# Uses of Pumice as Alternative Flux for Floor Tile Products

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***Abstract***— ***Pumice was used as an alternative fluxing agent in floor tiles, replacing albite content, and effect of such modification on the utilization and physical properties was investigated. In this work, two types of pumice (amorphous and crystalline) were researched. Pumice was added to floor tile body in different proportions (5%, 10%, 15%, 20%, 25%, 30% and 35%) as a flux, and comparison between body with albite and bodies with pumice addition was made in terms of physical properties. According to the results, it was found that firing strength and water absorption values were improved as well as decreasing milling time. Started powder and final products were characterized by Particle Size Analyzer, Heat Microscope, XRF, XRD.***

***Index Terms***— ***Pumice, Floor Tile, Physical Properties.***

## I. INTRODUCTION

The amount and composition of the glassy and crystalline phases comprising the fired structure are considered to be dependent on composition of the raw materials. During the firing of ceramic clay masses two entirely different types of reaction may occur depending on whether there is a mix earth alkali compounds or not[1]. In the first type reaction, clay bodies containing lime and dolomite are model examples of sintering by reactions in the solid state. In the second type reaction, in contrast, clay bodies containing only alkaline compounds as flux, form eutectic melts[2].

Feldspar minerals form the biggest ratio of group minerals found in the earth (about 60-65 %). According to their formation and chemical compositions, they can be split into two groups: Alkaline feldspars, such as orthoclase, sanidine and adularia are formed by a monoclinic system, and anorthoclase has triclinic symmetry. Plajioclase feldspars are also formed in a triclinic system. Generally, feldspars have 6 degrees of hardness according to the Mohs Hardness Scale, and their specific gravity varies from 2.62 to 2.67 g/cm$^3$. The chemical compounds of alkaline feldspars can be converted from orthoclase ($KAlSi_3O_8$) to albite ($NaAlSi_3O_8$). The group of feldspar minerals which include albite and anorthite have a melting point between 1122 to 1550°C and those being of a continuous series of mixed crystals (plagioclase) have a melting point at 1450°C. Plagioclase ($Al_{50}$-$An_{50}$ ) starts to melt at 1287° C. Orthoclase starts to melt at 1150°C [3-4].
Pumice is an volcanic rock which is based glassy phase tuffic character. Pumice can be differentiated from likewise magmatic glassy rocks (perlite, obsidien etc.) with its colour, porosity and the absense of crystalline water content [5-6].
Feldspar is widely used as a flux in stoneware and tile production. However, the rising cost and limited reserves of feldspar have created a pressing need to find alternatives for this material in the ceramic industry.

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Many feldspar mines have been exhausted or can no longer economically produce this mineral. Pumice functions as a flux in ceramic composition in a manner similar to that of feldspar.

## II. EXPERIMENTAL STUDIES

Chemical analysis results of the raw materials used in the floor tile mass formula are shown in Table 1. Representative samples of these raw materials were analysed for chemical compound by atomic absorption methods on Rigaku CAA-3000. The mineralogic compounds of pumice raw materials were studied by X-ray powder diffraction (XRD) on Rigaku RAD IIb, and these results are shown in Figure 2 and 3. Humidity of the raw materials was also determined, and then charged in a ball mill, which has about 1 kg. capacity, and then ground about 8 hours. The grain-size distribution analysis of dried granulized floor tile mass was determined on a Malvern 2000 Mastersizer Particle Size Analyzer.
In this study, for the production of floor tile mass; two different types of clay and kaoline were used, which is used in ceramic industry, Quartz sand from Bilecik-Pazaryeri, and Albite from Mugla-Milas, and two type of Pumice from Nevsehir and Isparta region.

**Table 1. Chemical Composition of the Raw Materials**

| Raw Materials | SiO2 | Al2O3 | Fe2O3 | TiO2 | CaO | MgO | Na2O | K2O | *L.I. |
|---|---|---|---|---|---|---|---|---|---|
| Kaoline | 52,4 | 32,3 | 1,7 | 0,7 | 0,18 | 0,08 | 0,12 | 0,07 | 12,5 |
| Clay-1 | 58,78 | 24,64 | 3,52 | 1,2 | 0,17 | 0,6 | 0,14 | 2,31 | 8,4 |
| Clay-2 | 67,2 | 21,1 | 0,9 | 1,1 | 0,6 | 0,52 | 0,38 | 1,8 | 6,4 |
| Albite | 67,8 | 19,29 | 0,26 | 0,1 | 0,80 | 0,15 | 10,01 | 0,55 | 0,75 |
| Pegmatite | 66,27 | 19,9 | 2,18 | 0,8 | 0,33 | 0,39 | 1,32 | 2,24 | 6,18 |
| Nevşehir Pumice | 72,21 | 12,94 | 1,09 | 0,07 | 0,79 | 0,10 | 3,63 | 4,42 | 4,47 |
| Isparta Pumice | 57,35 | 17,50 | 4,65 | 0,6 | 5,03 | 1,70 | 5,41 | 5,65 | 2,49 |

*L.I.: Loss Ignition

Two types of pumice were analysed by XRD, and Nevsehir Pumice has amorphos phase (Fig. 1), Isparta Pumice has a cristalline structure.

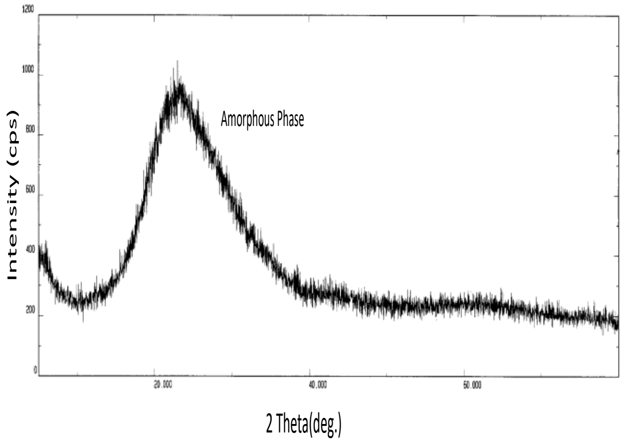


**Fig. 1: XRD Pattern of Nevsehir Pumice.**

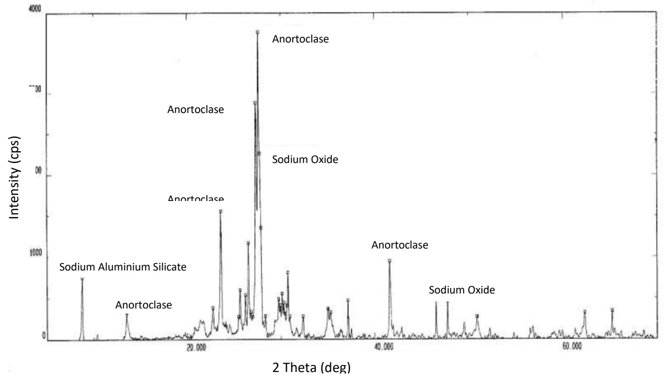


**Fig. 2: XRD pattern of Isparta Pumice**

Heat Microscope results of two types of Pumice and Albite Raw Materials shown in Table 2.

**Table 2: Heat Microscope results of pumice and Albite.**

| Raw Materials | Melting Point (Softening Degree) |
|---|---|
| Albite | 1180 °C |
| Nevşehir Pumice | 1060 °C |
| Isparta Pumice | 1005 °C |

The prepared formula used in floor tile mass is given in Table 3. In this mass formula, feldspar raw material (Albite) was used in varying amounts. Decreasing amounts in the floor tile mass formula with albite, and at the same time pumice was increased by 5, 10, 15, 20, 25, 30, 35 percent in the floor tile formula, and thus 15 different types of floor tile formula were prepared. These bodies were called "I.P., N.P." according to pumice type in this study. The prepared bodies were compared to those with albite additions, and comparisons were made on their mechanical and physical characteristics, such as shrinkage, water emission values, mechanical strength and thermal expansion co-efficient. Floor tile mass were ground under 63µm sieve value were 4-5.3% against each other mass. The ground masses were dried at 125˚C in electrical laboratory furnaces and these masses were crushed to under 0.8mm., and given a 5-9% humidity for shaping, and pressed at 137 bar. Pressed mass dimensions were 100mm.x200mm. These masses were fired at 1188˚C, 1198˚C and 1220˚C at conditions of factory roller furnace.

**Table 3: Mixing ratio of floor tile body Raw Materials with Isparta Pumice addition.**

| | St. | I.P.5 | I.P.10 | I.P.15 | I.P.20 | I.P.25 | I.P.30 | I.P.35 |
|---|---|---|---|---|---|---|---|---|
| Clay-A | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Clay-B | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Kaolinite | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Quartz | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| **Albite** | **45** | **40** | **35** | **30** | **25** | **20** | **15** | **10** |
| **Isparta Pumice** | **0** | **5** | **10** | **15** | **20** | **25** | **30** | **35** |

**Table 4: Mixing ratio of floor tile body Raw Materials with Nevsehir Pumice addition**

| | St. | I.P.5 | I.P.10 | I.P.15 | I.P.20 | I.P.25 | I.P.30 | I.P.35 |
|---|---|---|---|---|---|---|---|---|
| Clay-A | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Clay-B | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Kaolinite | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Quartz | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| **Albite** | **45** | **40** | **35** | **30** | **25** | **20** | **15** | **10** |
| **Nevşehr Pumice** | **0** | **5** | **10** | **15** | **20** | **25** | **30** | **35** |

Floor tile mass were ground under 63µm sieve values were 4-5.3% against each other mass. Though grinding time of standard floor tile formula was 8 hours, with the pumice addition of these bodies, grinding time were degreased and sieve value at 63 µm were degreased (Figure 3).

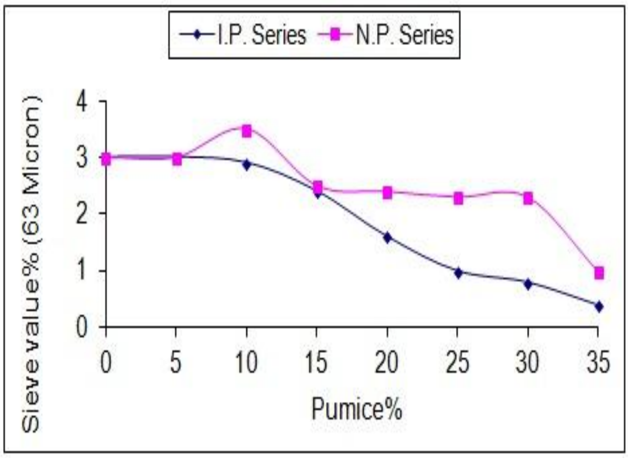


**Fig. 3: Sieve values changes of floor tile bodies with pumice addition**

Green Bending Strength of floor tile bodies with pumice addition were increased especialy I.P. Series (Fig 4).

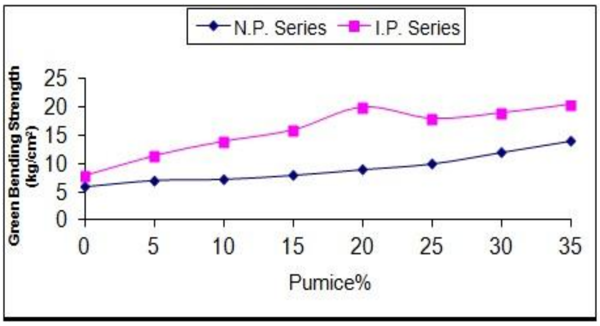


**Fig. 4: Green Bending Strength values change of floor tile bodies.**

Firing shrinkages of the floor tile body were increased due to pumice addition. Figure 5 shows a clear increase in the firing shrinkage of the sintered floor tile body when pumice was added at sintering conditions 1190 ˚C, 1200 ˚C and 1220 ˚C.

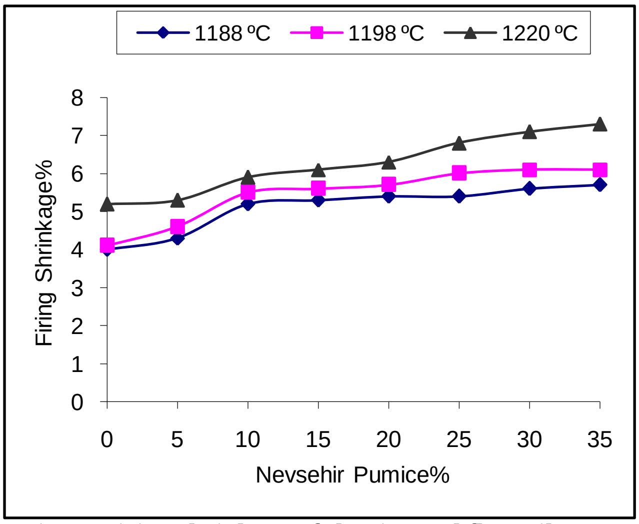


**Fig. 5: Firing shrinkage of the sintered floor tile mass Nevsehir Series**

It has been observed that the bending strength of floor tile bodies with pumice addition were higher than those with albite addition bodies, due to increased pumice addition. Bending strength results are shown in Figure 6a and b.

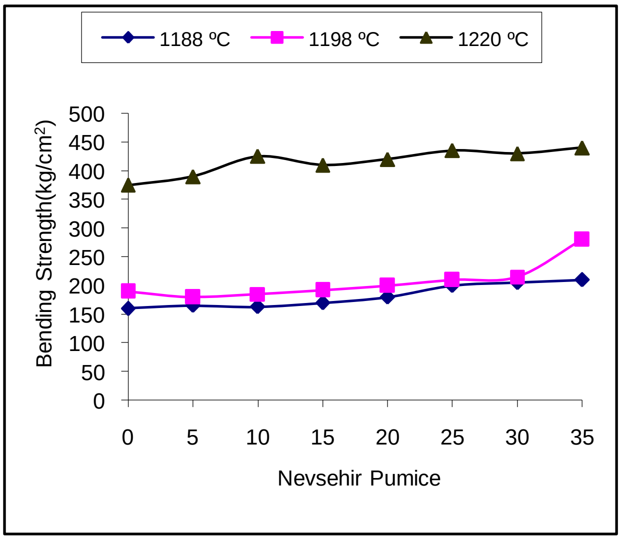


**Fig. 6.a: Bending strength of the sintered floor tile mass N.P. series.**

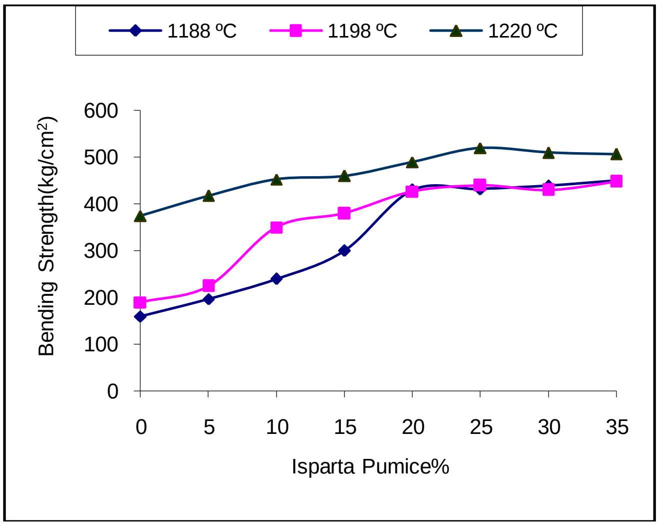


**Fig. 6 b.: Bending strength of the sintered floor tile mass I.P. series.**

Water absorption values for the standard floor mass formula experiments were found to be not enough up to 1220 °C in the case of formula with albite additions. When compared, the results of the increased percentages of pumice additions shoved a change in water absorption values degreased from 3 to 0.06%, compared to the use of albite. Fig.7 a and b showed that the water absorption values of sintered bodies were reduced when pumice was used.

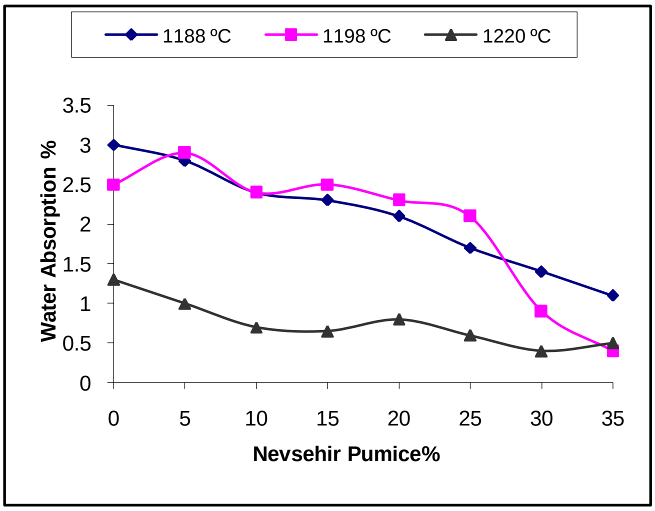


**Fig.7.a: Water Absorption Values of the sintered floor tile mass N.P. series.**

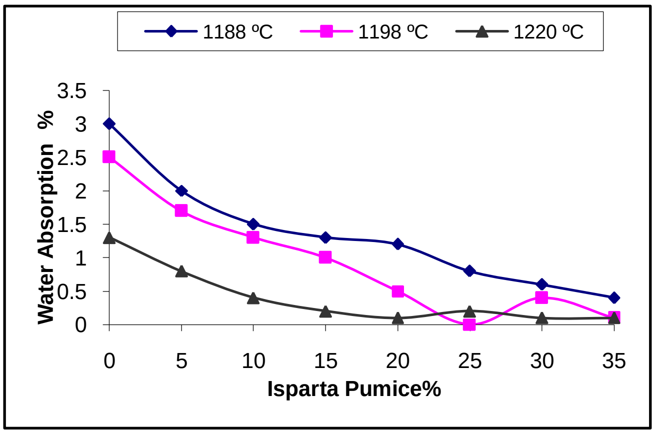

**Fig.7.b: Water Absorption Values of the sintered floor tile mass I.P. series.**

## III. CONCLUSION

The raw material of pumice effect an important role in the regulation of furnace performances, due to its lowering on the melting point and its wide glassy phase range. Results of the laboratory working of this material showed that two type of pumice melted at 1005°C -1060°C and reached glassy phase at 1170°C, while albite melted at 1170°C and reached glassy phase at 1200°C, on a heat microscope.

Water absorption values were reduced about 1%, and 0%. According to these results, it is possible to produce perfect products, at lower temperatures.

In conclusion, lower sintering temperatures and so lower energy costs may be achieved through the use of pumice in floor tile formulas. Studies showed that LPG brullors saved about 3.55% energy with pumice addition kiln furnace from the hot place point.

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