

Studies on Zircon-Dolomite **System for Refractory Application**

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Studies on Zircon-Dolomite **System for Refractory Application**

**A dissertation submitted in the partial fulfilment of the
requirements for the degree of Bachelor of Technology in
Ceramic Engineering of NIT, Rourkela**

By

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ROURKELA**

CERTIFICATE

This is to certify that the thesis entitled, “**Studies on Zircon-Dolomite System for Refractory Application**” submitted by **Ms. Ipsita Mohapatra (110CR0475)** in partial fulfilments for the requirements for the award of Bachelor of Technology degree in Ceramic Engineering at National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in this thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

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I am sure that all that I have gained and learnt in course of this project would be of immense help to me in the future, both personally and professionally.

Ipsita Mohapatra

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LIST OF ABBREVIATIONS

1. XRD : X-Ray Diffraction.
2. AP : Apparent Porosity.
3. BD : Bulk Density.
4. DTS : Diametral Tensile Strength.
5. Z1 : Zircon : Dolomite = 1 : 1.
6. Z2 : Zircon : Dolomite = 2 : 5.
7. Z3 : Zircon : Dolomite = 1 : 3.

ABSTRACT

Zircon (ZrSiO_4) and Dolomite ($\text{CaMg}(\text{CO}_3)_2$) are used as raw materials for preparation of porous refractory aggregates. Different compositions e.g. Zircon : Dolomite (Z:D) ratio 1:1, 2:5 and 1:3 (molar ratio) are chosen and the mixtures are reaction sintered in the temperature range 1150°C - 1300°C . Phase evolution as a function of temperature was studied in detail. It was found that the phases present in the sintered product differs by the presences of secondary phase – Ca_2SiO_4 or $\text{Ca}_3\text{Mg}(\text{SiO}_2)_2$ - depending on the Zircon dolomite ratio starting mixtures. Apparent Porosity, Bulk Density and Diametral Tensile Strength of the sintered samples has also been measured.

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

1.1. REFRACTORIES

According to ASTM C71, Refractories are non-metallic materials having those chemical and physical properties that make them applicable for structures, or as components of systems, that are exposed to environments above 1000°C. The main purpose behind the application of refractories can be summed up as: protection of process equipment, energy saving and creation of workable environment. They are widely used in kilns, furnaces, boilers and other applications in industries like iron and steel, cement, non-ferrous metals, glass, chemicals etc. Depending on their area of application, refractories should have optimum values of densities, strength, thermal shock resistance, wear resistance, thermal conductivity etc.

Currently, the Indian refractory industry has a collective production capacity of 20 lakh tonnes per annum. Its distribution among various sectors is shown in Fig. 1.

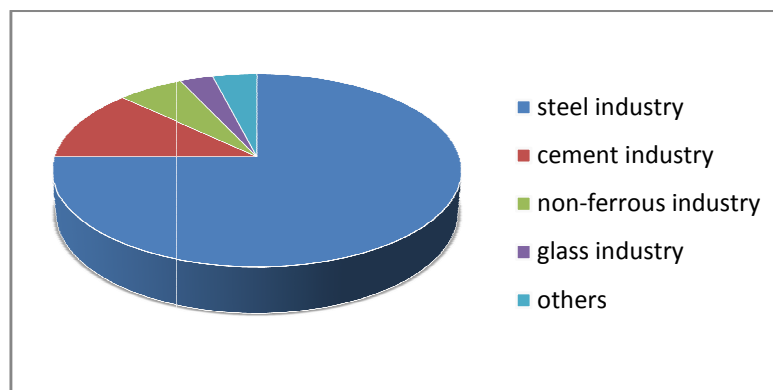


Fig 1: Sector wise refractory consumption in India

Refractories must be selected depending on the conditions where they are to be used. Different application areas demand specific properties. For example: Zirconia refractories are used in high temperature applications requiring high corrosion and abrasion resistance. Among non-oxides, silicon carbide is an important refractory material which can be used in severe temperature conditions. However, it oxidizes rapidly on contact with air and decomposes.

Binary compounds like tungsten carbide(WC) and boron nitride(BN) can be very refractory. Hafnium carbide is the most refractory binary compound known, having a melting point of

about 3900°C. The ternary compound tantalum hafnium carbide has one of the highest known melting points i.e. 4215 °C.

The general requirements for refractory materials are:

- Ability to withstand high temperature
- High load-bearing capacity
- Abrasion and wear resistance
- High resistance against corrosion by hot gases, molten metals and slag erosion
- Low coefficient of thermal expansion(TEC) and high thermal shock resistance

1.2. PROPERTIES OF REFRACTORIES

Important properties include melting point, dimensional stability, porosity, bulk density, compressive strength, refractoriness, creep, shrinkage, and thermal conductivity. Manufacture and quality control processes are based on controlling these properties.

1.3. CLASSIFICATION OF REFRACTORIES

- Based on chemical composition
 - Acidic refractories (eg. Silica, zirconia)
 - Neutral refractories (eg. Alumina)
 - Basic refractories (eg. Magnesite, dolomite)
- Based on physical form
 - Shaped refractories
 - Unshaped refractories or monolithics
- Based on porosity
 - Dense/non-porous refractories
 - Porous refractories
- Based on refractoriness
 - Low heat duty refractories (eg. Silica bricks)
 - Intermediate heat duty refractories (eg. Fireclay bricks)
 - High heat duty refractories (eg. Chromite bricks)
 - Super heat duty refractories (eg. Magnesite bricks)

- Based on carbon content
 - C-containing refractories (eg. MgO-C)
 - Non-carbon containing refractories (eg. SiO₂)

1.4. ZIRCON AS A REFRACTORY

Zircon is a remarkable mineral, if only for its ubiquitous presence in earth's crust. Its chemical name is zirconium silicate and corresponding chemical formula is ZrSiO₄. It has a tetragonal crystal structure. Its relatively high density and resistance to weathering have contributed to its wide-ranging use in heavy mineral studies. It is considered as a good refractory material because of the following reasons :

- Low coefficient of thermal expansion
- Chemical inertness
- High melting point
- Compatibility with novel chemical binders
- High refractive index

Zircon is the principal precursor to ZrO₂, one of the most refractory materials known. It consists of 67% Zirconia (ZrO₂) , 32.8% Silica (SiO₂) and typically about 1% Hafnium. It has good abrasion, impact and thermal shock resistance. It is stable in chemical environments and is non-magnetic as well as a non-conductor.

Zircon finds applications in foundry, refractory and glass industries. It is the most widely used opacifier in the ceramic industry. In refractory industries, they are used in steel ladle linings, high temperature bricks and glass tanks. Zircon is generally combined with other materials, including zircon flour, pre-fired zircon and bonding agents, to extend the ladle lining life up to 5-10 times that of alumina brick linings.

1.5. DOLOMITE AS A REFRACTORY

Dolomite is the double carbonate of calcium and magnesium (CaMg(CO₃)₂), having a density of 2.8. Generally it consists of 30% CaO and 20% MgO and 50% LOI due to CO₂ presence. The phase mixture of CaO and MgO is referred to as doloma. Because of the inherent basic oxides, it has a good corrosion resistance against alkalis. It is a high melting compound

possessing good refractoriness. Also, the high thermodynamic stability of CaO and MgO at high temperatures make dolomite highly resistant in reducing conditions.

Dolomite can be regarded as an attractive potential refractory for applications in metallurgical industries because of its worldwide abundant sources, high melting temperature and inhibition against deep infiltration by the reaction of CaO with acidic slag. However, poor hydration resistance restricts its applications. Free lime present in the material has a strong affinity for moisture and the expansion accompanying the hydration process causes associated disintegration of the sample into powders. Studies have been carried out to inhibit hydration by elimination of free lime by reacting with several oxides but this happens at the cost of refractoriness.

On heating dolomite in the range 700°C – 900°C, it loses CO₂ and decomposes in 2 steps. The reactions are shown as under :

- $\text{CaMg}(\text{CO}_3)_2 (\text{s}) \longrightarrow \text{Ca}_{1-x}\text{Mg}_x\text{CO}_3 (\text{s}) + \text{MgO} (\text{s}) + \text{CO}_2 (\text{g})$
- $\text{CaCO}_3 (\text{s}) \longrightarrow \text{CaO} (\text{s}) + \text{CO}_2 (\text{g})$

The mixture composed of CaO and MgO is also identified as caustic dolomite.

There are a lot many other applications of dolomite as well. It is well suited for use as refractory linings in CRKs (i.e. cement rotary kilns). It is capable of withstanding the temperatures and stresses associated with the burning zone support exceptional coatability. It may also be used as a steel-making slag flux and in glass ‘batch’ depending on the composition of glass to be made.

1.6. REACTIONS INVOLVED

Zircon (ZrSiO₄) and dolomite (CaCO₃.MgCO₃) were selected and the composition of the mixture was customized according to the following reactions :

1. $\text{ZrSiO}_4 + \text{CaCO}_3.\text{MgCO}_3 \longrightarrow \text{CaZrO}_3 + \text{MgSiO}_3 + 4\text{CO}_2$
2. $\text{ZrSiO}_4 + 3\text{CaCO}_3.\text{MgCO}_3 \longrightarrow 3\text{MgO} + \text{CaZrO}_3 + \text{Ca}_2\text{SiO}_4 + 6\text{CO}_2$
3. $2\text{ZrSiO}_4 + 5\text{CaCO}_3.\text{MgCO}_3 \longrightarrow 4\text{MgO} + 2\text{CaZrO}_3 + \text{Ca}_3\text{Mg}(\text{SiO}_4) + 10\text{CO}_2$

The pyrolysis of dolomite gives off CO₂ gas during the sintering process resulting in the formation of porous structure. These porous materials can serve as insulating refractories because of their good strength. Furthermore, in preparation of Zircon-Dolomite based insulating refractories, no pore formers like saw-dust are required; hence, the process does not release any combustible or harmful materials during the firing process and is environment friendly. These porous materials with good refractory phases find potential applications as refractory aggregates

CHAPTER 2

LITERATURE REVIEW

2. LITERATURE REVIEW

Dolomite-Zircon mixtures have become interesting sources for the production of dense as well as porous composites. Dense bulk-form $\text{CaZrO}_3/\text{MgO}$ nanocomposites have been successfully fabricated using reactive hot pressing from dolomite-zircon powders [1,2]. Both the green density and degree of agglomeration effect the sintering behaviour over the entire process. By adequate control of process parameters (particle size, sintering temperature), it is possible to obtain dense or porous materials [3].

Silica-bonded magnesia materials are known to have high thermal expansion coefficient and hence, poor thermal spalling resistance. When combined with Y_2O_3 ($\text{Y} = \text{Cr}^{+3}, \text{Al}^{+3}$), the thermal shock resistance of the material is enhanced [4, 5]. However, due to environmental protection regulations, which ban the use of chrome-based materials [6], we use zircon in order to form CaZrO_3 based materials. Zircon and Dolomite are very economical raw materials for the production of $\text{CaZrO}_3\text{-Ca}_2\text{SiO}_4\text{-MgO}$ materials [7]. The $\text{MgO-CaO-ZrO}_2\text{-SiO}_2$ system forms several high temperature compounds and may serve as viable alternatives for magnesia refractories.

Zirconia undergoes phase transitions at specific temperatures and thus, its volume changes on heating and cooling. At low temperatures, monoclinic phase is most stable. On heating above 1205°C it transforms to form tetragonal structure. The tetragonal to cubic phase transition occurs at high temperatures at around 2377°C . Oxides of magnesium and calcium may be added to stabilise zirconia. On the other hand, lime in dead-burnt dolomite has a strong affinity for moisture with associated disintegration because of expansion caused by hydration. This reaction can be inhibited to obtain an improved hydration resistance by purging of free lime by reacting with the oxides (iron oxides, silica, clay etc.) at the cost of refractoriness. This makes the mixing of dolomite-zircon an attractive option for the manufacture of low cost refractories. Apart from that, the reaction between these two compounds may be tailored to form high temperature refractory phases like calcium zirconate (melting temperature: $2250^\circ\text{C}\text{--}2550^\circ\text{C}$), forsterite Mg_2SiO_4 (melting temperature: 1890°C). The phase diagram of the $\text{MgO-ZrO}_2\text{-CaO-SiO}_2$ quaternary system with a diagrammatic representation of the intersection between the solid state compatibility planes and the dolomite-zircon formulation line is shown in Fig 2.

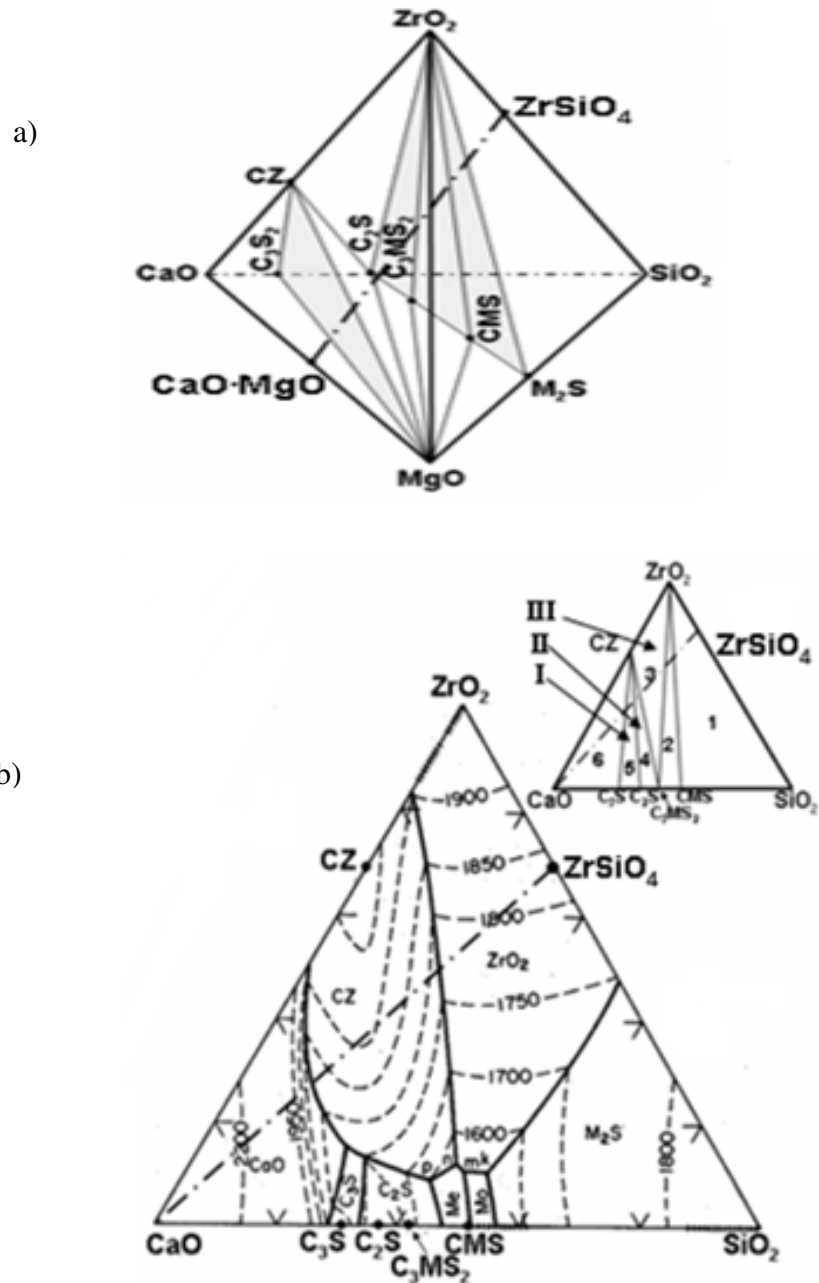


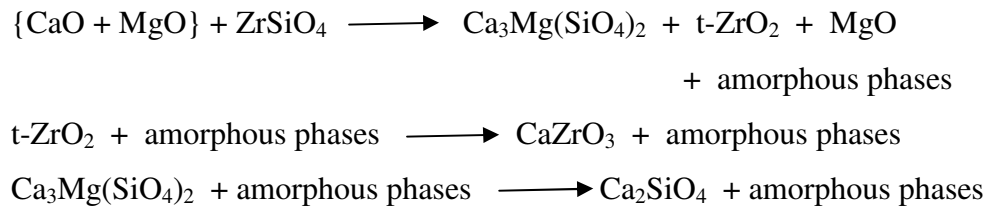
Fig 2. a) Phase diagram of MgO-ZrO₂-CaO-SiO₂ system b) projection from the MgO-apex onto the opposite face of quaternary tetrahedron CaO- ZrO₂-SiO₂

Reaction sintering of mixtures of zircon and dolomite produces CaZrO₃-Ca₂SiO₄-MgO based materials. Dicalcium silicate (Ca₂SiO₄) have five polymorphs, amongst which the (β) orthorhombic to (γ) monoclinic transformation is very similar to that of the tetragonal to monoclinic transformation observed in ZrO₂, i.e. both experience expansion on transformation during cooling. However, there exist differences between these two corresponding transformations. Firstly, in Ca₂SiO₄, the transformation occurs from a β

microstructure (twinning) to a γ structure that is untwined, while in ZrO_2 the reverse phenomenon occurs. Secondly, unlike in ZrO_2 , the transformation from β to γ is irreversible, as β is a metastable phase. Thirdly, the volume expansion associated with phase transformation is 12% for Ca_2SiO_4 , while it is just 4.9% for ZrO_2 (at room temperature) [8].

Dolomite-zircon compositions when heated, behave in the following manner [7,9] :

- Reaction between decomposed dolomite (CaO plus MgO) and zircon occurs above 1000°C.



- This is followed by sintering of the samples in 3 stages :
 - Initial stage : Rearrangement of particles and neck formation.
 - Intermediate stage : Growth of grains and pores and development of necks between particles.
 - Final stage : Elimination of remaining pores.

CHAPTER 3

EXPERIMENTAL WORK

3. EXPERIMENTAL WORK

3.1. SAMPLING OF RAW MATERIALS

High purity and fine batches of dolomite and zircon were used in the preparation of test samples. Samples of 3 different compositions were made. Batch compositions are as follows (Table-1):-

BATCH COMPOSITION			
Samples	Zircon (mol %)	Dolomite (mol %)	Z:D
Z1	50	50	1:1
Z2	28.5	71.5	2:5
Z3	25	75	1:3

Table 1. Batch composition

3.2. SAMPLE PREPARATION

The steps involved in the sample preparation process are shown below:

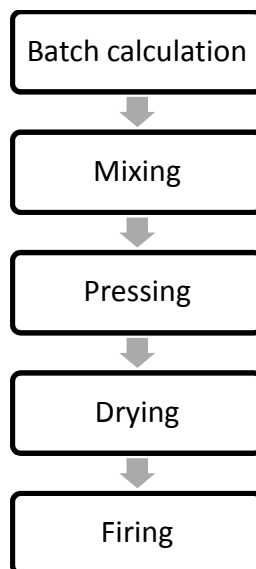


Fig 3. Flow diagram for sample preparation

3.2.1. BATCH CALCULATION

Based on the the percentage of $ZrSiO_4$ and Dolomite in each batch composition, the amount of raw materials required for 50g of each composition was calculated (Table 2).

Batch	Zircon (g)	Dolomite (g)
Z1	25.394	24.606
Z2	14.61	35.39
Z3	12.798	37.202

Table 2. Batch calculation for each composition

3.2.2. MIXING

For preparing powder mixes of each of the batches, ascertained measures of each of the crude material (as per Table 2) was taken in a mortar & pestle and dry mixed and ground. Requisite amount (3-4 drops approx) of 3% PVA solution was added as a binder and the mixture was blended properly. Care was taken to ensure that agglomerates were not formed in the process.

3.2.3. PRESSING

The prepared mix was then partitioned into batches of 1g each and pressed to form pellets (12mm dia) by applying a load of 4 tons for a dwelling time of 90 seconds in a Carver Hydraulic Press machine.

3.2.4. DRYING

Subsequent to pressing, the pellets were first air dried for 24 hrs followed by drying in an oven maintained at a temperature of 110°C for another 24 hours.

3.2.5. FIRING

Ten samples of each of the compositions of Table 1 were prepared and fired at each of the temperatures – 1150°C, 1200°C, 1250°C and 1300°C at a heating rate of 3°C/min and for a soaking time of 2 hours.

3.3. SAMPLE CHARACTERIZATION

3.3.1. PHASE ANALYSIS BY XRD

X-Ray diffraction technique can be used for phase identification, investigation of crystal structure of a material and unit cell parameter determination of novel materials. Each material has a unique XRD pattern that is distinctive of its structure.

The X-ray diffraction method was used to determine the present phases in the fired samples. The main aim was to study the phase evolution with temperature for different compositions. XRD measurements were performed at a 3°C/min scan rate using a Philips Advance D8 X-ray diffractometer operated at 40 keV and 30 mA and in the 2 theta range of 10° to 80°.

The samples in the form of pellets were sent for X-ray analysis. The X-ray analysis data was matched with the standard JCPDS software to identify the phases.

3.3.2. MEASUREMENT OF BULK DENSITY AND APPARENT POROSITY

Bulk density isn't an intrinsic material property. It may change with material handling ways. It's defined as the mass of particles divided by their volume. This volume includes the volume of particles, voids between them and volume of internal pores present.

Apparent porosity refers to the volume of open pores divided by the total volume (bulk volume) of the material.

The AP/BD measurements of refractories can be done by the evacuation method (applicable for all types) or boiling water method (for burnt bricks). Both these methods are based on the Archimedes' principle.

The A.P./B.D. measurements of the samples were carried out in kerosene so as to avoid the hydration of lime i.e. CaO. The bulk density and apparent porosity values can be calculated by the following sequence of steps :

- Dry weight of the samples was measured.
- The samples were soaked in kerosene in a beaker.
- The beaker was kept in a dessicator under vacuum conditions until bubble formation stopped.

- Then the suspended weight and soaked weight of the samples were measured using the AP/BD setup and weighing machine.

$$\mathbf{B.D. = \frac{D}{W-S} * \rho}$$

$$\mathbf{A.P. = \frac{W-D}{W-S} * 100}$$

Where,

D = dry weight

W = soaked weight

S = suspended weight

ρ = density of kerosene = 0.78

The variation of density with firing temperature for each batch composition was studied.

3.3.3. MEASUREMENT OF DIAMETRAL TENSILE STRENGTH

This test applies a compressive load onto a cylindrical disk sample through 2 diametrically opposite rigid plates. Such loading conditions produce almost uniform tensile stress over a major portion of diametric plane containing the applied load. The max. tensile stresses are relative to the applied load and grow in a direction perpendicular to loading direction. This test would yield correct results on the condition that fracture initiation occurs due to tensile stresses.

Prior to DTS measurement, the diameter and thickness of the pellets were measured using vernier callipers. DTS was measured using the Universal Testing Machine (UTM). The pellet was placed centrally between the plates of the machine in vertical orientation. The load range was selected depending on the material. The load was applied uniformly until the test piece failed, i.e. until it was unable to support the load. The maximum load indicated was recorded.

The diametral tensile strength was calculated from the following formula [10]:

$$DTS = \frac{2 * P}{\pi D t}$$

Where,

P = maximum force at which fracture occurs

D = diameter of the sample

t = thickness of the sample

CHAPTER 4

RESULTS AND DISCUSSIONS

4. RESULTS AND DISCUSSIONS

4.1. RAW MATERIAL CHARACTERIZATION

4.1.1. XRD PATTERN OF ZIRCON

Characterization of zircon was done by X-ray diffraction method. Fig 4. shows the XRD pattern of Zircon powder used in the study.

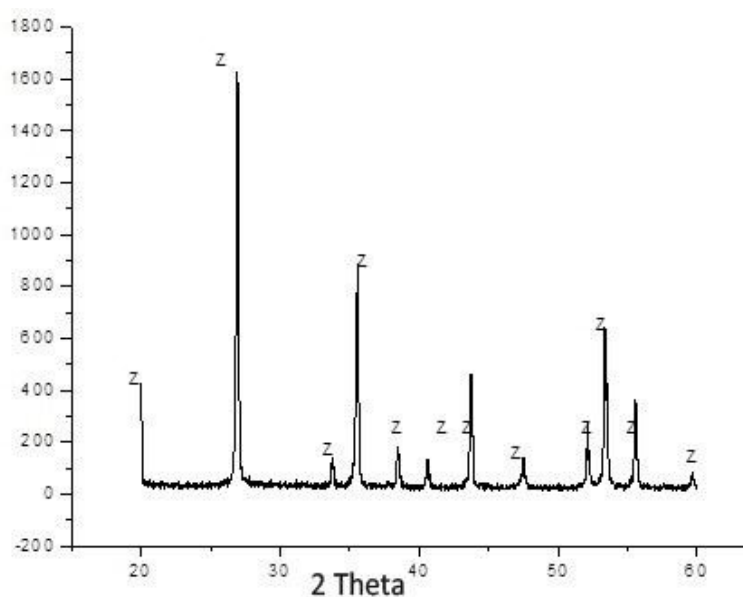


Fig 4. XRD analysis of zircon powder

The XRD curve shows the presence of zircon in all high intensity peaks. No other impurity phases could be detected from the pattern. XRD pattern was matched with JCPDS file number 81-0589.

4.1.2. XRD PATTERN OF DOLOMITE

Characterization of dolomite was done by X-ray diffraction method. Fig 5 shows the XRD pattern of dolomite used in the study.

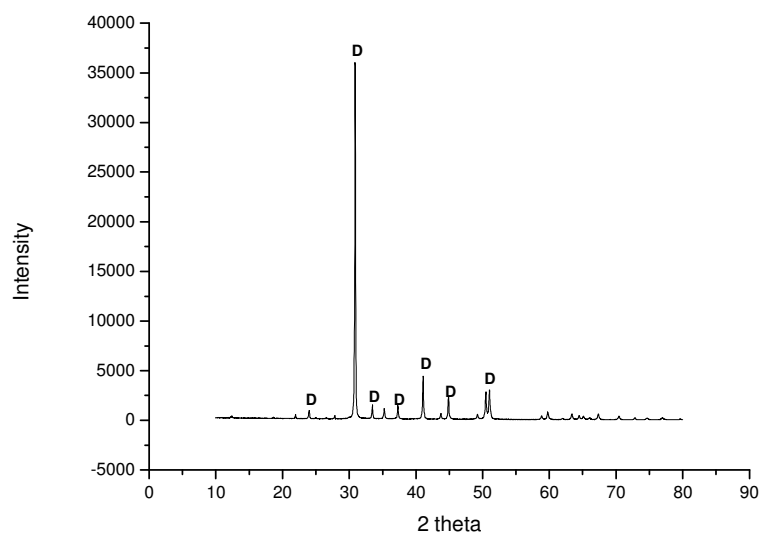


Fig 5. XRD analysis of dolomite powder

The XRD curve shows the presence of dolomite in all high intensity peaks. No trace of other impurities could be detected from the pattern. The XRD pattern was matched with JCPDS file number 36-0426.

4.1.3. CHEMICAL ANALYSIS OF DOLOMITE

The typical composition of the dolomite used in present study is shown in Table 3.

	%
SiO ₂	2.386
Fe ₂ O ₃	1.1
Al ₂ O ₃	0.6
CaO	32.608
MgO	18.98
LOI	46.36

Table 3. Chemical composition of dolomite

Wet chemical analysis method was used for determining the oxide composition of dolomite. The percentage of silica, alumina, calcia and magnesia were determined by gravimetric analysis. The amount of iron oxide was determined by titrating against standard mercurous nitrate solution.

4.1.4. DSC/TGA OF DOLOMITE

Fig 6 shows the thermal decomposition behaviour of dolomite powder used in this study.

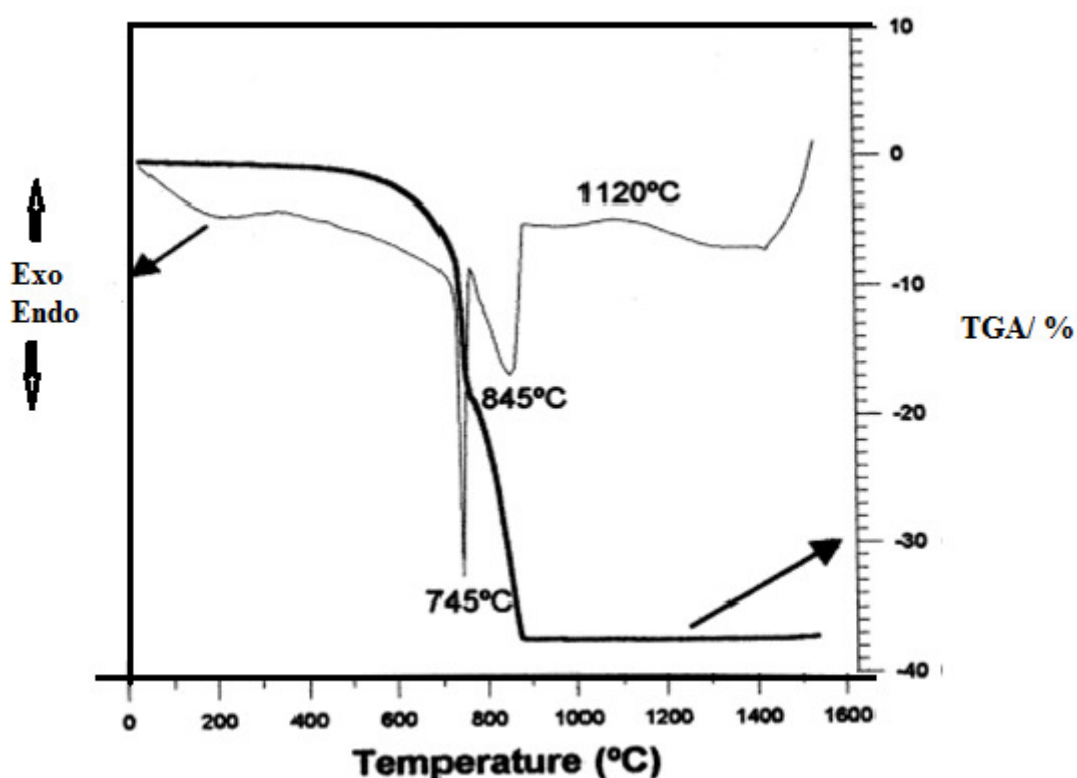


Fig 6. Thermal decomposition behaviour of dolomite powder

The two endothermic peaks in the DSC curve correspond to the decomposition of dolomite to form CaO and MgO. The first one reaches a peak at 745°C and the second one reaches a peak at 845°C. The lower temp. peak shows the decomposition of dolomite structure, by releasing CO₂ from the carbonate ion allied with magnesium part in the composition resulting in the formation of MgO and calcite. The higher temp. peak represents calcite decomposition associated with CO₂ evolution. There is a mass loss of about 37% due to decarbonation. Beyond 1000°C, CaO and MgO react with zircon which is shown by a broad exothermic peak with maximum at 1120°C.

4.2. SAMPLE CHARACTERIZATION

4.2.1. XRD ANALYSIS

The XRD patterns of the Z1 samples as a function of temperature are shown in Fig 7.

INDEX:

& - ZrO₂

\$ - CZ

- C₂S

* - Calcium Magnesium silicates

@ - Enstatite

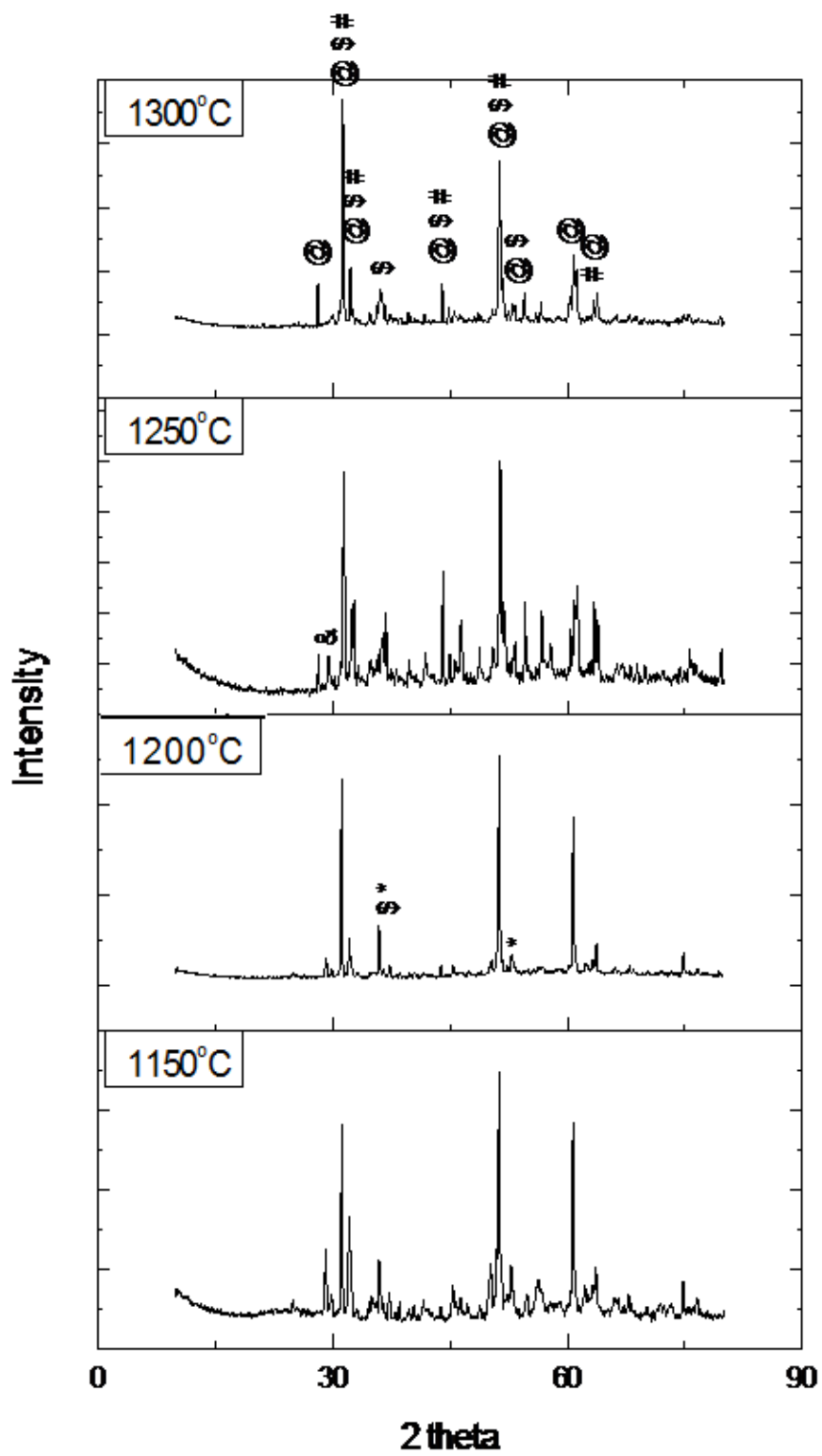


Fig 7. XRD patterns of Z1 samples as a function of temperature

The main phases observed in the XRD analysis of Z1 samples are listed below:

- Calcium zirconium oxide (CaZrO_3)
- Calcium silicate (Ca_2SiO_4)
- Zirconium oxide (ZrO_2)
- Enstatite ($\text{Mg}_{0.944}\text{Ca}_{0.056}\text{SiO}_3$)
- Calcium Magnesium silicates ($\text{CaMgSi}_2\text{O}_6$)

It was seen that some unreacted ZrO_2 remains in the samples fired at relatively lower temperatures. Calcium Magnesium silicates are formed in samples fired at 1150°C and 1200°C but not in those at still higher temperatures. This corroborates the theoretical finding from literature that transitory amorphous silicate phases and transitory solid phases like calcium magnesium silicates and t- ZrO_2 are formed in the initial stage of reaction which later forms stable phases like CZ and C_2S . Also, low melting phases like enstatite are formed which start forming liquid beyond 1300°C . Formation of enstatite is the main reason for the melting of Z1 samples when fired at temperatures above 1300°C .

The XRD pattern for Z2 and Z3 samples fired at different temperatures show the presence of CZ, C_2S and C_3MS_2 as the major phases.

INDEX :

§ - CZ

- C_2S

* - C_3MS_2

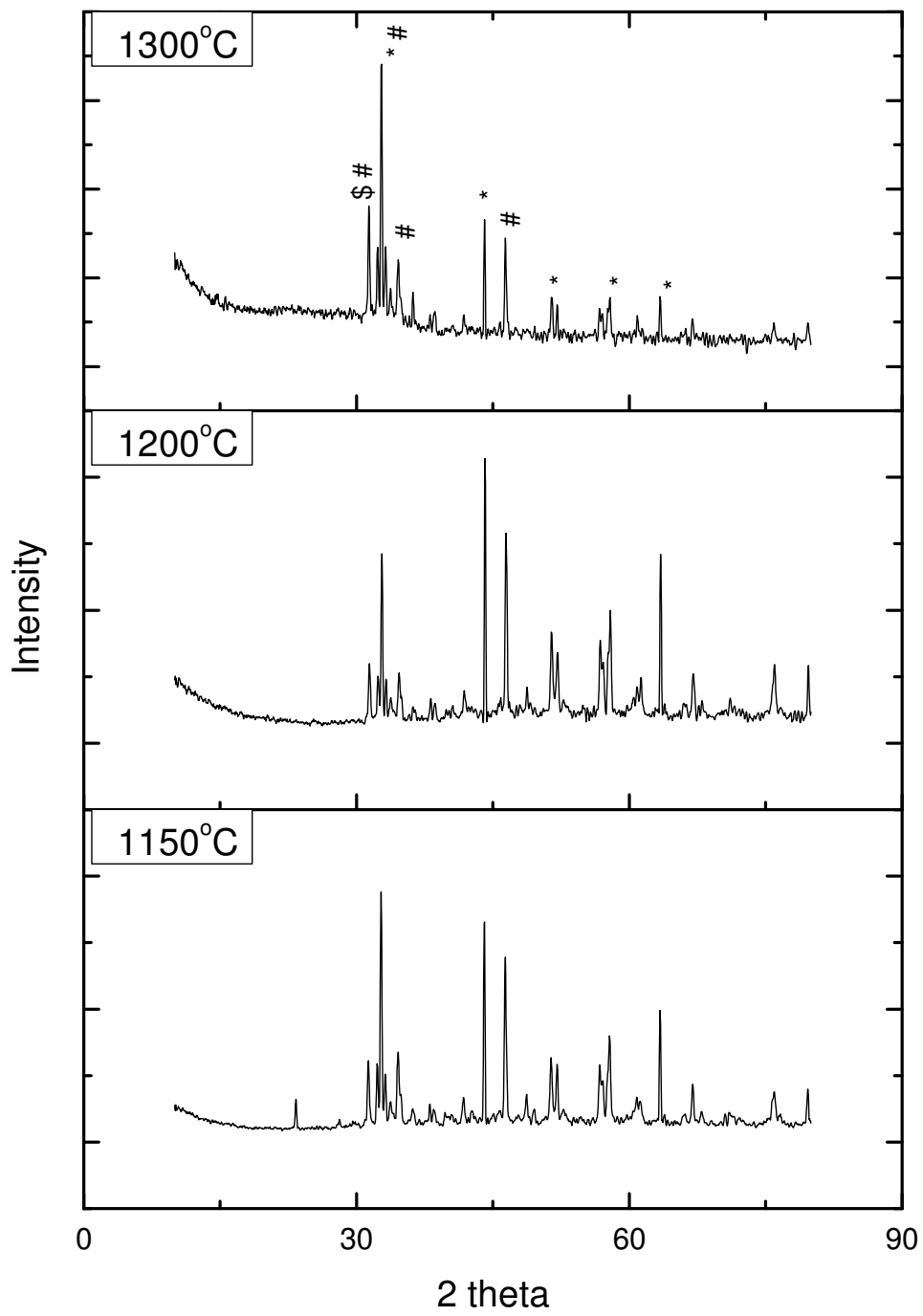


Fig 8. XRD patterns of Z2 samples as a function of temperature

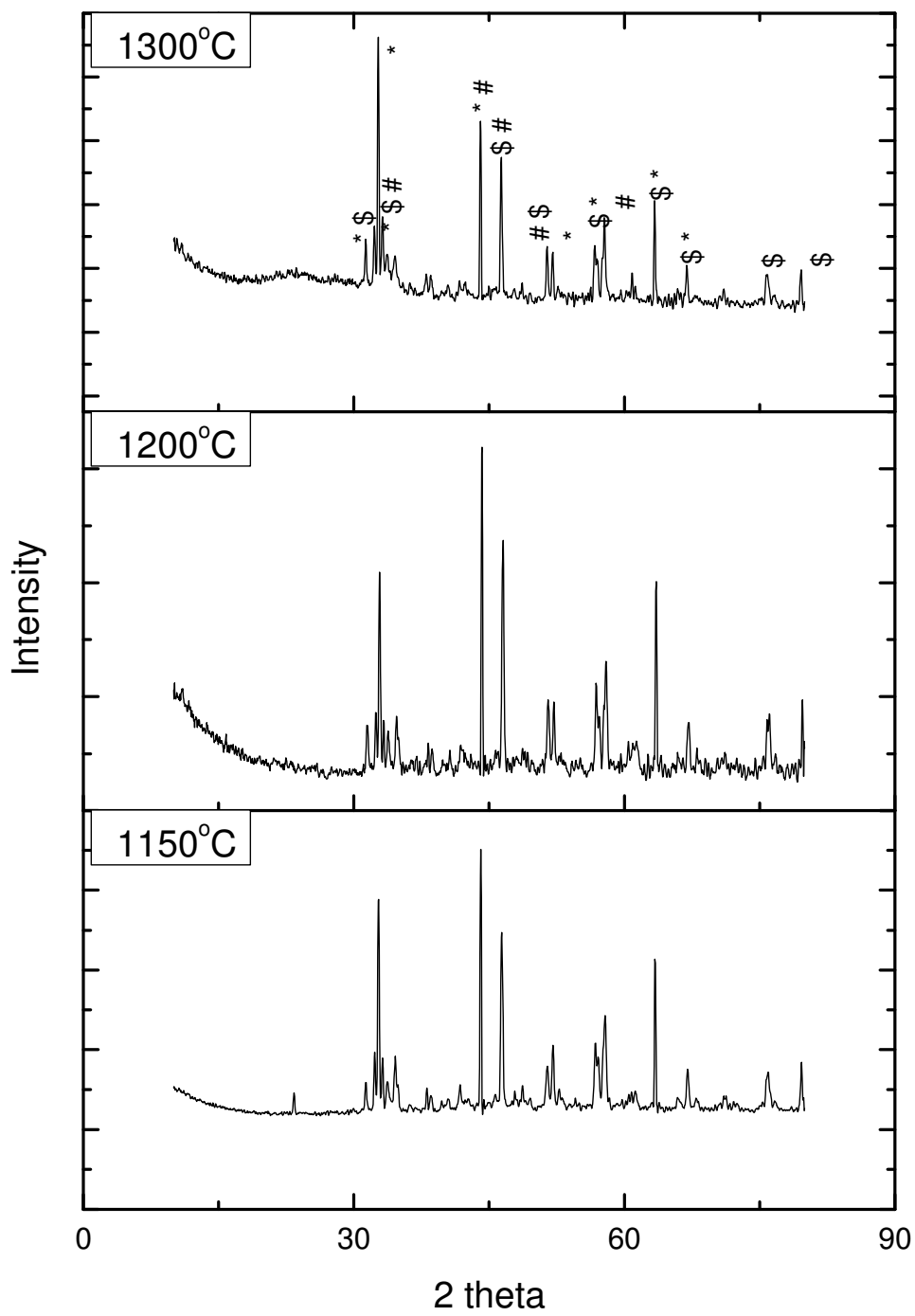


Fig 9. XRD patterns of Z3 samples as a function of temperature

4.2.2. APPARENT POROSITY/BULK DENSITY MEASUREMENTS

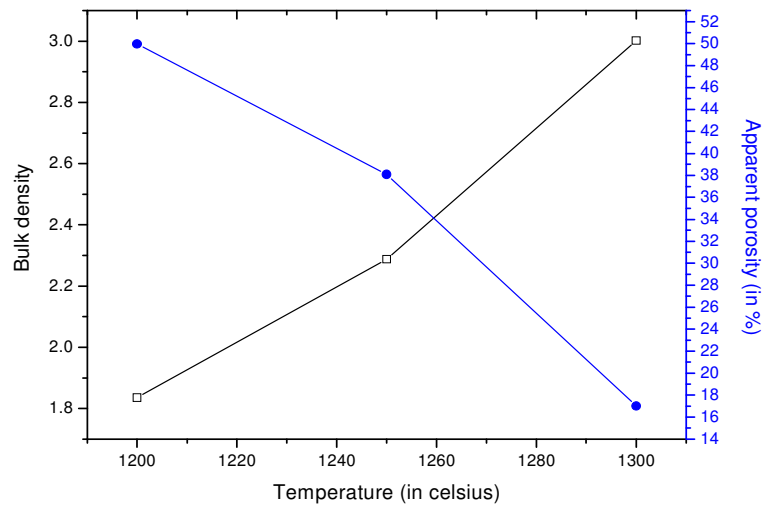


Fig 10. AP/BD of Z1 samples as a function of temperature

Fig 10 depicts the variation of AP/BD of Z1 samples with different temperatures of firing. The density increases and porosity decreases with increase in firing temperature. This behaviour may be attributed to higher densification in the samples on firing at higher temperatures.

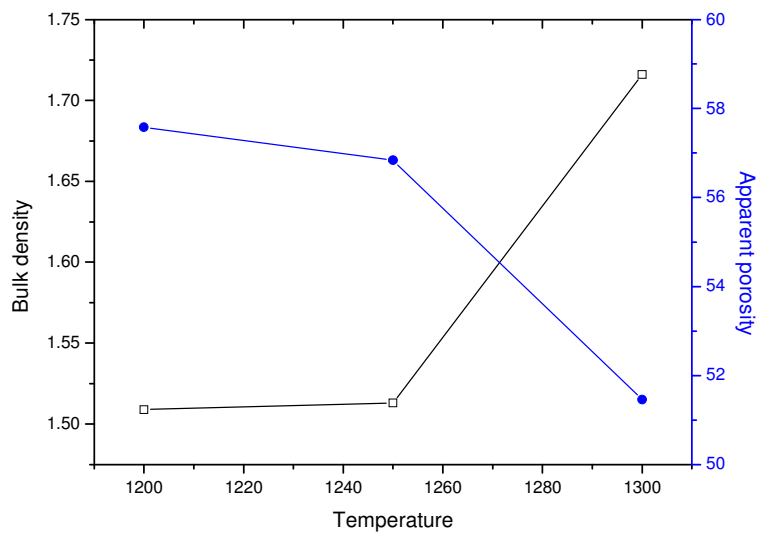


Fig 11. AP/BD of Z2 samples as a function of temperature

The AP/BD of Z2 samples as a function of temperature is shown in Fig 11. The variation of density and porosity with firing temperature is in good agreement with theoretical prediction. There is a decrease in porosity and increase in density with increase in firing temperature because of densification of the sample.

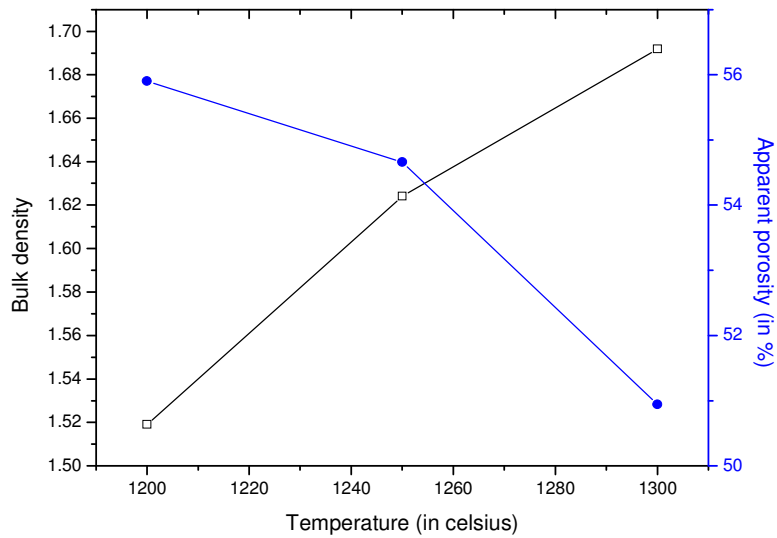


Fig 12. AP/BD of Z3 samples as a function of temperature

Densification studies of the samples were carried out by measuring apparent porosity and bulk density. The density of the Z1 samples was considerably higher than that of Z2 and Z3 samples. This is because of lower dolomite content which in turn results in lesser CO₂ removal from the structure. Bulk density increases and apparent porosity decreases with increase in firing temperature due to higher degree of sintering and hence densification. It was also found that high dolomite containing samples sinter at lower temperatures.

4.2.3. DIAMETRAL TENSILE STRENGTH MEASUREMENT

The tensile strengths of Z1, Z2 and Z3 samples as a function of temperature are shown in Figures 13, 14 and 15 respectively.

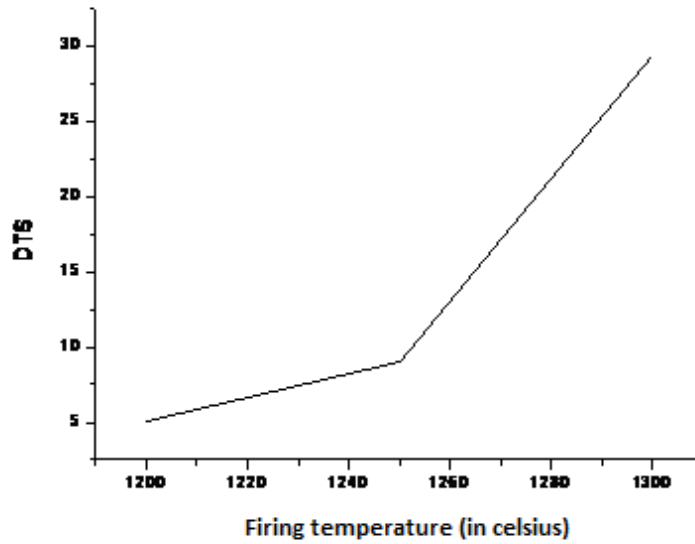


Fig 13. Tensile strength of Z1 samples as a function of temperature

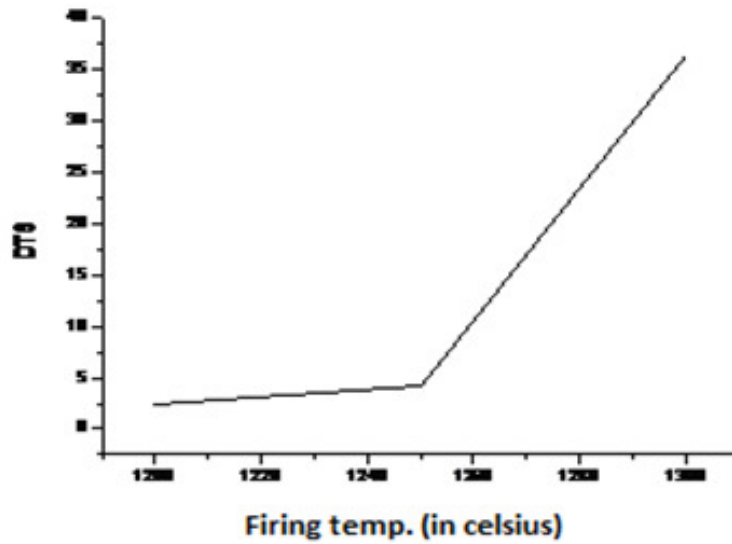


Fig 14. Tensile strength of Z2 samples as a function of temperature

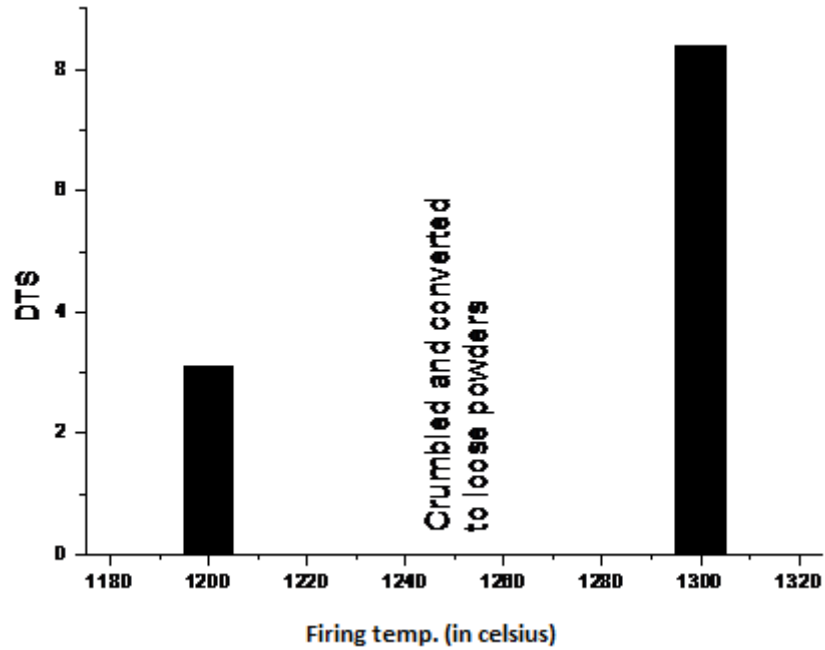


Fig 15. Tensile strength of Z3 samples as a function of temperature

Strength of the samples increases with firing temperature due to higher densification and formation of high strength refractory phases. But in case of higher dolomite containing samples (especially Z3), on holding for a few hours, they get disintegrated on their own and convert to loose powders. This happens because lime present in the samples takes up moisture from surroundings and expands and causes unstabilisation of calcined dolomite.

CHAPTER 5

CONCLUSION

5. CONCLUSION

- The main phases present in Z1 samples are CZ and C_2S with small amounts of Calcium magnesium silicates and unreacted zirconia. Calcium magnesium silicate phases are present in samples fired at low temperatures which then convert to form C_2S and enstatite(in high zircon compositions) at higher temperatures.
- The major phases present in Z2 and Z3 samples are CZ, C_3MS_2 and C_2S .
- High zircon containing samples get fused at a relatively lower temperature due to the formation of low melting phases in the CaO-MgO-SiO₂ system.
- Higher dolomite samples sintered at relatively lower temperatures.
- Density and tensile strength of the samples was found to increase with increase in firing temperature.
- In some cases, high dolomite containing samples crumbled automatically and gets converted to disintegrated powders. This un-stabilization may be due to expansion caused by hydration of lime.

CHAPTER 6

REFERENCES

6. REFERENCES

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