**Summary of the Invention**

The present invention provides a process for mineral carbonation, which process comprises the steps of:

providing a bed of hydroxylated magnesium silicate mineral particles in a heating vessel;

agitating the bed of particles under conditions of a sub-atmospheric pressure and at a temperature of at least 600°C to produce particles of dehydroxylated magnesium silicate mineral; and

reacting the dehydroxylated magnesium silicate mineral with carbon dioxide, carbonate ions and/or bicarbonate ions to form magnesium carbonate;

wherein the sub-atmospheric pressure is generated, partly or in full, by a condensing heat exchanger, which condenses steam produced during production of the dehydroxylated magnesium silicate mineral.

In accordance with the present invention, agitation of the mineral particles under conditions of sub-atmospheric pressure and a temperature of at least 600°C has been found to provide improved activation of the mineral with respect to its reactivity in subsequent carbonation reactions.

It is preferred that the particles are agitated in a continuous manner, or at least frequently on the order of every five minutes or less if done sporadically, under these conditions. It has been found that heating under these conditions for a relatively short period of time (possibly about 10 to 180 minutes) may provide suitably activated mineral that has increased reactivity in mineral carbonation processes. The activated mineral may exhibit increased solubility in moderately acidic aqueous solutions used to perform the carbonation reactions than mineral activated under a nitrogen purge gas or under other conditions of heat activation such as without agitation.

The present invention also provides a reactor system adapted to perform the process of the present invention. The reactor system comprises a heating vessel for receiving a bed of hydroxylated magnesium silicate mineral particles, a mechanism for heating the bed of particles, a mechanism for evacuating the heating vessel to provide sub-atmospheric pressure which comprises a condenser that reduces the pressure in the heating vessel

through condensation of steam exiting the heating vessel and a mechanism for agitating particles during heating under sub-atmospheric pressure.

Sub-atmospheric pressure (partial vacuum) may be provided by a vacuum system. A particularly advantageous embodiment of the invention provides a vacuum system that comprises a condensing heat exchanger in combination with a vacuum pump. The condensing heat exchanger reduces the pressure by condensation of steam evolved during dehydroxylation through cooling.

Agitation may be provided by mechanical stirring, shaking or vibration or by rotation, for example in a cylindrical heating vessel. Other forms of agitation may also be applied, for example by fluidising or partially fluidising the particles within a fluidised bed operated at sub-atmospheric pressure. Various combinations of these forms of agitation may be used, for example fluidisation in combination with mechanical stirring and/or vibration, or rotation in combination with mechanical stirring or vibration.

It is preferable to recover as much of the sensible heat from the mineral particles as possible after heat activation. In this regard, heat transfer from the heated mineral particles to a fluid or gas may be applied to the heat activation process. An example is heat transfer to air that is pre-heated for use in a combustion process that is employed to supply the heat required for mineral activation. Another example is heat transfer to air that is used to pre-heat the mineral before entering the heat activation heating vessel. Pre-heating of the mineral involves elevating the temperature of the mineral to a temperature below 600°C. This can improve the overall efficiency of the process of the invention. Pre-heating can take place in the heating vessel or in another vessel with pre-heated mineral particles then being transferred (with minimal cooling) to the heating vessel in which thermal activation takes place. Pre-heating may involve heating the mineral particles to a temperature of from 200 to 600°C, for example from 200 to 500°C.

It is also preferable to recover as much of the sensible heat from the combustion flue gases from such a process as possible. This recovered heat may also be used elsewhere such as

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A process for mineral carbonation, which process comprises the steps of:

providing a bed of hydroxylated magnesium silicate mineral particles in a heating vessel;

agitating the bed of particles under conditions of a sub-atmospheric pressure and at a temperature of at least 600°C to produce particles of dehydroxylated magnesium silicate mineral; and

reacting the dehydroxylated magnesium silicate mineral with carbon dioxide, carbonate ions and/or bicarbonate ions to form magnesium carbonate;

wherein the sub-atmospheric pressure is generated, partly or in full, by a condensing heat exchanger, which condenses steam produced during production of the dehydroxylated magnesium silicate mineral.

2. A process according to claim 1, wherein the hydroxylated magnesium silicate mineral comprises serpentine.

3. A process according to claim 2, wherein the hydroxylated magnesium silicate mineral comprises lizardite, antigorite or chrysotile, or mixtures of one or more thereof.

4. A process according to any one of the preceding claims, wherein the hydroxylated magnesium silicate mineral has a volume weighted average particle size of up to 5 mm.

5. A process according to any one of the preceding claims, wherein the temperature in the heating vessel is in the range 600-680°C.

6. A process according to any one of the preceding claims, wherein the mineral particles are heated in the heating vessel for a period of 10 to 180 minutes.

7. A process according to any one of the preceding claims, wherein the mineral particles are preheated to a temperature of 200 to 500°C before heating to produce particles of dehydroxylated magnesium silicate mineral.

8. A process according to any one of the preceding claims, wherein the mineral is cooled after exiting the heating vessel and sensible heat from the dehydroxylated mineral is recovered.

9. A process according to any one of the preceding claims, wherein heat supplied to the heating vessel is sourced from combustion of a fuel.

10. A process according to claim 9, wherein heat is recovered from combustion gases produced by combustion of the fuel.

11. A process according to any one of claims 7, 9 and 10, wherein heating or cooling is conducted using a series of heat exchange stages.

12. A process according to any one of the preceding claims, wherein formation of the magnesium carbonate occurs in a single step or two step carbonation process.

13. A process according to any one of the preceding claims, wherein the formation of the magnesium carbonate occurs in an aqueous slurry.

14. A reactor system adapted to perform the process of claim 1, the reactor system comprising a heating vessel for receiving a bed of hydroxylated magnesium silicate mineral particles, a mechanism for heating the bed of particles, a mechanism for evacuating the heating vessel to provide sub-atmospheric pressure which comprises a condenser that reduces the pressure in the heating vessel through condensation of steam exiting the heating vessel and a mechanism for agitating particles during heating under sub-atmospheric pressure.

15. The reactor system according to claim 14, comprising a gas-tight rotary kiln furnace that can be evacuated and held under partial vacuum at an absolute pressure of less than 0.5 atmospheres by a vacuum system.

16. The reactor system according to claim 15, wherein the rotary kiln furnace comprises internal structures to ensure that when the kiln is rotated the bed of mineral particles is agitated causing relative motion between particles and between particles and the internal surfaces of the kiln.

17. The reactor system according to claim 14, comprising a fluidised or partially fluidised bed.

18. The reactor system according to claim 14, which contains solid media to enhance mixing and heat transfer are added to the reactor system during agitation.