EQUATION OF STATE OF MgO: A REVIEW

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ABSTRACT*:* It is of great interest to study the condition and chemical composition of the region of the earth's interior to determine the equation of state for magnesium oxide. A white, hydroscopic solid mineral known as magnesium oxide (MgO) which arise in natural world as periclase. It is made up of an empirical MgO formula consisting of a gill of Mg^{2+} and O^{2-} ions that are connected by ionic bonding. The hardness of the mohs is 5.5. Magnesium oxide is used as a gemstone called periclase**.** In the Earth sciences, physics, and chemistry periclase (MgO) is considered as one of the most common mineral. The other name given to magnesium oxide are magnesia alba, calcined magnesia, magnesia and periclase. The magnesium oxide study provides information about the deep–earth mineral's high-pressure conduct. This review paper deals with the about on the occurrence of MgO, its properties, its applications, its experimental as well as theoretical status and its equation of state.

Index Terms: MgO, equation of state, elasticity, thermal expansion

1. INTRODUCTION

A equation of state is the relationship between state functions like temperature, pressure, volume, internal energy and specific heat. The physical properties of the material are useful to understand and the relation of pressure to volume is called the EoS. To portray the property of fluid, combination of fluid and solids equation of state is essential**.** In investigating the properties of material, equation of state became a crucial concept and in which the isothermal (P,V,T) relation has the importance in high pressure studies. Therefore it is essential to accurate display the relationship of magnesium oxide pressure volume temperature. For different scientific field which comprise of geophysics, material science and high-pressure physics knowledge of the pressure-volume-temperature of equation of state for important materials is important [1] [2]. The objective of this study is to examine the geophysical mineral MgO.

In ancient time magnesium oxide was recognized as magnesium Alba which was used to distinguish from magnesia negra. By the calcinations of naturally occurring minerals such as magnesium carbonate and magnesium hydroxide the bulk of magnesium oxide is produce. Magnesium oxide is a geophysical mineral and it consists of 20% of the lower earth mantle [3]. MgO is of great interest for understanding the cores of giant planets in our solar system at high pressure as well it is possible for super-earth planets revolving near other stars [4][5][6]. The very high melting temperature of MgO is above 3000 K [7][8]. By clay compound magnesium oxide (MgO) is made which can be easily moulded, and is improve by the high mobility of displace [9].

Arcangelo Cache discovered periclase (MgO) in 1840 at Monte Soma, Vesuvius, Italy, a mineral which is mix by ferrous oxide. From the Greek word peri, which meant to be “around,” and the word kola, which meant to be “to cut,” the word periclase is obtained. Periclase is used as restorative for other gemstones. Periclase is colorless, grayish white, brown, brownish yellow, green, and black. Due to the presence of iron, periclase is in yellow brown and black color. Periclase is the characteristic of metamorphic limestone and dolomites.

Mg–rich ferropericlase is the second largest of the earth’s bottom and periclase is the end part of the series (Mg,Fe)O solid solution [10] [11]. With a cubic NaCl structure stable up to mega bar pressures magnesium oxide is a simple oxide[12] [13] [14]. The end member of magnesiowtistite (Mg,Fe)O is a most important element of the earth's inferior blanket [10][11] . To recognize the thermo physical property of the earth’s lower mantle magnesium oxide play a vital role. By action of humidity in normal atmospheric conditions periclase can change and modify to Brucite and other magnesium minerals.

The sources of magnesium oxide are the underground deposits in which salt, sea water and deep beds are processed using magnesium hydroxide. Magnesium oxide of different reactivity produces calcining at different temperatures. In the calcined material the source determine the level and nature of impurities. Dead burned magnesia is obtained in a tunnel and spinning at temperature ranging from 1500^0 C to 2000^0 C ($3,000^0$ F to $4,000^0$ F) so called the final product .Dead burned magnesia is used as refractory brick for cement kilns, furnaces and used in the manufacture of steel. Hard burned magnesia also known as caustic burned is obtained by the calcining temperature ranging from 1000^0 C- 1500^0 C ($2,000^0$ F and $3,000^0$ F) which has limited reactivity). Hard burned magnesia has many applications in extraction of uranium oxide from the uranium ore, in the production of fertilizers and animal feed, for the tanning of leather, in the synthesis of magnesium compounds ,it remove sulphur dioxide from plant exhaust gases in pollution control devices. Light burning magnesia is obtained in which the temperature ranges between 700^0C to 1000^0C (1500^0 F to 2000^0 F). Light burning magnesia has many uses such as an element in a host of household and special care products such as dusting powders, cosmetics and pharmaceuticals, in the processing of paper and pulp and as filler made in products of rubber. Fused magnesia is obtained in an electric curve chamber from caustic calcined magnesia at temperature in surplus at 2650^0 C (4800^0 F). Fused magnesia is used as refractory linings for electric arc furnace and in insulating materials used in many domestic electrical products.

The properties of magnesium oxide (periclase) are given as-

1. The magnesium oxide crystal system is Isometric.

2. Density of magnesium oxide ranges from 3.55 to 3.68 g/cm^3. The magnesium oxide radiation density is 3.581 g/cm^3.

3. 1.7350 at 633 nm is the refractive index of periclase.

4. The electrical resistance of periclase is measured as 2.3 $*10^9$ ohm cm at 700^{0}C and is the utmost.

5. 2800^{0}C is the melting point of magnesium oxide and 3600^{0}C is the boiling point of magnesium oxide.

6. Heat capacity values are at 3600 K from ambient temperature for the specific heat capacity of magnesium oxide.

7. The standard magnesium oxide formation enthalpy is -601.241kJ/mol.

8. Magnesium oxide magnetic susceptibility at 25.8C is 20.25(k) 1026 emu/g [15].

Magnesium oxide, a physically and chemically stable high temperature is cherished as a refractory material. Magnesium oxide has two features one of them is highest thermal conductivity and the other one is lowest electrical conductivity. In construction materials magnesium oxide is utilized as a fireproofing element. In dehydrated processed plants magnesium oxide is used a raw material used to make Portland cement. The excess amount of magnesium oxide when added to the cement it becomes extroverted. In relief of heart burn and sour stomach magnesium oxide is used as an antacid. To improve the symptom of indigestion magnesium oxide is used.

As magnesium oxide has good diffusing and reflective properties so magnesium oxide is apply as a indicating white color in colorimeter. MgO is used as an electrical insulator in tubular construction of heating elements. The American Foundry Society uses the most commonly 40 and 80 mesh. Magnesium oxide will generally be crushed with minimum air vacuum or void compacted. As an insulator magnesium oxide is used in heat resistant electrical cable.

As an optical material pressed magnesium oxide is used. It is transparent from 0.3 to 7µm. In infrared optics, crystalline pure magnesium oxide has its use and is commercially available .To control the solubility of a chemical element that release radiation in which magnesium oxide is covered around a element having a higher atomic number then uranium waste at the Waste Isolation Power plant .In library sciences and collections management, an aerosolized solution of magnesium oxide is used for the deacidify of hazard objects.

2. REVIEW OF LITERATURE

In order understand the seismic observations and the interior of Earth the properties of earth materials at high pressures and high temperatures play important roles. Diamond anvil cell studies have shown several materials which are important for understanding the planetary interiors under extreme pressures and temperatures [16][17][18][19]. Using isothermal equations of states thermal elastic properties, such as bulk module isothermal, youth elasticity module and geophysical MgO shear stress, have been examined at a high temperature and high pressure. In high pressure conditions, it is necessary for the exact mineralogical model for magnesium oxide or periclase to be constructed in the lower mantle of the Earth.

The pressure-volume-temperature equation of magnesium oxide is usually used as a pressure scale in static compression experiments. At high pressures and high temperatures up to 300 GPa and 3000 K, the DAC experiment was performed to calculate the MgO state equation of pressure-volume-temperature as a consistent pressure scale. Based on the shock, Hugoniot data of the pressure-volume-temperature equation of the MgO state was calculated at pressures up to 300 GPa and temperatures up to 3000k and a simple thermal pressure model was calculated within the Mie-Gruneisen type analysis framework. The calculated pressure-volume-temperature equation of state is fully compatible with the accessible volume compression data over a wide pressure range at 300K and also over the pressure-temperature ranges of 12GPa 53GPa and 1700K 2500K. The calculations were in excellent agreement with the MgO pressure scale with a small difference of less than 2 percent in the pressure and temperature range of 240 GPa and 3000 K [20]. The pressure-volume-temperature equation of the MgO state needs to further verified by more EOS measurements at higher pressure and higher temperature region. The pressure volume temperature relationship has important advantages in the Mie-Gruneisen-Einstein approach such as simplicity and analyticity.

From Shock-wave measurements equation of state of magnesium oxide was known [21]. There was inaccuracy found in the equation of state of magnesium oxide at elevated temperature because of the anharmonic contribution not given and by molecular dynamic imitation the thermal equation of state of magnesium oxide was obtain that gives a fine description of volume thermal expansivity and isothermal bulk modules at both higher absolute temperature and pressure [22]. For real pressure set at privileged temperature the EoS of magnesium oxide is used[23][24][25][26][27][28][29] .The equation of state give a better relation of lowest-pressure XRD information on the exact volume of MgO to 52 GPa and shock-movement record to 203 GPa which are based on Mie-Gruneisen–Debye assumptions[30][31][32][33]. At temperature greater than 2,200 K at close pressure it was noted that the equation of state of magnesium oxide becomes stable [23]. The combination of QHA calculations with lower pressure experimental data from the first principles of the local density approximate produced an EOS of magnesium oxide ,which corresponds very well to the shock compressor data [34]. By parameters from up to pressure 150 GPa, the pressure-volume-temperature data of the equation of state for MgO were well describe as third-order Birch–Murnaghan equation of state was applied rather then the fourth-order Birch–Murnaghan equation in the equation of state[34].

At high pressure the elasticity of minerals is of physical and geological interest. As comparing to the equation of state the experimental and theoretical study of the higher-pressure elastic actions of magnesium oxide were partly. At 3 GPa temperature dependence of elastic property is calculated around a broad range temperature at ambient pressure by resonance process[35][36][37][38][39][40]. The elastic modulus of magnesium oxide was carried out a thorough study of elasticity and it is based on no first-principle prediction [41]. By the calculation of the stress generated by small strains the elastic constants were determined [42]. Equilibrium lattice parameters for magnesium oxide were obtained at different pressures up to 150 GPa. The pressure derived of zero-pressure bulk shear moduli are calculated and there values are compared with the experiments [43][40][14][44]. By the diamond-cell measurement the B1-B2 phase transition for magnesium oxide is obtain to 227 GPa and to 200 GPa from shock-wave study, indicating the stability range of magnesium oxide in the BI phase[14][12]. The structure of BI for magnesium oxide was found in the state of stability all over the earth mantle from the experimental and theoretical studies. The values which were obtain by the experimental values from ultrasonic and resonance were compared with the zero-pressure value of all elastic moduli which were slightly underestimate[40][35]. At high pressures the calculated values differ largely from the extrapolated data but the dependence of the initial pressure were calculated with elastic modulus which is accurate for the experiment.

The calculations of the thermodynamic properties of MgO at high pressure temperature were described by the first quasi-harmonic principles (QHA) within the approximation validity regime [45][46][47][48][49]. In first principle QHA calculations .The thermal pressure is accurate in the calculations of QHA in the first principle, which is very helpful for experiments suffering from major thermal pressure uncertainties. Anharmonic effects are not negligible at very high temperatures, no phase transition was observed experimentally at ambient pressure up to 2.3 Mbar above 1000K [14]. MgO isochores derived after the volume was included as well as anharmonic corrections. The state equation of Hugoniot is pretty accurate at temperature of shock pressure. The main source of uncertainity is the shock Hugoniot temperature by measuring the thermal radiation of shocked MgO at four wavelengths is determined by the main source of uncertainty which is the shock (Hugoniot) temperature [50]. Quasiharmonic calculation gives the remaining source of uncertainity to the thermal pressure. MgO has been extensively documented by comparisons with experimental high pressure-volume-temperature data [45][46].

To investigate extreme pressure-volume-temperature conditions shock wave propagation was a great process in use [51][52]. Shock wave is produce as when a strong force of a flyer plate is hit to a fixed target in diamond anvil cell and the uniaxial compression gives a deviatoric stress in a sample [53]. The difference in the lattice parameters from different diffraction lines is related to the shear stress produced [54][14]. Magnesium oxide is consistently increased to 0.3% or in the same pressure series in a non-hydrostatic compression experiment. The evaluate temperature on the Hugoniot depends on the value of specific heat at constant volume and shock wave information is covered over a large pressure-volume area. As reported by four pressure-volume-temperature shock data temperature is generally find out by calculating the range given by shock-induced thermal radiation [50]. The thermodynamic models were largely inconsistent with the static compression data as for the no reason being selected the higher value for the pressure derivative of the bulk modulus at ambient state [55][56].

In the rock forming minerals the accurate data of thermal expansion have a great importance in theoretical and experimental methods to clarify the EoS inside the earth. Dilatometric method was used to measure the thermal expansion of magnesium oxide (periclase) through the temperature which ranges from room level near 1000 degrees Celsius. MgO from deliberate thermal expansion coefficients is given in a range of temperature from -250 to 1500 degree Celsius which support the theory of Gruneisen's thermal expansion. The thermal expansion values of MgO(periclase) specimen were read at 20 or 5 degrees Celsius intervals and the corrections made were due to the bare test and the expansion of the reference sample was made. Unusual methods contrasted the calculate values of the thermal expansion coefficients with the results [57][58][59][60][61]. The precise interferometric method in the extrapolated range of temperature shows the pure specimen results showing admirable consent. The data obtained was not accurate enough for comparison by the X-ray method.

3. CONCLUSION

This paper is all about equation of state of MgO. One of the most of the equation of state is use is Birch Murnughan equation of state. This review paper is about thermal expansion of minerals and elasticity of MgO. The equation of sate of MgO was in outstanding agreement with the data on shock wave. The value of elastic parameter shows by the use of state and the birch equation of Murnaghan, while the Born-Mayer state equation shows variability in values. Anharmonic effects had to be taken into account and temperature regime based on the low pressure QHA and at high temperature had to be extended.The structural and elastic properties of magnesium oxide were studied with the first principles of the pseudopotential method in the local density approximation up to 150 GPa. The elastic module and wave speed were in great agreement with the experiments and their calculated zero pressure values. The experimental methods for magnesium oxide static compression at 300K were performed under quasihydrostatic conditions upto 52 GPa using helium as a pressure transmitting medium. Only a marginal agreement with the shock wave data is shown by existing theoretical models. With the help of perfect thermal expansion information, it provides a good judgment of elastic wave velocities and other physical constants, which are very useful in the learning of the equation of state of the interior of earth mantle.

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