrumidi, 1999). The cement industry is an industry that is being intensively developed at this time in Indonesia to meet these infrastructure needs, so the exploration of limestone as a raw material for cement is currently being intensely carried out in several regions in Indonesia (Wakila et al., 2021).

Morowali Regency, Central Sulawesi Province is one of the largest nickel laterite-producing areas in the world, on the other hand, this area also has abundant limestone potential, one of the areas that has limestone potential is the Tangofa area, Bungku Coastal District, Morowali Regency. Limestone is a class C excavation material, a type of industrial mineral composed of calcium carbonate (CaCO3) and contains other elements, including magnesium (Maulana et al., 2021; Jafar et al, 2022). The absence of information related to the chemical composition of limestone in the Tangofa Area, Bungku Pesisir Subdistrict, Morowali Regency, is the basis for this research. The chemical composition of limestone needs to be known to determine the quality parameters of limestone such as MgO and CaO content, especially for its utilisation as a cement raw material.

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METHODS

This research method was carried out with several stages consisting of literature study, field data collection, and laboratory analysis. Literature study was conducted on previous studies that examined limestone, especially the quality and utilisation of limestone as cement raw material. Field data collection began by taking rock samples at several points where limestone outcrops were found and based on colour differences (Thamsi et al, 2022; Thamsi et al, 2023). In addition to sampling, observations were also made of the geological conditions around the research area, and descriptions (megascopic analysis) of rock samples to obtain information in the form of rock position, direction of rock distribution, outcrop coordinates, and mineral content of rocks megascopically (Wakila et al., 2022).

The next stage is laboratory analysis with several methods, namely petrography, X-Ray Diffraction (XRD), and X-Ray Fluorescence (XRF). Petrographic analysis was conducted to determine the mineral content of the limestone. XRD analysis was conducted to determine the name of the minerals contained in the sample and their levels (percentage) (Wakila et al., 2023; Chalik et al, 2023). And XRF analysis was conducted to determine the chemical content of limestone, especially the content of CaO and MgO as parameters used to determine the quality of limestone. X-Ray Fluorescence (XRF), which serves to analyse elements in materials qualitatively and quantitatively (Jamaludin and Adiantoro, 2012). According to PT Holcim Indonesia Tuban Plant in Khunaifi (2018), limestone is categorised into 2 types, namely high grade limestone with CaO content (>48%) and low grade limestone with CaO content (<48%). The MgO content refers to the National Standardisation Agency SNI 15-2049-2004, in which the good MgO content for cement does not exceed 6%. All analyses were conducted at the Laboratory of Analysis and Processing of Excavated Materials, Mining Engineering Study Programme, Faculty of Engineering, Hasanuddin University. The following is the flow chart of this research (Figure 1).

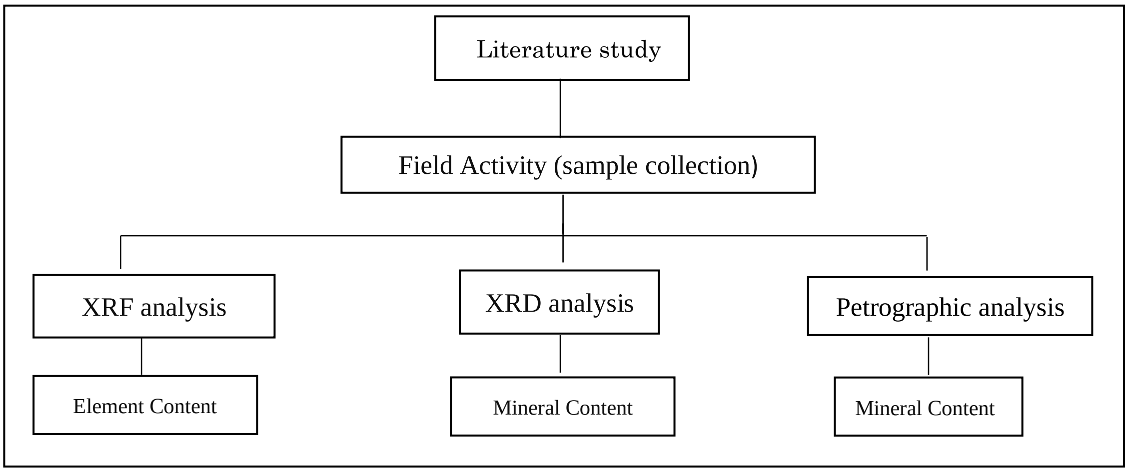

Figure 1. Research Flowchart

RESULTS AND DISCUSSION

In general, the study area is in the early Jurassic to late Jurassic Tokala Formation, which consists of intensively quarried, poorly fermented bioclastic limestones that often form karst terraces on the southeastern arm of Sulawesi, extending in some places separately. One of them is the Tokala Formation (TRJt), which is composed of limestone, shale, calcilutite, marl, mudstone and sandstone. This formation is estimated to be of Early Triassic-Jurassic age. This unit is characterised by small hills with rivers below ground level. (Surono, 2013). Limestone is an industrial mineral composed of calcium carbonate ($CaCo_3$) and contains other elements, including magnesium. One of the important things that must be known in analysing is the presence of Ca and Mg elements. If Ca levels are high and Mg levels are low, it means the quality is good, otherwise if Ca levels are low and Mg levels are high, the quality is poor. High Mg levels will interfere with the hardening process, because the Mg element cannot be bound to the elements (Santika and Mulyadi, 2017). The following is the appearance of limestone outcrops in the research area (Figure 2).

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Figure 2. Appearance of limestone outcrops in the Study Area

Megascopic Analysis

Sample 1

Sample 1 is located at coordinates X: 422846, Y: 9678388, and Z: 46 MDPL. The area in sample 1 has a hilly geomorphology, and steep relief. Sample 1 has a white fresh colour, brown weathered colour, then has a non-clastic texture, with poor permeability, and poor porosity. Small fractures (kinks) were also found in sample 1. The mineral found in sample 1 is the mineral Calcite ($CaCO_3$). Calcite mineral consists of two types, namely: (1) Low-Mg calcite, if formed in cold areas and the composition of $MgCO_3$ 4% (Widiarso, 2017). The following is documentation of sample 1 (Figure 3).

Figure 3. Limestone Sample 1

Sample 2

Sample 2 is located at coordinates X: 423057, Y: 9678650, and Z: 23 M. The area in sample 2 also has a hilly geomorphology, and steep relief. Sample 2 also has a fresh brown colour, white weathered colour, then has a non-clastic texture, with poor permeability, and poor porosity. Small fractures (kinks) were also found in sample 2. The mineral found in sample 2 is the mineral Calcite ($CaCO_3$). The following is documentation of sample 2 (Figure 4).

Figure 4. Limestone Sample 2

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Sample 3

Sample 3 is located at coordinates X: 423170, Y: 9678434, and Z: 38 M. The area in sample 3 also has a hilly geomorphology, and steep relief. Sample 3 also has a white fresh colour, white weathered colour, then has a non-clastic texture, with poor permeability, and poor porosity. Small fractures (kinks) were also found in sample 3. The mineral found in sample 3 is the mineral Calcite ($CaCO_3$). The following is documentation of sample 3 (Figure 5).

Figure 5. Limestone Sample 3

Petrographic analysis

1. Sample 1

Based on the petrographic analysis of sample 1, the minerals in the sample coded A are the result of parallel nicol photos showing quartz and calcite minerals while the sample photo coded B is the result of cross nicol which shows the results of calcite and quartz. Crystal size between 0.04-0.15 µm. It can be seen that the fresh colour is white and the weathered colour is grey, the pleochrism is low to absent, and the grain shape is anhedral. Based on this analysis, the rock name is limestone. Below is the microscope view of sample 1 (Figure 6).

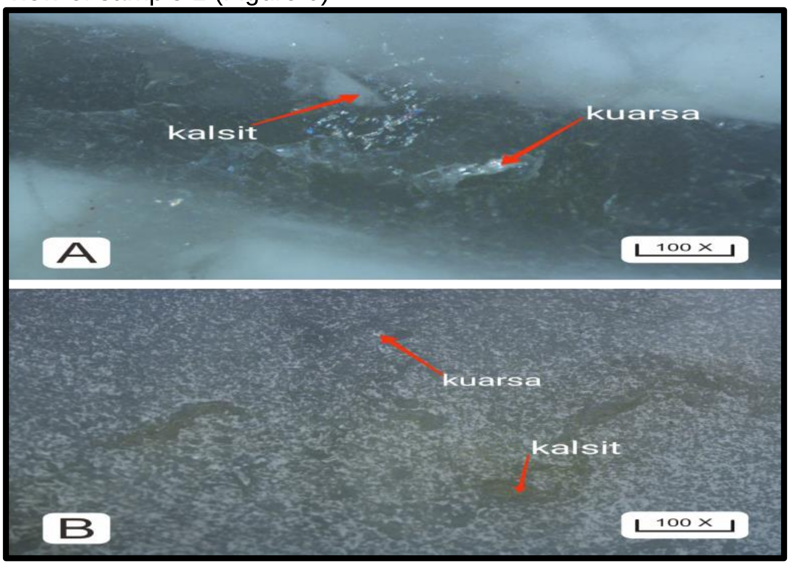

Figure 6. Results of Petrographic Analysis of Sample 1

2. Sample 2

Based on petrographic analysis, the minerals in the sample coded A are the result of parallel nicol photos showing quartz and calcite minerals while the sample photo coded B is the result of cross nicol showing calcite and quartz results. Crystal size between 0.04-0.15 mm. It can be seen that the fresh colour is white and the weathered colour is grey, the pleochrism is low to absent, and the grain shape is anhedral. Based on this analysis, the rock name is limestone (Figure 7).

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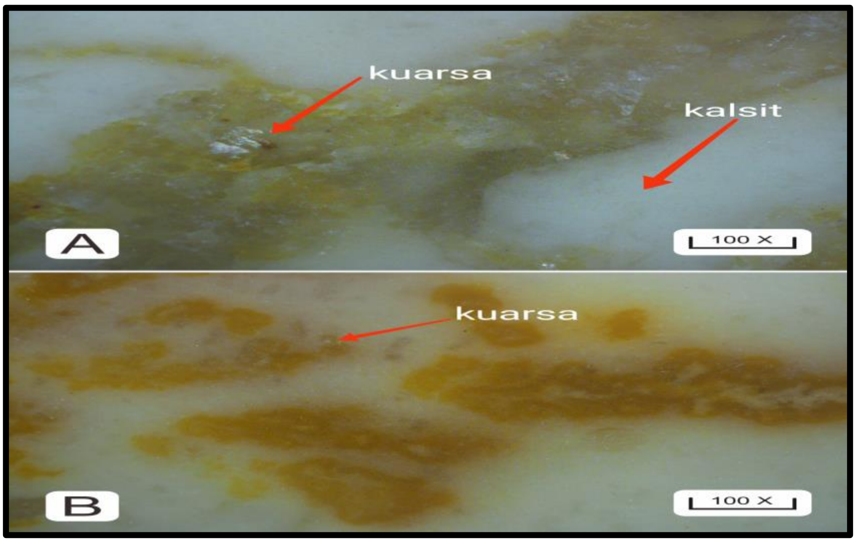

Figure 7. Results of Petrographic Analysis of Sample 2

3. Sample 3

Based on petrographic analysis, the minerals in the sample coded A are the result of parallel nicol photos showing quartz and calcite minerals while the sample photo coded B is the result of cross nicol showing calcite and quartz results. Crystal size between 0.04-0.15 mm. It can be seen that the fresh colour is white and the weathered colour is grey, the pleochrism is low to absent, and the grain shape is anhedral. Based on this analysis, the rock name is limestone (Figure 8).

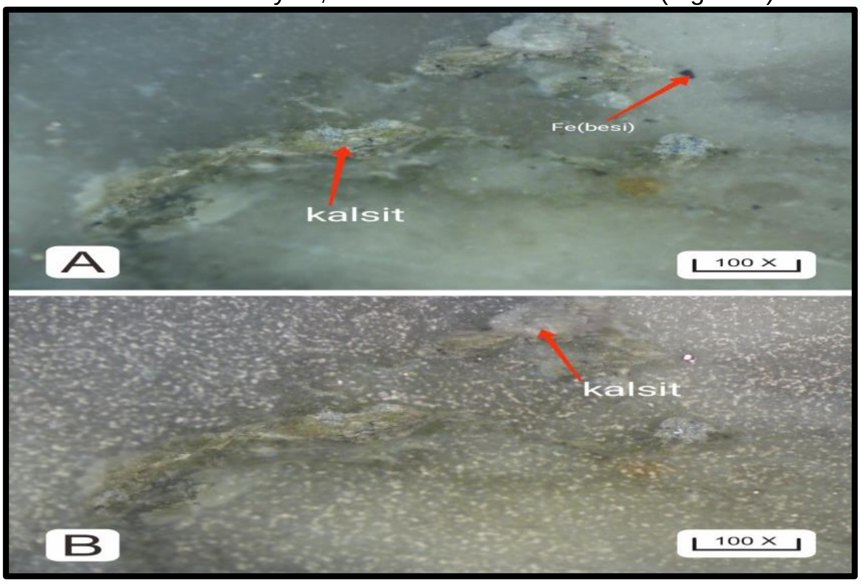

Figure 8. Results of Petrographic Analysis of Sample 3

X-Ray Diffraction analysis

1. Sample 1

The results of XRD analysis, it is known that the main mineral constituent of sample 1 is calcite mineral ($CaCO_3$) with a percentage of 100%, can be seen in the following sample 1 diffractogram (Figure 9).

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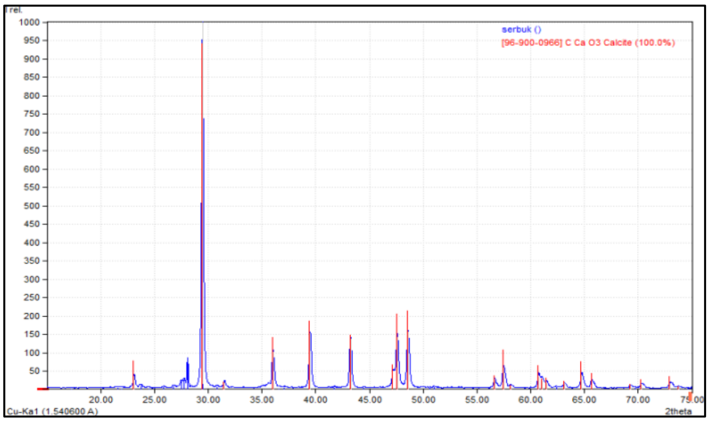

Figure 9. Difractogram of sample 1

2. Sample 2

Based on the results of X-Ray Diffraction analysis, sample 2 is composed of minerals such as Calcite mineral ($CaCO_3$) with a percentage of 98.2% and Quartz mineral (SiO_2) with a percentage of 1.8%. (Figure 10) shows the diffractiongram image of sample 2.

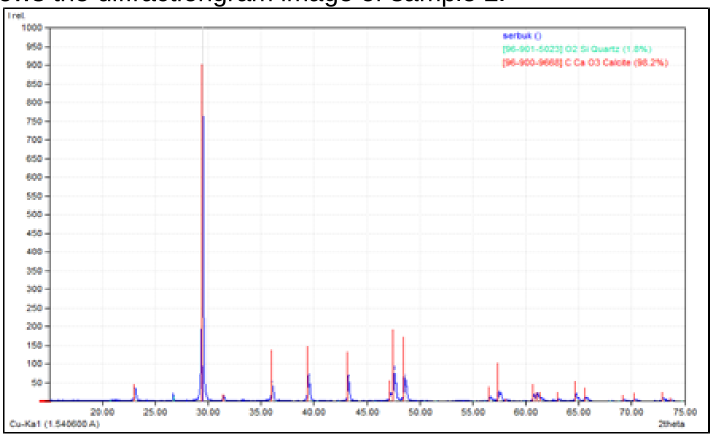

Figure 10. Difractogram of sample 2

3. Sample 3

Based on X-Ray Diffraction, sample 3 is composed of minerals such as Calcite mineral ($CaCO_3$) with a percentage of 95.6% and Quartz mineral (SiO_2) with a percentage of 4.4%. The following figure shows the appearance of the diffractionogram of sample 1 (Figure 11).

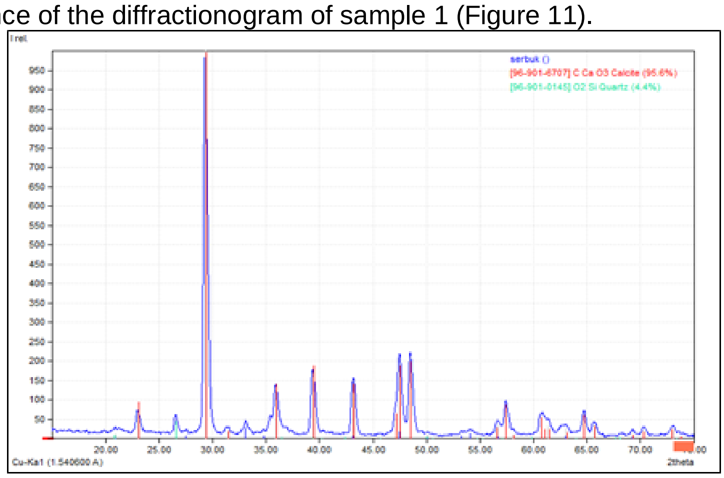

Figure 11. Difractogram of sample 3

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X-Ray Fluorescence Analysis

Sample 1

Based on the results of chemical analysis using the XRF (X-Ray Fluorescence) method, sample 1 has a CaO content of 58.22%, the chemical composition of CaO is obtained from the Calcite mineral. Then the percentage of Fe_2O_3 chemical composition is 20.61%, the chemical composition of Cl with 9.31%, then SO_3 by 8.7%, then MgO by 1.6% and several other compounds whose percentage is below 1% such as RuO_4, Rh_2O_3, TiO_2, PdO, Ag_2O, and Sb_2O_3. The following is a table listing the chemical composition of sample 1 based on XRF analysis.

Table 1. Chemical composition of sample 1

Element/Oxide	Quantitative (%)
CaO	58.22
Fe_2O_3	20.61
Cl	9.31
SO_3	8.7
MgO	1.6
RuO4	0.514
Rh_2O_3	0.465
TiO_2	0.336
PdO	0.128
Ag_2O	0.079
Sb_2O_3	0.0098

Sample 2

Based on the results of chemical analysis using the XRF (X-Ray Fluorescence) method, sample 2 has a CaO content of 75.75%, the chemical composition of CaO is obtained from the Calcite mineral. Then the percentage of Fe_2O_3 chemical composition is 11.81%, SiO_2 with a percentage of 4.56%, then MgO by 6.06%, then MnO by 1.54% and several other compounds with percentages below 1% such as PbO, Nb_2O_5, MoO_3, In_2O_3, Sb_2O_3, RuO_4, and SnO_2. The following is a table listing the chemical composition of sample 2 based on XRF analysis.

Table 2. Chemical composition of sample 2

Unsur/Oksida	Kuantitatif (%)
CaO	75.75
Fe_2O_3	11.81
MgO	6.06
SiO_2	4.65
MnO	1.54
PbO	0.106
Nb_2O_5	0.0303
MoO_3	0.0209
In_2O_3	0.0087
Sb_2O_3	0.0087
RuO_4	0.008
SnO_2	0.0073

3. Sample 3

Based on the results of chemical analysis using the XRF (X-Ray Fluorescence) method, sample 3 has a CaO content of 57.19%, the chemical composition of CaO is obtained from the Calcite mineral. Then the percentage of the chemical composition of the Fe_2O_3 compound is 28.7%, SiO_2 with a percentage of 10%, then MgO of 3.2%, as well as several other compounds whose percentage is below 1% such as K_2O, PbO, Nb_2O_5, CuO, Sb2O3, RuO_4, SnO_2, and In_2O_3. The following is a table listing the chemical composition of sample 3 based on XRF analysis.

Table 3. Chemical composition of sample 3

Unsur/Oksida	Kuantitatif (%)
CaO	57,19
Fe_2O_3	28,7
SiO_2	10
MgO	3,2
K_2O	0,46
PbO	0,238
Nb_2O_5	0,0391
CuO	0,029
Sb_2O_3	0,0128
SnO_2	0,0118
RuO_4	0,0096
In_2O_3	0,0091

Quality of Limestone as Cement Raw Material Based on CaO and MgO Parameters

Sample 1

Based on the results of the XRF analysis, it can be seen that sample 1 has a CaO content of 58.22%, so that the limestone in this study can be categorised as high grade limestone, because it has a CaO content> 48% according to PT Holcim Indonesia Tuban Plant in Khunaifi (2018). And based on the MgO content, sample 1 has an MgO content of 1.6% so that the limestone sample in the research area is economically valuable because it does not exceed the maximum limit of 6%, according to the National Standardisation Agency SNI 15-2049-2004.

Sample 2

Based on the results of the XRF analysis, it can be seen that sample 2 has a CaO content of 75.75%, so that the limestone in this study can be categorised as high grade limestone, because it has a Ca content of > 48% according to PT Holcim Indonesia Tuban Plant in Khunaifi (2018). And based on the MgO content, sample 1 has an MgO content of 6.06% so that the limestone sample in the research area is not economically valuable because it slightly exceeds the maximum limit of 6%, according to the National Standardisation Agency SNI 15-2049-2004.

Sample 3

Based on the results of the XRF analysis, it can be seen that sample 3 has a CaO content of 57.19%, so that the limestone in this study can be categorised as high grade limestone, because it has a Ca content of > 48% according to PT Holcim Indonesia Tuban Plant in Khunaifi (2018). And based on the MgO content sample 1 has an MgO content of 3.2% so that the limestone sample in the research area is economically valuable because it does not exceed the maximum limit of 6%, according to the National Standardisation Agency SNI 15-2049-2004.

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CONCLUSION

Based on the research conducted, it can be concluded that the constituent minerals of limestone in the study area are calcite and quartz minerals. Oxide compounds constituent of limestone in the study area are: CaO, MgO, K_2O, PbO, Nb_2O_5, CuO, Sb_2O_3, RuO_4, SnO_2, and In_2O_3. Rh_2O_3, TiO_2, PdO, and Ag_2O. The CaO content of the three samples has a percentage of >48%, while the average MgO content does not exceed 6%, so it can be concluded that the limestone in the study area has good quality for cement raw materials.

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