Phase Equilibrium on Liquidus Surface of the System $3CaO \cdot P_2O_5$-$CaO \cdot MgO \cdot 2SiO_2$-$MgO \cdot SiO_2$

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As a continuation of the author's preceding reports, which were on the phase relationship in the systems $3CaO \cdot P_2O_5$–$MgO \cdot SiO_2$–SiO_2[1] and $3CaO \cdot P_2O_5$–$CaO \cdot MgO \cdot 2SiO_2$–$SiO_2$[2], an equilibrium study on the system $3CaO \cdot P_2O_5$–$CaO \cdot MgO \cdot 2SiO_2$–$MgO \cdot SiO_2$, a side plane of a tetrahedron of a system $3CaO \cdot P_2O_5$–$CaO \cdot MgO \cdot 2SiO_2$–$MgO \cdot SiO_2$–$SiO_2$, was carried out by the usual quenching method. On the phase relationship of this 3-component system, no paper has ever been presented.

Of the three component system concerned, data of the two partial systems, $3CaO \cdot P_2O_5$–$CaO \cdot MgO \cdot 2SiO_2$ and $3CaO \cdot P_2O_5$–$MgO \cdot SiO_2$, were already given by the author's reports. Another partial system $CaO \cdot MgO \cdot 2SiO_2$–$MgO \cdot SiO_2$ was investigated by Bowen[3]. In his phase diagram, it is characterized that forsterite is a primary phase at 22∼100% of $MgO \cdot SiO_2$. However, in the phase diagram published in 1952 by Atlas[4], who studied the matter by adding LiF, the primary phase may be a solid solution at overall range, which is decomposed to a clinoenstatite, diopside, protoenstatite or rhombic enstatite solid solution in a crystalline phase. In this report the author followed Bowen's diagram, and constructed the phase diagram on the liquidus surface of this system.

1) T. Sata, This Bulletin, **31**, 408 (1958).
2) T. Sata, ibid, **32**, 105 (1959).
3) N. L. Bowen, *Z. anorg. u. allgem. Chem.*, **90**, 1—66 (1914).
4) L. Atlas, *J. Geology*, **60**, 140 (1952).

Experimental

The nine compositions taken on the system $CaO \cdot MgO \cdot 2SiO_2$–$MgO \cdot SiO_2$ are listed in Table I. Then on the line joining these nine compositions with $3CaO \cdot P_2O_5$ point, thirty-two sample points were taken in the system $3CaO \cdot P_2O_5$–$CaO \cdot MgO \cdot 2SiO_2$–$MgO \cdot SiO_2$ and plotted in Fig. 1.

Powdered batches of these compositions, prepared by quenching into a glass after being kept at above their melting points, were again held at constant temperatures in a silicon carbide resister furnace and then quenched in water. Thenceforth the equilibrium phases found therein were determined by optical and X-ray examination. For measuring the temperature a thermocouple of platinum-platinum rhodium (10%) was used. Details of the experimental procedures are similar to those already described in the preceding report[1].

TABLE I. COMPOSITIONS OF SAMPLES TAKEN FROM THE SYSTEM $CaO \cdot MgO \cdot 2SiO_2$–$MgO \cdot SiO_2$

No.	$CaO \cdot MgO \cdot 2SiO_2$	$MgO \cdot SiO_2$
	wt. %	
225	85	15
240	80	20
—	75	25
209	70	30
230	60	40
210	50	50
238	40	60
211	20	80

Results

Data on the quenching runs for this 3-component system are listed in Table II,

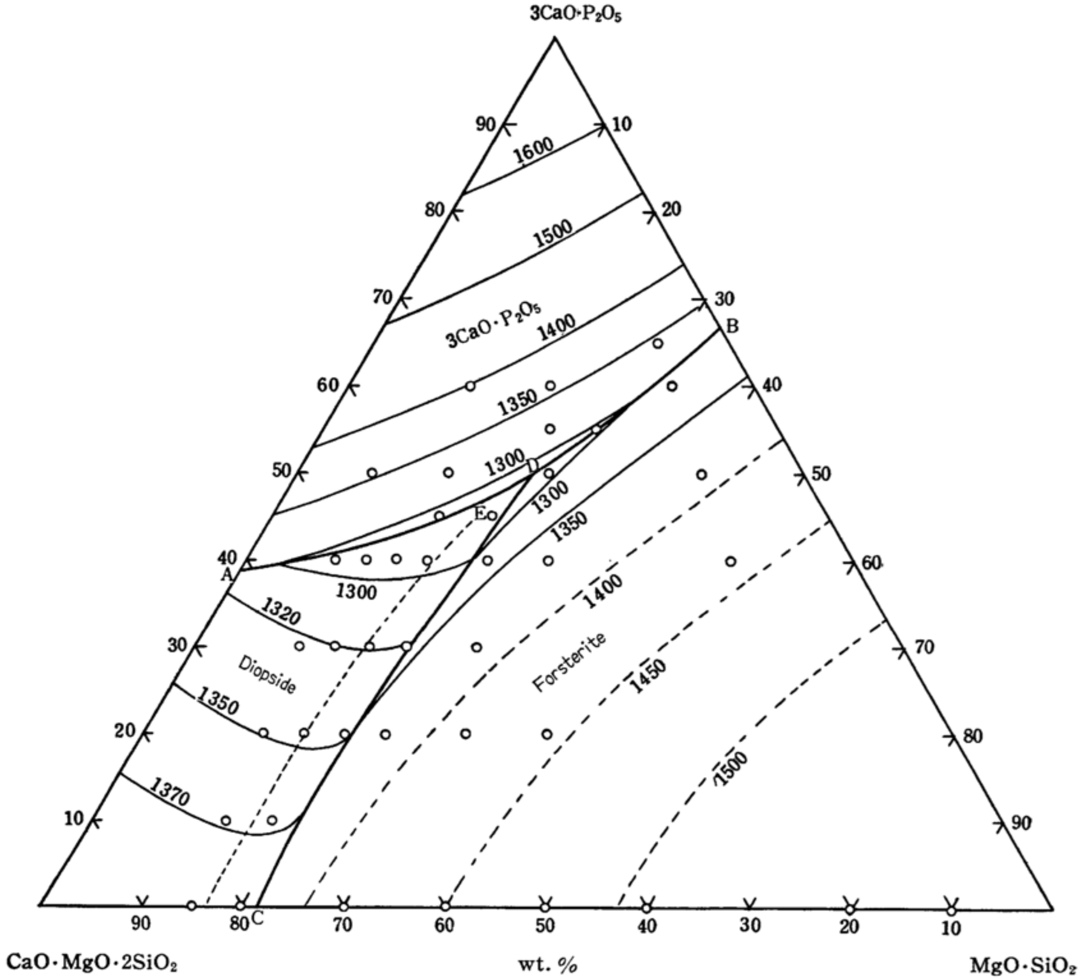

Fig. 1. The system $3CaO \cdot P_2O_5$–$CaO \cdot MgO \cdot 2SiO_2$–$MgO \cdot SiO_2$.
(A: 1314°C, B: 1308°C, C: 1390°C)

from which the equilibrium diagram on the liquidus surface was constructed as shown in Fig. 1. Primary crystals in this system are tricalcium phosphate (α or β), diopside and forsterite, respectively, and forsterite occupies a wide field. Accordingly it is found that this system is not a ternary one.

A lower liquidus temperature range is located in the center of this triangle, its minimum temperature being 1277±5°C. A temperature minimum at 1389°C in the system $CaO \cdot MgO \cdot 2SiO_2$–$MgO \cdot SiO_2$ falls slowly toward the neighborhood of this lowest point as shown by a dotted line. However, it can not be decided in this report whether this valley of temperature attains to this point or not. Clinoenstatite does not appear as a primary crystal on the liquidus surface. Hence a decomposition of pyroxene solid solution to colinoenstatite may occur under the liquidus.

Summary

The phase relationship on the liquidus surface of the system $3CaO \cdot P_2O_5$–$CaO \cdot MgO \cdot 2SiO_2$–$MgO \cdot SiO_2$ was investigated by the usual quenching method. The three primary crystals are α- or β-tricalcium phosphate, diopside and forsterite, and the range of the lowest temperature is located at the center of this triangle (1277°C). From these results, it is found that this system should be considered as a partial system in the 4-component system $3CaO \cdot P_2O_5$–$CaO \cdot MgO \cdot 2SiO_2$–$2MgO \cdot SiO_2$–$SiO_2$.

TABLE II. QUENCHING DATA IN THE SYSTEM $3CaO\cdot P_2O_5$–$CaO\cdot MgO\cdot 2SiO_2$–$MgO\cdot SiO_2$

No.	Composition wt. %					Holding temp. °C	Holding time min.	Phases present
	wt. %		C_3P	CMS_2 wt. %	MS*			
	C_3P	No. 225						
226	50	50	50	42.5	7.5	1347	30	gl.*
						1340	30	β-C_3P, gl.
227	40	60	40	51.0	9.0	1307	30	gl.
						1298	30	faint diopside, gl.
						1290	40	diopside, gl.
						1282	40	all crystal
228	30	70	30	59.5	10.5	1332	60	gl.
						1325	30	small diopside, gl.
						1290	30	diopside, gl.
						1282	30	all crystal
235	20	80	20	68.0	12.0	1356	30	gl.
						1347	30	faint diopside, gl.
236	10	90	10	76.5	13.5	1372	30	gl.
						1364	30	diopside, gl.
						1340	30	diopside, small gl.
	C_3P	No. 240						
241	40	60	40	48	12	1307	30	faint diopside, gl.
						1290	30	diopside, gl.
242	30	70	30	56	14	1332	60	gl.
						1325	30	small diopside, gl.
						1307	30	diopside, gl.
243	20	80	20	64	16	1356	20	gl.
						1347	30	small diopside, gl.
244	10	90	10	72	18	1372	30	gl.
						1364	30	diopside, gl.
245**			40	45	15	1302	30	small diopside, gl.
						1294	30	diopside, gl.
						1286	30	diopside, gl.
246**			30	52.5	17.5	1314	40	gl.
						1307	40	diopside, gl.
247**			20	60	20	1357	50	gl.
						1347	30	faint diopside, gl.
	C_3P	No. 209						
212	60	40	60	28	12	1356	40	gl.
						1348	40	β-C_3P, gl.
						1282	40	β-C_3P, gl.
213	50	50	50	35	15	1330	40	gl.
						1307	40	small C_3P, gl.
						1282	40	β-C_3P, gl.
						1273	30	all crystal
221	45	55	45	38.5	16.5	1307	30	gl.
						1282	30	small C_3P, gl.
						1274	50	all crystal
214	40	60	40	42	18	1302	30	gl.
						1294	30	faint diopside, gl.
						1286	30	small diopside, gl.
						1273	30	all crystal

* Abbreviations: $C_3P=3CaO\cdot P_2O_5$; $CMS_2=CaO\cdot MgO\cdot 2SiO_2$; $MS=MgO\cdot SiO_2$; gl.=glass.

** No. 245, 246, 247 were prepared from 1 : 1 mixture of No. 241—No. 214, No. 242—No. 222, No. 243—No. 229, respectively.

222	30	70	30	49	21	1324	40	gl.
						1314	40	faint diopside, gl.
						1282	40	diopside, small gl.
229	20	80	20	56	24	1407	30	gl.
						1397	40	small forsterite, gl.
						1340	50	forsterite, gl.
						1332	60	forsterite, diopside, gl.
						1322	60	forsterite, diopside, gl.
	C_3P No. 230							
231	45	55	45	33	22	1290	30	gl.
						1282	30	small diopside, gl.
						1272	30	diopside, β-C_3P, gl.
						1265	30	all crystal
232	40	60	40	36	24	1323	60	gl.
						1314	60	small forsterite, gl.
						1299	60	forsterite, gl.
						1290	40	forsterite, diopside, gl.
233	30	70	30	42	28	1397	40	gl.
						1390	30	small forsterite, gl.
						1323	30	forsterite, gl.
						1314	60	forsterite, small diopside, gl.
						1250	60	forsterite, diopside, β-C_3P
234	20	80	20	48	32	1460	30	gl.
						1450	30	small forsterite, gl.
	C_3P No. 210							
215	60	40	60	20	20	1348	40	gl.
						1340	40	very small C_3P, gl.
						1332	40	small C_3P, gl.
223	55	45	55	22.5	22.5	1314	40	gl.
						1307	30	small C_3P, gl.
216	50	50	50	25	25	1298	30	gl.
						1290	30	faint forsterite, gl.
						1282	20	forsterite, gl.
						1277	30	forsterite, C_3P, gl.
217	40	60	40	30	30	1365	50	gl.
						1356	40	small forsterite, gl.
237	20	80	20	40	40	1499	15	gl.
						1480	20	small forsterite, gl.
	C_3P No. 238							
239	55	45	55	18	27	1297	30	faint C_3P, forsterite, gl.
						1290	30	C_3P, forsterite, gl.
	C_3P No. 211							
224	65	35	65	28	7	1340	30	gl.
						1332	40	small C_3P, gl.
						1299	30	β-C_3P, gl.
						1290	30	β-C_3P, forsterite, gl.
218	60	40	60	32	8	1314	40	gl.
						1307	50	small forsterite, C_3P, gl.
219	50	50	50	40	10	1422	30	gl.
						1407	30	small forsterite, gl.
						1365	50	forsterite gl.
						1250	60	forsterite, β-C_3P, diopside
220	40	60	40	48	12	1479	15	gl.
						1460	20	small forsterite, gl.
						1432	20	forsterite, gl.

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