

A NOTE ON STRONTIUM MAGNESIUM CARBONATE

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ABSTRACT

The compound $\text{SrMg}(\text{CO}_3)_2$ and solid solutions $(\text{Sr}, \text{Ca})\text{Mg}(\text{CO}_3)_2$ have been synthesized, and the system $\text{CaCO}_3 - \text{SrCO}_3 - \text{MgCO}_3$ has been investigated in the range $530^\circ\text{C} - 660^\circ\text{C}$ and 1–4 kb. The powder diffraction pattern of $\text{SrMg}(\text{CO}_3)_2$ is very similar to that of dolomite and norsethite, $\text{BaMg}(\text{CO}_3)_2$. The hexagonal unit cell constants are $a = 4.905 \text{ \AA}$ and $c = 16.44 \text{ \AA}$.

In order to determine whether MgCO_3 is soluble in strontianite, mixtures of SrCO_3 and MgCO_3 and of SrCO_3 and dolomite, together with some water, were subjected to high temperatures and pressures (Froese & Winkler, 1967). As a result, the compound $\text{SrMg}(\text{CO}_3)_2$ and solid solutions $(\text{Sr}, \text{Ca})\text{Mg}(\text{CO}_3)_2$ were synthesized. Experimental techniques and starting materials (except for MgCO_3) are described by Froese & Winkler (1967). The MgCO_3 used was reagent grade material (Merck).

In Table 1, the x -ray reflections of $\text{SrMg}(\text{CO}_3)_2$ are given, based on a diffraction pattern taken with a 114 mm powder camera using $\text{CuK}\alpha$ radiation. Silicon was used as an internal standard. The intensities were measured by means of a diffractometer, also using $\text{CuK}\alpha$ radiation. The powder pattern can be indexed on the basis of the dolomite structure. Table 1 lists not only the observed reflections, but also all possible reflections as given by Graf (1961). Mrose *et al.* (1961) found that, although the powder pattern of norsethite, $\text{BaMg}(\text{CO}_3)_2$, can be indexed on the basis of the dolomite structure, norsethite belongs to space group $R\bar{3}2$ rather than $R\bar{3}$. This may also be true of $\text{SrMg}(\text{CO}_3)_2$. The x -ray data of Table 1 are based on a sample which was synthesized from SrCO_3 and MgCO_3 ($610^\circ\text{C} \pm 10^\circ$; $3.92 \text{ kb} \pm 2\%$; 39 days) and co-existed with strontianite. The hexagonal unit cell constants are $a = 4.905 \pm 0.003 \text{ \AA}$ and $c = 16.44 \pm 0.01 \text{ \AA}$. Another sample was synthesized ($610^\circ\text{C} \pm 20^\circ$; $3.92 \text{ kb} \pm 2\%$; 39 days) from a mixture with an excess of MgCO_3 , and the final assemblage was $\text{SrMg}(\text{CO}_3)_2$, magnesite, and brucite. The unit cell constants of this sample are $a = 4.904 \pm 0.003 \text{ \AA}$ and $c = 16.46 \pm 0.01 \text{ \AA}$. This shows that there is no appreciable solid solution between $\text{SrMg}(\text{CO}_3)_2$ and either strontianite or magnesite.

In the system $\text{CaCO}_3 - \text{SrCO}_3 - \text{MgCO}_3$, solid solutions $(\text{Sr}, \text{Ca})\text{Mg}(\text{CO}_3)_2$ are formed. The unit cell constants of dolomite and $\text{SrMg}(\text{CO}_3)_2$

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TABLE 1. X-RAY POWDER DIFFRACTION DATA FOR $\text{SrMg}(\text{CO}_3)_2$
 Hexagonal unit cell constants: $a = 4.905 \pm 0.003 \text{ \AA}$, $c = 16.44 \pm 0.01 \text{ \AA}$

hkl	$d \text{ \AA}$ calc.	$d \text{ \AA}$ meas.	$I/I_{\max}$	hkl	$d \text{ \AA}$ calc.	$d \text{ \AA}$ meas.	$I/I_{\max}$
00.3	5.480	5.507	6	31.2	1.166	1.166	2
10.1	4.113	4.113	14	21.10	1.149	1.150	3
01.2	3.774	3.776	16	13.4	1.133	1.133	7
10.4	2.954	2.957	100	01.14	1.132		
00.6	2.740	—	—	22.6	1.119	1.120	4
01.5	2.600	2.604	24	30.9	1.119		
11.0	2.453	2.452	20	31.5	1.109	—	—
11.3	2.239	2.239	26	00.15	1.096	1.096	1
02.1	2.106	2.106	16	12.11	1.094		
20.2	2.056	2.056	33	02.13	1.087	—	—
10.7	2.055			40.1	1.060	—	—
02.4	1.887	1.888	9	04.2	1.052	—	—
01.8	1.850	1.855	31	13.7	1.053	—	—
11.6	1.827	1.830	42	40.4	1.028	1.030	3
00.9	1.827			20.14	1.028		
20.5	1.784	—	—	31.8	1.022	1.023	4
	1.598	1.597	6	22.9	1.018	—	—
12.2	1.576	1.576	14	04.5	1.011	—	—
02.7	1.575			11.15	1.001	1.003	3
10.10	1.533	1.538	4	10.16	0.9986	—	—
21.4	1.496	1.496	12	21.13	0.9934	—	—
20.8	1.477	1.480	8	30.12	0.9845	0.9858	2
11.9	1.465	1.465	5	32.1	0.9728	0.9725	1
12.5	1.443	1.442	6	23.2	0.9677		
03.0	1.416	1.415	6	40.7	0.9676	0.9679	2
01.11	1.410	—	—	13.10	0.9576		
30.3	1.371	1.372	6	32.4	0.9482	0.9496	3
00.12	1.370	—	—	12.14	0.9478	0.9465	3
21.7	1.325	1.327	5	04.8	0.9434	—	—
02.10	1.300	1.302	6	01.17	0.9429	—	—
12.8	1.265	1.267	5	23.5	0.9343	—	—
	1.258	1.258	3	14.0	0.9270	0.9271	3
30.6	1.226	1.226	4	31.11	0.9252	—	—
22.0	1.222	—	—	02.16	0.9249	—	—
20.11	1.222	—	—	41.3	0.9140	0.9152	3
10.13	1.212	1.214	2	22.12	0.9137	—	—
22.3	1.197	1.198	6	00.18	0.9133	—	—
11.12	1.196						
13.1	1.175	1.175	2				

being known, the composition of a solid solution can be determined on the assumption that the lattice dimensions, *e.g.* $d(10.4)$, vary linearly with composition expressed as mole percentage. Only trace amounts of MgCO_3 are incorporated in aragonite-strontianite solid solution; therefore, its composition can be determined by measuring the spacing of a suitable reflection, such as $d(132)$ (Froese & Winkler, 1967). In Table 2, the composition of aragonite-strontianite coexisting with calcite and dolomite is given, and in Table 3, the composition of aragonite-strontianite and of

TABLE 2. COMPOSITION OF ARAGONITE-STRONTIANITE COEXISTING WITH CALCITE AND DOLOMITE

Starting material	Run	Temperature °C	Pressure kb $\pm 2\%$	Time days	$d(132) \text{ \AA}$	Composition mole % $\text{SrCO}_3 \pm 2.5\%$
Calcite + SrCO_3 + dolomite	39-1-1	572 ± 10	0.98	14	1.8663	55.0
"	19-21-3	630 ± 20	3.92	10	1.8643	53.0
"	7-1-6	540 ± 20	6.86	33	1.8498	37.5
"	22-3-1	653 ± 10	0.98	31	1.8721	62.0
"	19-21-1	666 ± 10	3.92	10	1.8672	56.0
"	7-1-2	655 ± 10	6.86	33	1.8602	48.5

TABLE 3. COMPOSITION OF ARAGONITE-STRONTIANITE AND $(\text{Sr}, \text{Ca})\text{Mg}(\text{CO}_3)_2$ FROM ARAGONITE-STRONTIANITE + $(\text{Sr}, \text{Ca})\text{Mg}(\text{CO}_3)_2$ + DOLOMITE ASSEMBLAGES*

Run	Temperature °C	Pressure kb $\pm 2\%$	Aragonite-strontianite		$(\text{Sr}, \text{Ca})\text{Mg}(\text{CO}_3)_2$	
			$d(132) \text{ \AA}$	Composition mole % $\text{SrCO}_3 \pm 2.5\%$	$d(10.4) \text{ \AA}$	Composition mole % $\text{SrMg}(\text{CO}_3)_2 \pm 4\%$
22-13-1	647 ± 10	0.98	1.8759	66.0	2.918	46
22-13-3	595 ± 20	0.98	1.8843	75.0	2.919	47
22-13-5	530 ± 20	0.98	1.8911	83.0	2.931	64
30-2-2	657 ± 10	3.92	1.8803	70.5	2.923	53
19-21-4	630 ± 20	3.92	1.8850	76.0	2.931	64
30-2-5	540 ± 20	3.92	1.8935	85.5	2.943	81

*Starting materials: dolomite and SrCO_3 . Run 19-21-4 for 10 days, all others 21 days.

$(\text{Sr}, \text{Ca})\text{Mg}(\text{CO}_3)_2$ from aragonite-strontianite + $(\text{Sr}, \text{Ca})\text{Mg}(\text{CO}_3)_2$ + dolomite assemblages is given. Part of this information is shown on a phase diagram of the system $\text{CaCO}_3 - \text{SrCO}_3 - \text{MgCO}_3$ at 660°C and 3.92 kb (Fig. 1). The composition of dolomite is practically pure $\text{CaMg}(\text{CO}_3)_2$. There is, however, the possibility that strontium-bearing dolomite cannot be quenched. The composition of calcite coexisting with dolomite is taken from Goldsmith & Heard (1961) and the composition of aragonite-strontianite coexisting with calcite from Froese & Winkler (1967). The composition field of calcite is shown approximately. Three-phase triangles, such as aragonite-strontianite + calcite + dolomite and aragonite-strontianite + $(\text{Sr}, \text{Ca})\text{Mg}(\text{CO}_3)_2$ + dolomite will shift in response to variations in temperature and pressure. These changes may be shown by plotting the composition of aragonite-strontianite against temperature at constant pressure (Fig. 2). It is seen that the compositions of aragonite-strontianite from the two assemblages become equal at

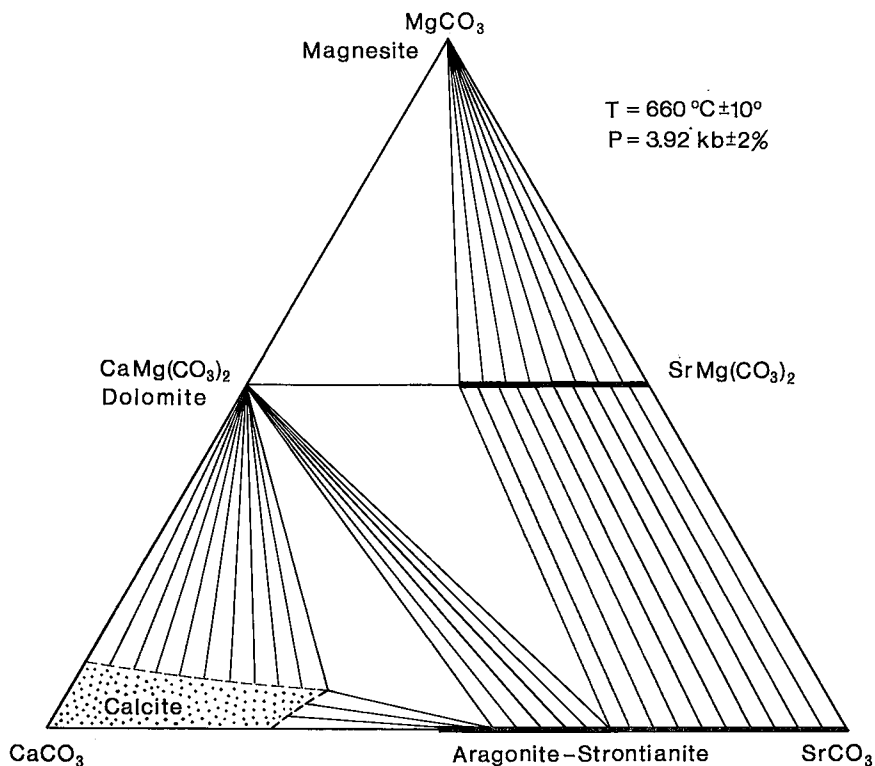
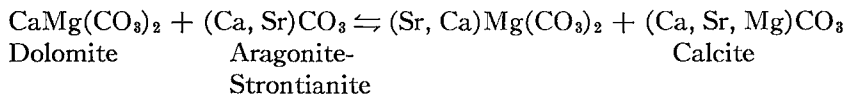


FIG. 1. The system $\text{CaCO}_3 - \text{SrCO}_3 - \text{MgCO}_3$ at 660°C and 3.92 kb .

certain temperature and pressure conditions. These are the equilibrium conditions of the reaction



Dolomite and $\text{SrMg}(\text{CO}_3)_2$ may be considered as belonging to the system $\text{CaMg}(\text{CO}_3)_2 - \text{SrMg}(\text{CO}_3)_2$. The compositions of solid solutions $(\text{Sr}, \text{Ca})\text{Mg}(\text{CO}_3)_2$ coexisting with dolomite (Table 3) are shown in an approximate phase diagram (Fig. 3). In one case (run 22-13-1), the composition of $(\text{Sr}, \text{Ca})\text{Mg}(\text{CO}_3)_2$ appears to be inconsistent with the other data. Possibly this is due to a difficulty of quenching solid solutions with a relatively low content of strontium end member.

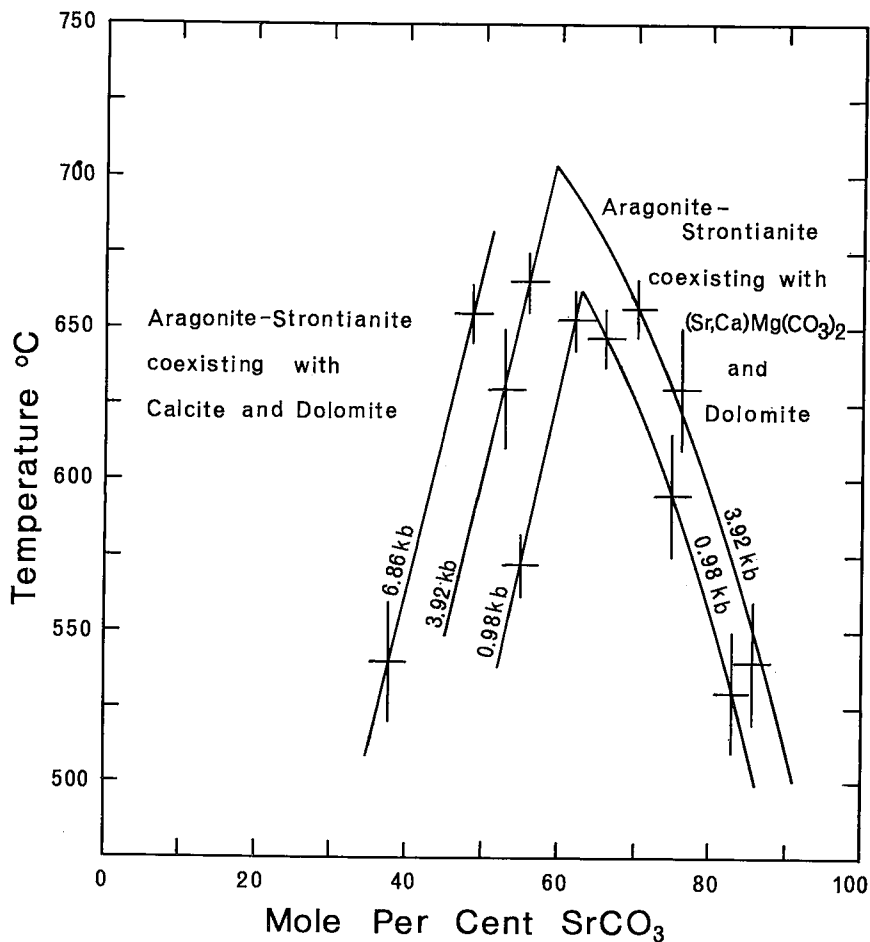
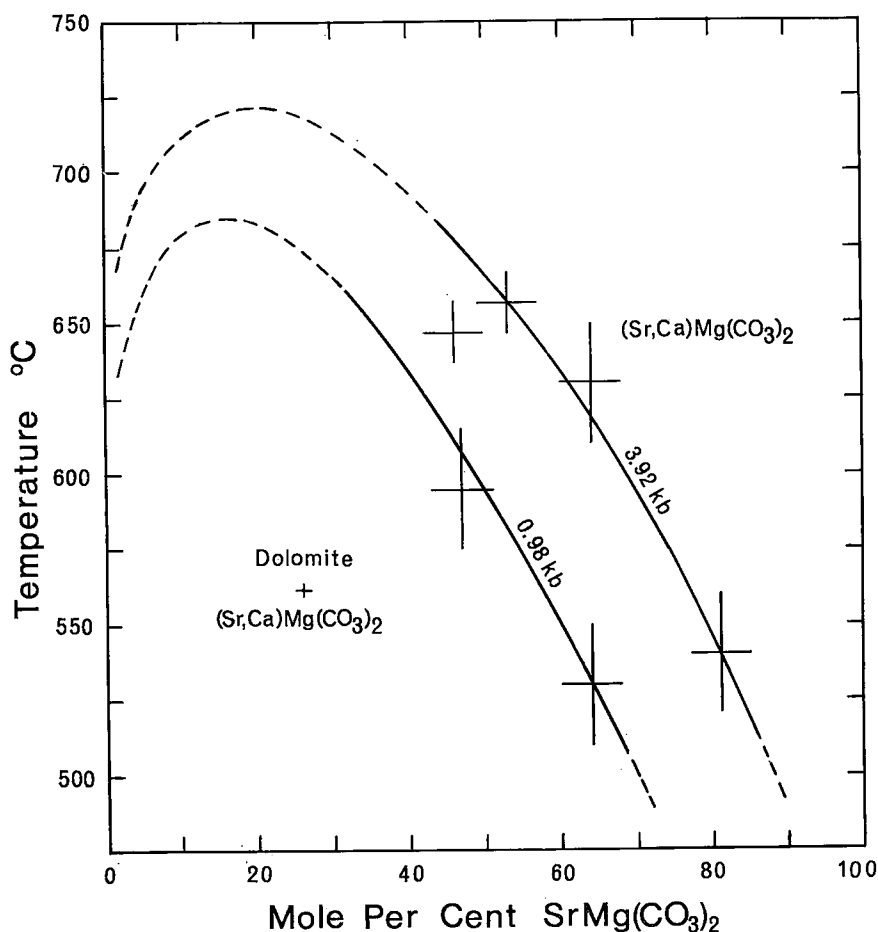


FIG. 2. Variation of the composition of aragonite-strontianite from three-phase assemblages in the system $\text{CaCO}_3 - \text{SrCO}_3 - \text{MgCO}_3$.

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FIG. 3. The system $\text{CaMg}(\text{CO}_3)_2 - \text{SrMg}(\text{CO}_3)_2$.

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