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The scientific analysis of potteries
(Focus on potteries excavated from kiln site
at Gyeongsang Nam - do)

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ABSTRACT

The scientific analysis and provenance study of potteries excavated from kiln site at Gyeongsang Nam-do were carried out using XRD, ICP-AES and NAA.

We can summary the following Result :

1. As a result of XRD analysis, it showed that soft potteries consisted of quartz, feldspar and clay minerals while hard potteries consisted of high temperature crystals such as mullite, tridymite, cristobalite.

In case of firing temperature which are determined by XRD, potteries consisted of quartz, feldspar and clay mineral had very low firing temperature. While potteries having only cristobalite ranged above 1200 .

2. As a result of correlation analysis using trace element, the selected characteristic elements which was able to distinguish from each kiln site was Sn, Cs, Sc, Eu, Hf.

3. Discriminant analytical showed that each kiln site were classified into 4-groups; Kimhaeci Daesungdong, Hamangun Myosari, Changyounggun Yochori and one group mixed Kimhaeci Guosandong, Kimhaeci Sangyeri. This suggests that there are no correlations between the raw materials used in each kiln sites except Kimhaeci Guosandong, Kimhaeci Sangyeri.

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(3).

가

161

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1.

5

161

Table 1

Table 2

1	가	28	
2	가	31	
3	가	48	
4	가	34	
5	가	20	
		161	

Table 1.

2.

가

110

X
(NAA)

(XRD)

(ICP - AES)

SPSS(Statistical

Package for the Social Science)

Table 2.

1		1	가	가
2		1	"	"
3		1	"	"
4		1	"	"
5		1	"	"
6	"	1	"	"
7	"	1	"	"
8		1	"	"
9	"	1	"	"
10	"	1	"	"
11		1	"	"
12	"	1	"	"
13		1	"	"
14		1	"	"
15	"	1	"	"
16	"	1	"	"
17	"	1	"	"
18	"	1	"	"
19	"	1	"	"
20	"	1	"	"
21	"	1	"	"
22	"	1	"	"
23		1	"	"
24	"	1	"	"
25	"	1	"	"
26	"	1	"	"
27	"	1	"	"
28	"	1	"	"
29		1	가	
30	"	1	"	"
31	"	1	"	"
32	"	1	"	"
33	"	1	"	"
34	"	1	"	"
35	"	1	"	"
36	"	1	"	"
37	"	1	"	"
38	"	1	"	"
39	"	1	"	"
40	"	1	"	"
41	"	1	"	"

42		1	가	
43	"	1	"	"
44	"	1	"	"
45	"	1	"	"
46	"	1	"	"
47	"	1	"	"
48	"	1	"	"
49	"	1	"	"
50	"	1	"	"
51	"	1	"	"
52	"	1	"	"
53	"	1	"	"
54	"	1	"	"
55	"	1	"	"
56	"	1	"	"
57	"	1	"	"
58	"	1	"	"
59	"	1	"	"
60	()	1	가	가
61	"	1	"	"
62	"	1	"	"
63	"	1	"	"
64	"	1	"	"
65	"	1	"	"
66	"	1	"	"
67	"	1	"	"
68	"	1	"	"
69	"	1	"	"
70	"	1	"	"
71	"	1	"	"
72	"	1	"	"
73	"	1	"	"
74	"	1	"	"
75	()	1	"	"
76	"	1	"	"
77	"	1	"	"
78	"	1	"	"
79	"	1	"	"
80	"	1	"	"
81	"	1	"	"
82	"	1	"	"

83	()	1	가	가
84	"	1	"	"
85	"	1	"	"
86	"	1	"	"
87	"	1	"	"
88	"	1	"	"
89	"	1	"	"
90	"	1	"	"
91	"	1	"	"
92	"	1	"	"
93	"	1	"	"
94	"	1	"	"
95	"	1	"	"
96	"	1	"	"
97	"	1	"	"
98	"	1	"	"
99	"	1	"	"
100	"	1	"	"
101	"	1	"	"
102	"	1	"	"
103	"	1	"	"
104	"	1	"	"
105	"	1	"	"
106	"	1	"	"
107	"	1	"	"
108		1	가	
109	"	1	"	"
110	"	1	"	"
111	"	1	"	"
112	"	1	"	"
113	"	1	"	"
114	"	1	"	"
115	"	1	"	"
116	"	1	"	"
117	"	1	"	"
118	"	1	"	"
119	"	1	"	"
120	"	1	"	"
121	"	1	"	"
122	"	1	"	"
123	"	1	"	"

124		1	가	
125	"	1	"	"
126	"	1	"	"
127	"	1	"	"
128	"	1	"	"
129	"	1	"	"
130	"	1	"	"
131	"	1	"	"
132	"	1	"	"
133	"	1	"	"
134	"	1	"	"
135	"	1	"	"
136	"	1	"	"
137	"	1	"	"
138	"	1	"	"
139	"	1	"	"
140	"	1	"	"
141		1	"	"
142		1	가	
143		1	"	"
144		1	"	"
145		1	"	"
146		1	"	"
147	"	1	"	"
148		1	"	"
149		1	"	"
150		1	"	"
151		1	"	"
152	"	1	"	"
153		1	"	"
154		1	"	"
155		1	"	"
156		1	"	"
157		1	"	"
158		1	"	"
159		1	"	"
160		1	"	"
161		1	"	"

1) X (XRD) X (MXP18VA, Japan) X Target Cu 30kV, 50mA, scanning speed 8. /min .

2) (ICP-AES) 50mg 100Mℓ (HNO₃) (HF) 5Mℓ 가 가 200 (HNO₃) 3Mℓ + (HClO₄) 5Mℓ 가 가 , 100g (Al, K, Na, Ca, Mg, Ti, Fe, Mn) (Sr) . (SPS 1500R, Japan) 1.31kW, 가 18 /min, 가 0.5 /min, 가 1.0 /min, 12.4mm , K, Na 0.7kW .

3) (NAA) 90 110mg (Maximun thermal neutron flux of HANARO. $5 \times 10^{14} \text{n/cm}^2 \cdot \text{sec}$, Power 20MW($1.7 \times 10^{13} \text{n/cm}^2 \cdot \text{sec}$) (SRM) 1 . HPGe Semiconductor Detector가 8,000 (EG&G ORTEC, USA) . 가 1 , Na(15) , K(12) 가 . , Peak

15 (Co, Rb, Sc, La, Hf, Yb, Cr, Lu, Ce, Sm, Nd, Ta, Ba, Cs, Eu)

1. X

Table 3

5	Quartz
Feldspar	
Quartz Feldspar가	
Quartz, Feldspar	Mullite가 Mullite
Tridymite가	Mullite Cristobalite가
	가
Feldspar	1000
	Mullite, Tridymite, Cristobalite
가	SiO ₂ Quartz 870 Tridymite
	1200 Cristobalite Quartz
	. 1200
Mullite	Tridymite, Cristobalite

X

Table 3.

			Quartz (SiO ₂)	Tridymite (SiO ₂)	Cristobalite (SiO ₂)	Mullite (Al ₂ SiO ₅)	Feldspar (Na · K)AlSi ₃ O ₈		etc.
							Albite	Microcline	
1									
2									
3									
4									Cordierite
5									Cordierite
6		"							
7		"							
8									Anorthite
9		"							
10		"							
11									
12		"							Cordierite
13									
14									
15		"							
16		"							
17		"							
18		"							
19		"							
20		"							
21		"							
22		"							
23									
24		"							
25		"							Anorthite
26		"							
27		"							Anorthite Muscovite
28		"							
29									
30		"							
31		"							
32		"							
33		"							
34		"							
35		"							
36		"							
37		"							
38		"							
39		"							

			Quartz (SiO ₂)	Tridymite (SiO ₂)	Cristobalite (SiO ₂)	Mullite (Al ₂ SiO ₅)	Feldspar (Na · K)AlSi ₃ O ₈		etc.
							Albite	Microne	
80		()							Sanidine
81		"							
82		"							Muscovite
83		"							Anorthite
84		"							Orthoclase Muscovite
85		"							
86		"							Muscovite
87		"							Orthoclase
88		"							Muscovite
89		"							
90		"							Muscovite
91		"							Orthoclase
92		"							Orthoclase
93		"							Orthoclase
94		"							
95		"							
96		"							Muscovite
97		"							Muscovite
98		"							Muscovite
99		"							
100		"							
101		"							Muscovite
102		"							
103		"							Muscovite
104		"							Muscovite
105		"							
106		"							Illite
107		"							
108									
109		"							Orthoclase
110		"							Anorthoclase
111		"							Muscovite
112		"							
113		"							
114		"							Anorthoclase
115		"							Muscovite
116		"							
117		"							
118		"							

			Quartz (SiO ₂)	Tridymite (SiO ₂)	Cristobalite (SiO ₂)	Mullite (Al ₂ SiO ₅)	Feldspar (Na · K)AlSi ₃ O ₈		etc.
							Albite	Microcline	
157									
158									
159									
160									
161									Talc

Quartz Feldspar
 가가 , Quartz Feldspar

Feldspar Mullite가 1000
 , Feldspr가

Feldspar가
 Cristobalite가 가 1200

가 .

2.

Co, Rb, Sc, La, Hf, Yb, Cr,
 Lu, Ce, Sm, Nd, Ta, Ba, Cs, Eu 15

, ICP - AES Al, K, Na, Ca, Mg, Ti, Fe, Mn, Sr
 가 ,

Table 4 .

Table 5

,
 가

출토지	시료 번호	%										ppm													
		FeO	Al ₂ O ₃	K ₂ O	Na ₂ O	CaO	MgO	TiO ₂	MnO	Sm	Yb	Cr	La	Ba	Cs	Sc	Rb	Ta	Eu	Nd	Ce	Lu	Hf	Zr	Sr
	1	59	22	23	06	04	14	10	002	11	80	92	230	94	18	160	08	15	34	74	04	10	11	70	
	2	56	22	22	06	04	15	10	003	11	93	123	59	60	10	160	12	16	34	88	04	85	11	70	
	3	67	28	29	10	06	18	12	003	62	98	100	78	250	97	20	14	20	43	100	09	44	13	110	
	4	63	22	24	08	04	15	09	003	12	86	79	55	550	10	20	15	20	56	120	06	72	15	90	
	5	55	24	25	09	04	15	09	002	13	96	82	60	570	12	22	94	17	19	110	04	54	13	90	
	6	69	22	26	08	04	17	09	007	94	96	98	56	430	89	19	13	24	66	130	08	68	26	90	
	7	64	22	22	08	05	16	07	003	12	92	10	71	400	10	18	14	16	43	100	09	89	15	90	
	8	47	21	25	10	07	11	09	002	10	89	97	43	330	58	17	09	13	38	73	03	98	91	160	
	9	38	17	16	06	04	09	06	002	13	80	10	39	50	10	20	89	15	19	110	05	59	16	70	
	10	58	23	25	06	02	15	10	003	90	75	99	75	440	11	21	100	15	17	150	05	11	15	60	
	11	42	25	26	07	05	17	07	004	14	82	120	64	720	14	19	160	17	34	160	03	91	30	80	
	12	57	24	22	08	04	14	10	003	10	72	10	51	680	2	20	160	15	24	130	03	98	18	90	
	13	57	23	21	05	03	15	09	002	85	67	10	55	470	3	19	160	11	15	110	04	89	11	60	
	14	38	17	16	06	05	11	09	001	99	60	97	39	430	11	16	130	15	23	42	77	03	11	70	
	15	67	25	23	07	06	15	10	003	92	61	100	36	470	2	19	160	15	12	80	100	02	82	22	90
	16	68	23	23	07	06	15	10	004	73	59	98	78	470	3	17	120	17	18	31	100	01	97	14	80
	17	62	22	19	07	05	13	09	003	10	74	10	30	520	88	19	120	08	23	94	02	93	13	90	
	18	53	21	30	09	08	17	08	005	89	62	120	39	70	2	19	120	13	28	36	10	02	84	21	130
	19	58	23	23	05	05	15	10	004	95	61	110	37	460	3	19	60	16	26	27	110	04	88	15	80
	20	53	23	22	05	05	15	10	003	92	58	120	62	500	5	20	150	11	20	130	03	93	19	90	
	21	43	20	20	04	03	13	10	002	93	55	110	61	30	14	18	120	19	19	110	02	11	91	70	
	22	42	19	17	05	03	12	09	002	91	51	98	50	380	2	17	130	10	22	100	04	97	12	70	
	23	47	14	19	09	06	10	07	003	62	42	87	39	790	61	12	130	12	14	14	85	02	13	110	
	24	58	23	05	05	15	09	002		12	76	100	16	570	14	19	150	08	18	41	190	03	84	34	90
	25	56	22	17	05	05	14	09	006	75	51	110	70	380	11	18	98	14	15	36	89	03	91	15	120
	26	72	23	16	04	04	14	10	004	75	42	110	65	540	94	18	100	14	19	32	93	03	10	27	90
	27	49	19	17	06	06	10	07	006	11	43	94	55	520	91	17	120	22	19	27	99	03	89	16	130

함안군
묘사리

Table 4.

출토지	시료 번호	%										ppm													
		FeO	Al ₂ O ₃	K ₂ O	Na ₂ O	CaO	MgO	TiO ₂	MnO	Sm	Yb	Cr	La	Ba	Cs	Sc	Rb	Ta	Eu	Nd	Ce	Lu	Hf	Co	Sr
	28	44	18	19	06	05	11	08	003	3	42	93	50	450	13	16	160	17	27	30	110	02	10	13	90
	29	19	14	27	12	08	04	003	48	38	37	120	530	74	3	95	29	18	30	75	06	13	37	90	
	30	41	15	27	14	06	04	05	002	54	34	57	120	760	68	3	140	20	20	32	84	05	96	56	110
	31	48	15	21	17	10	05	03	003	71	37	53	120	950	51	5	88	26	21	40	97	07	99	41	170
	32	32	14	18	14	09	03	04	002	56	36	46	63	900	47	4	130	25	22	37	78	06	81	50	160
	33	34	12	21	13	09	05	04	007	11	52	54	93	1000	70	2	110	20	21	24	74	05	98	55	180
	34	15	15	22	16	10	05	04	003	64	42	50	81	850	60	4	120	19	16	37	96	08	61	36	120
	35	33	11	16	09	06	10	06	004	2	33	60	91	950	97	4	170	13	31	42	95	06	98	89	110
	36	17	13	20	14	09	04	04	007	77	36	62	66	880	44	11	150	08	22	21	69	09	13	58	150
	37	33	14	25	13	08	04	04	003	95	42	58	51	80	46	11	180	19	20	44	90	08	98	81	150
	38	27	16	22	12	06	04	04	005	90	41	49	45	790	37	13	140	13	28	44	77	07	95	43	140
	39	44	14	19	07	18	05	06	006	80	25	54	38	790	42	5	170	10	19	36	75	05	77	85	190
	40	16	11	20	10	07	04	05	005	98	38	53	24	80	63	11	140	05	25	42	98	06	84	40	120
	41	64	20	16	15	10	08	07	008	11	43	70	68	950	58	17	120	15	36	52	110	04	92	11	160
	42	51	14	17	07	11	06	09	003	84	34	12	56	630	60	16	120	11	16	33	85	05	78	11	110
	43	19	13	24	14	09	03	03	005	88	37	66	22	80	49	11	130	13	27	46	88	06	11	42	150
	44	47	18	21	13	12	05	04	005	11	43	73	89	1400	53	14	100	10	31	47	110	08	81	84	210
	45	182	17	08	07	04	05	004		98	28	45	53	1000	57	12	120	14	22	63	100	04	76	45	120
	46	36	16	20	13	11	05	03	004	85	37	57	54	1100	42	13	120	10	25	36	89	06	75	37	160
	47	29	17	21	17	10	04	03	005	12	54	46	70	980	46	15	110	10	30	53	140	09	10	51	150
	48	32	15	17	11	09	08	05	003	91	39	51	57	990	56	17	83	15	33	52	87	05	95	72	180
	49	41	17	24	11	09	05	06	004	84	34	46	56	960	47	13	150	11	33	33	79	05	87	50	160
	50	12	12	22	14	13	03	02	004	87	36	44	66	1000	45	12	130	08	33	41	87	06	67	31	180
	51	27	17	22	14	09	04	05	006	13	57	41	92	360	49	13	92	12	28	55	130	09	84	42	160
	52	21	15	21	15	13	05	03	006	12	46	52	49	980	32	14	140	15	20	53	130	09	10	35	210
	53	22	16	26	18	16	02	03	006	93	40	41	49	1200	29	12	88	10	21	37	100	07	10	32	210
	54	35	15	24	13	10	04	05	005	82	35	53	34	1400	37	11	130	15	19	50	90	08	99	39	180

김혜시
대상동

출토지	시료 번호	%										ppm													
		FeO	Al ₂ O ₃	K ₂ O	Na ₂ O	CaO	MgO	TiO ₂	MnO	Sm	Yb	Cr	La	Ba	Cs	Sc	Rb	Ta	Eu	Nd	Ce	Lu	Hf	Co	S
김해시 대성동	55	55	16	20	12	10	0.4	0.4	0.04	68	28	51	45	90	41	11	120	15	30	40	92	06	93	39	80
	56	45	17	21	18	0.8	0.5	0.03	56	33	37	43	80	37	12	100	13	24	40	98	06	85	70	130	
	57	46	16	21	13	1.0	0.4	0.05	65	38	44	44	70	34	12	130	10	18	40	81	05	11	40	190	
	58	21	12	21	11	0.7	0.5	0.04	82	36	62	46	80	61	13	140	11	25	46	90	08	77	47	130	
	59	13	12	19	12	1.0	0.4	0.04	95	40	53	40	80	43	13	110	10	25	43	100	11	77	25	140	
	60	62	19	30	10	0.4	1.4	1.5	0.07	12	19	95	91	50	91	18	98	28	20	34	98	03	66	16	100
	61	62	19	28	16	0.5	1.1	1.4	0.07	11	29	89	79	80	88	18	95	24	23	39	91	04	74	14	120
	62	69	19	28	19	0.4	1.3	1.3	0.09	78	23	100	71	50	56	19	51	20	14	35	81	03	54	21	130
창녕군 어초리	63	74	18	29	0.9	0.2	1.4	1.2	0.07	11	30	86	61	40	89	13	120	24	17	56	06	67	20	90	
	64	65	18	33	1.0	0.4	1.3	1.3	0.07	14	32	93	49	60	85	14	85	25	24	35	98	06	70	13	90
	65	67	19	29	1.1	0.4	1.3	1.5	0.09	91	25	92	74	44	80	17	62	20	16	38	89	04	67	18	100
	66	72	18	31	1.0	0.4	1.6	1.4	0.06	83	31	90	66	80	10	19	110	29	20	34	96	04	72	14	100
	67	65	22	30	2.0	0.5	1.2	1.4	0.12	10	33	95	74	40	90	18	76	29	19	43	95	06	68	21	150
	68	62	20	33	0.9	0.4	1.4	1.3	0.05	14	37	98	71	330	12	18	180	14	17	100	170	15	11	11	100
	69	72	19	28	1.0	0.4	1.5	1.3	0.04	98	29	97	90	380	13	19	120	15	15	48	79	07	88	13	110
	70	67	14	25	1.6	0.4	1.0	1.4	0.04	13	36	93	96	330	65	18	120	14	19	32	10	09	82	14	110
	71	42	20	26	1.2	0.3	1.1	1.3	0.02	13	32	100	89	550	13	17	130	16	14	56	10	07	90	74	80
	72	53	17	26	1.3	0.4	0.8	1.5	0.06	10	25	94	89	320	67	16	110	16	19	37	96	08	99	14	100
	73	48	14	31	1.1	0.3	0.9	1.2	0.10	89	25	79	81	570	77	16	110	11	18	42	80	09	99	19	90
	74	62	16	25	1.3	0.4	1.1	1.4	0.07	14	40	100	92	460	11	19	110	15	24	47	86	07	65	17	100
	75	51	18	30	2.7	0.5	1.2	1.0	0.03	99	33	100	84	460	66	16	62	15	20	50	68	08	80	20	180
	76	66	18	31	2.1	0.5	1.6	1.0	0.03	99	28	100	81	580	83	15	91	08	14	36	64	06	68	19	160
	77	68	18	34	1.7	0.6	1.4	0.9	0.03	11	26	94	81	470	87	16	120	18	17	34	65	07	69	20	170
	78	51	17	34	2.2	0.7	1.0	0.7	0.02	10	29	100	80	600	73	16	100	09	16	35	57	09	52	13	260
79	67	16	25	0.5	0.6	0.9	1.0	0.07	11	27	91	69	70	77	15	77	14	14	48	70	09	72	13	170	
80	52	15	32	2.2	0.6	0.9	0.7	0.03	11	23	90	48	60	53	15	84	17	20	53	61	11	66	18	220	
81	52	17	35	1.8	0.5	1.4	1.0	0.03	14	21	110	94	470	79	14	140	12	13	45	68	05	80	15	150	

출토지	시료 번호	%										ppm													
		FeO	Al ₂ O ₃	K ₂ O	Na ₂ O	CaO	MgO	TiO ₂	MnO	Sm	Yb	Cr	La	Ba	Cs	Sc	Rb	Ta	Eu	Nd	Ce	Lu	Hf	Co	S
	82	63	5	28	15	06	09	07	002	85	20	90	39	580	68	16	100	14	14	35	64	09	83	11	160
	83	52	8	36	19	05	13	10	002	77	25	91	66	380	67	13	120	09	15	32	64	05	72	15	150
	84	34	5	34	17	06	05	05	003	95	26	83	36	620	53	14	89	13	17	23	85	07	85	21	180
	85	49	7	36	22	06	13	08	004	12	29	85	30	470	65	16	98	11	20	45	88	09	81	33	190
	86	55	5	31	22	06	09	08	002	93	25	87	47	400	45	14	98	07	17	33	63	03	84	15	20
	87	58	6	32	16	04	10	08	004	81	24	100	36	430	73	16	110	11	10	52	72	08	97	13	150
	88	70	6	25	06	05	09	08	002	85	27	110	41	880	78	16	70	14	23	42	76	08	98	99	140
	89	50	6	34	17	05	13	09	002	11	26	90	31	420	63	14	110	12	18	41	66	08	85	15	150
	90	62	5	24	05	05	09	10	006	91	32	82	37	440	81	15	83	11	17	42	68	12	98	15	150
	91	58	7	29	16	05	09	09	004	87	25	86	37	570	68	17	120	09	09	43	60	06	96	13	180
	92	58	6	28	21	07	11	06	002	82	23	88	34	630	35	14	61	10	19	34	48	05	92	15	230
	93	56	7	32	18	06	11	09	003	81	26	83	32	460	62	14	88	11	23	43	56	06	86	26	180
	94	51	6	28	20	07	09	08	005	83	28	80	34	590	51	14	77	11	11	34	50	03	11	11	230
	95	64	7	32	17	06	15	10	003	81	30	91	48	640	72	15	92	22	16	42	79	07	86	20	170
	96	53	25	28	04	03	16	10	001	11	42	95	51	560	16	25	95	17	15	29	110	13	10	11	70
	97	65	7	29	15	06	10	09	002	75	25	96	64	300	70	17	98	10	17	28	77	06	87	18	190
	98	72	8	28	12	06	10	10	003	92	37	95	61	780	10	16	120	11	09	27	110	06	10	13	180
	99	41	7	26	13	06	11	09	003	92	36	82	44	1000	97	16	130	11	19	42	120	11	96	14	160
	100	63	8	32	17	07	09	07	003	84	32	90	51	860	77	16	130	13	16	50	120	03	62	26	230
	101	55	8	28	14	05	08	09	003	65	27	96	30	110	63	16	100	12	13	22	95	08	94	11	170
	102	72	9	24	06	03	12	06	003	84	29	96	43	660	80	19	120	12	14	42	110	04	97	14	90
	103	56	9	34	11	05	10	09	003	80	29	74	57	300	95	14	130	13	20	36	100	06	79	11	120
	104	73	8	28	06	06	09	08	003	76	31	97	51	110	89	17	130	16	14	43	91	03	92	10	190
	105	64	8	30	14	06	15	10	004	82	29	89	60	570	73	15	120	17	14	46	88	04	84	32	170
	106	69	6	23	09	05	08	08	007	77	35	91	95	1000	67	15	90	16	19	31	73	07	10	17	180
	107	49	20	30	12	06	12	11	002	92	32	94	82	480	12	18	120	12	18	35	94	09	73	13	150
	108	37	20	26	08	04	05	09	001	72	35	74	84	70	60	16	75	14	14	31	89	10	80	60	80

창녕군
어초리

김해시삼계리

시료 번호	%										ppm													
	FeO	Al ₂ O ₃	K ₂ O	Na ₂ O	CaO	MgO	TiO ₂	MnO	Sm	Yb	Cr	La	Ba	Cs	Sc	Rb	Ta	Eu	Nd	Ce	Lu	Hf	Co	S
109	47	16	21	08	05	06	11	002	79	39	69	59	540	80	5	84	15	13	35	94	05	91	11	90
110	75	23	24	06	05	07	10	001	61	22	77	49	600	93	19	140	15	18	42	80	11	63	73	70
111	47	18	22	09	05	05	09	002	58	34	63	82	670	54	5	91	16	17	36	66	07	11	64	100
112	44	17	21	09	05	05	09	002	77	35	63	90	780	76	16	120	21	15	34	89	05	10	10	90
113	61	19	28	09	04	06	10	002	83	30	88	74	740	72	5	130	22	22	45	90	07	92	91	80
114	81	24	23	06	05	07	11	002	62	24	69	60	790	98	19	99	12	13	25	80	07	61	71	70
115	61	20	31	08	03	03	08	001	57	27	63	50	700	69	5	80	15	22	34	78	06	71	67	60
116	41	20	27	08	05	06	09	002	60	33	61	64	660	12	16	100	16	17	27	77	05	78	63	90
117	55	18	20	05	04	06	12	002	60	28	61	74	880	80	13	130	13	15	37	82	04	74	67	70
118	58	22	23	08	06	07	10	003	70	34	74	65	900	10	17	100	17	18	36	87	06	94	11	100
119	53	25	31	07	07	07	11	002	59	26	70	52	820	10	17	110	12	19	40	86	09	60	91	90
120	56	21	22	06	05	06	06	002	78	34	63	47	550	91	16	100	17	18	36	100	12	79	74	70
121	63	22	28	08	05	06	04	002	62	30	50	46	970	77	5	100	16	19	35	86	06	71	63	80
122	69	24	28	05	04	06	09	001	41	21	80	48	850	80	14	130	16	19	22	51	05	64	75	60
123	54	18	25	06	03	04	10	001	42	20	65	57	420	75	13	98	15	19	21	50	05	77	46	60
124	39	19	27	13	08	04	06	002	99	32	53	53	330	54	17	110	11	20	66	130	05	73	86	130
125	55	21	26	06	02	03	09	001	65	24	61	29	360	52	5	130	17	17	47	73	05	36	50	60
126	53	18	26	06	03	04	10	001	58	70	72	69	530	65	14	98	17	11	53	60	05	53	50	60
127	69	23	25	04	03	05	12	002	82	75	70	44	770	47	17	87	14	20	73	88	06	58	76	60
128	60	21	27	04	04	06	12	001	79	73	70	88	590	71	16	110	11	18	61	69	04	52	60	60
129	67	22	29	05	05	06	10	002	95	54	76	57	450	70	5	120	11	14	88	70	06	52	64	70
130	5823	29	06	04	06	11	002		83	56	67	63	530	59	17	110	15	20	54	70	09	51	73	70
131	63	20	25	07	03	03	11	001	83	68	76	63	790	53	16	74	15	19	86	66	04	57	45	70
132	54	22	30	05	04	07	09	002	10	50	86	74	360	93	13	96	14	18	34	63	04	47	60	70
133	55	20	28	06	04	05	10	002	76	37	69	28	720	47	5	120	14	19	42	71	05	60	68	70
134	77	21	31	04	06	06	06	002	70	24	76	66	490	63	14	110	10	21	63	56	04	42	67	70
135	70	22	29	05	05	06	11	001	67	44	76	73	430	64	5	130	16	21	64	58	06	51	68	70

김해시
삼계리

출토지	시료 번호	%										ppm													
		FeO	AlO ₃	K ₂ O	Na ₂ O	CaO	MgO	TiO ₂	MnO	Sm	Yb	Cr	La	Ba	Cs	Sc	Rb	Ta	Eu	Nd	Ce	Lu	Hf	Co	S
김해시 삼계리	136	67	19	29	04	05	05	12	002	73	44	63	88	70	58	12	100	15	13	37	52	05	50	71	70
	137	48	19	25	05	04	07	08	002	93	72	88	13	650	74	16	120	12	17	30	75	07	55	70	70
	138	70	23	28	06	04	06	10	001	81	37	70	50	480	74	17	87	12	16	82	60	04	46	70	70
	139	66	20	27	05	05	06	10	001	84	37	72	32	640	71	16	100	17	16	71	68	07	60	64	70
	140	66	20	24	06	05	06	08	001	0	73	72	37	530	73	16	100	17	23	48	70	05	46	63	70
	141	27	22	26	10	05	06	06	002	13	65	45	38	490	53	17	95	15	29	130	130	09	83	60	10
	142	53	19	24	11	07	05	09	002	0	72	50	35	440	51	16	77	16	18	65	73	04	73	12	10
	143	37	17	16	06	05	06	11	002	11	64	72	85	440	67	15	81	12	23	68	82	05	55	62	80
	144	40	19	18	09	06	05	10	002	97	62	48	44	480	69	16	49	13	16	68	64	06	76	73	90
	145	48	20	12	06	04	05	10	001	89	50	61	70	340	49	15	40	15	19	56	76	06	67	68	70
	146	65	21	17	04	04	06	10	001	91	75	80	31	750	59	16	71	14	19	54	74	04	61	71	60
	147	39	20	24	14	10	04	07	002	11	66	33	72	440	28	88	29	15	21	68	90	08	73	78	140
	148	47	17	21	08	04	05	10	001	0	65	56	56	600	45	13	58	09	18	60	87	07	67	79	70
	149	54	21	19	08	05	06	10	002	11	69	67	75	480	55	16	85	15	21	63	92	05	52	80	80
150	37	20	23	15	09	04	08	002	11	71	72	25	600	43	18	69	15	22	69	100	07	80	77	140	
151	45	19	22	13	10	05	11	002	84	73	46	85	650	34	18	57	12	27	56	130	11	66	12	130	
152	40	19	15	07	05	05	10	001	0	51	65	83	500	69	17	120	20	19	52	120	08	83	80	70	
153	49	23	23	14	10	05	13	002	12	38	57	60	370	62	19	81	19	21	45	130	09	97	11	150	
154	50	19	21	11	07	06	10	002	13	41	52	71	480	58	16	91	15	19	41	75	08	94	11	100	
155	74	19	22	09	07	05	10	002	98	44	57	86	530	66	13	110	17	16	41	70	06	86	85	100	
156	57	17	30	09	07	05	11	002	82	29	59	78	470	83	14	110	20	21	35	84	06	10	83	100	
157	70	18	19	07	06	05	11	002	11	41	64	62	450	81	14	120	14	15	40	89	06	79	91	90	
158	94	21	15	03	04	06	11	002	11	41	68	70	390	71	15	94	14	22	38	92	06	78	75	50	
159	46	17	18	09	05	05	09	002	56	33	44	81	470	50	15	86	19	16	34	81	04	97	68	90	
160	55	19	16	07	05	06	10	002	52	39	61	83	430	73	15	88	12	16	42	58	06	81	92	70	
161	40	19	14	06	04	05	09	001	90	35	62	95	230	65	14	44	15	15	23	72	06	88	79	70	

김해시
구산동

	Sm	Yb	Cr	La	Ba	Cs	Sc	Rb	Ta	Eu	Nd	Ce	Lu	Hf	Co	Sr
	10	6.9	103	56	507	11	18	134	1.4	2.0	39	107	0.4	9.0	16	90
	2.0	1.8	11	15	147	2.2	1.8	31	0.3	0.5	13	32	0.2	1.8	6.3	23
	21	26	11	27	29	20	9.9	23	24	25	34	30	52	20	39	25
	8.7	3.9	51	63	900	5.1	13	124	1.4	2.4	42	94	0.7	9.1	5.4	155
	2.1	0.7	11	27	207	1.4	1.7	24	0.6	0.6	9.2	18	0.2	1.6	2.2	32
	24	18	22	43	23	28	13	19	39	23	22	19	24	17	42	20
	9.8	2.9	93	61	567	8.0	16	103	1.5	1.7	41	84	0.7	8.3	16	151
	2.0	0.5	7.7	21	198	2.3	2.0	24	0.6	0.4	12	22	0.3	1.5	5.3	46
	20	18	8.3	35	35	29	13	23	36	21	29	26	40	18	33	30
	7.5	4.1	69	57	617	7.3	16	105	1.5	1.8	48	77	0.6	6.6	7.0	75
	1.8	1.8	9.0	18	162	1.7	1.6	16	0.3	0.4	23	19	0.2	1.8	1.6	16
	24	42	13	31	26	24	10	16	18	20	47	24	34	27	23	21
	9.7	5.3	59	67	481	5.9	15	78	1.5	1.9	51	87	0.6	7.8	8.5	93
	1.9	1.6	11	20	115	1.5	2.3	27	0.3	0.3	13	20	0.2	1.4	1.7	29
	19	29	19	30	24	25	15	34	20	16	26	23	27	18	20	31

Table 5.

1)

5 (, , , ,) 161 . 가
 가 가 ,
 가 (4).

Sr Rb
 CaO - Sr, K₂O - Rb
 (5).

Fig. 1 CaO - Sr, K₂O - Rb

Fig. 1 CaO-Sr 가 , K₂O-Rb
 . CaO-Sr
 . CaO-Sr
 . CaO Sr
 , , ,
 CaO Sr
 .
 CaO Sr
 .
 가 ,
 가 . Table 5 가
 , 가 가

Fig. 2
 , 가 ,
 . 가 가 가
 ,
 Sm, Cs, Sc, Eu, Hf
 5 .
 5 가 Cr
 (5).
 2)
 D X1, X2,

X3,

$$D = \mu_0 + \mu_1 X_1 + \mu_2 X_2 + \mu_3 X_3 + \dots + \mu_p X_p$$

(D: , μ_0 : , $\mu_1 \dots \mu_p$:)

Table 6 8 . Ba, Co, Cr, Cs, Sc, Rb, Yb, Sr

Table 6
1, 2 0.949, 0.880 , Wilks
1, 2

Table 7 .

$$1 = -0.003\text{Ba} - 0.001\text{Ce} + 0.111\text{Co} + 0.079\text{Cr} + 0.144\text{Cs} - 0.773\text{Eu} + 0.192\text{Hf} - 0.011\text{La} - 0.544\text{Lu} - 0.002\text{Nd} - 0.008\text{Rb} + 0.085\text{Sc} + 0.025\text{Sm} + 0.006\text{Sr} + 0.070\text{Ta} + 0.157\text{Yb} - 7.692$$

$$2 = 0.007\text{Ce} - 0.024\text{Co} - 0.020\text{Cr} + 0.078\text{Cs} + 0.937\text{Eu} + 0.193\text{Hf} - 0.006\text{La} - 2.170\text{Lu} - 0.024\text{Nd} + 0.011\text{Rb} - 0.001\text{Sc} - 0.170\text{Sm} - 0.009\text{Sr} - 0.302\text{Ta} + 0.777\text{Yb} - 1.377$$

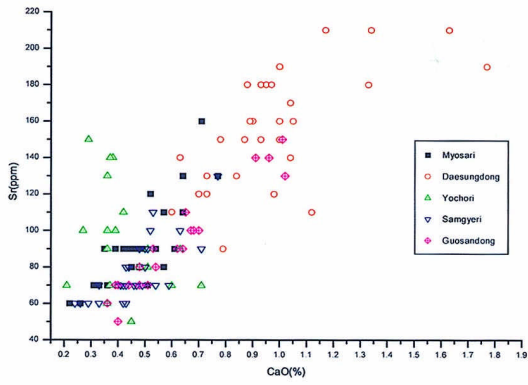
Table 8

Hit ratio가 95%

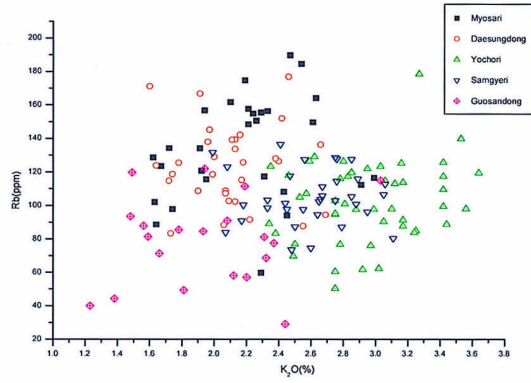
가

Fig. 3

4



(a)



(b)

Fig. 1.

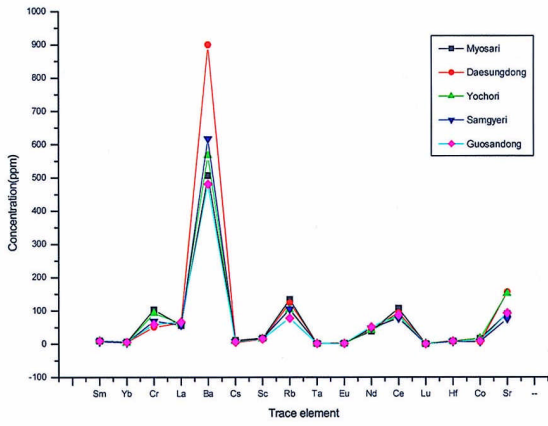


Fig. 2

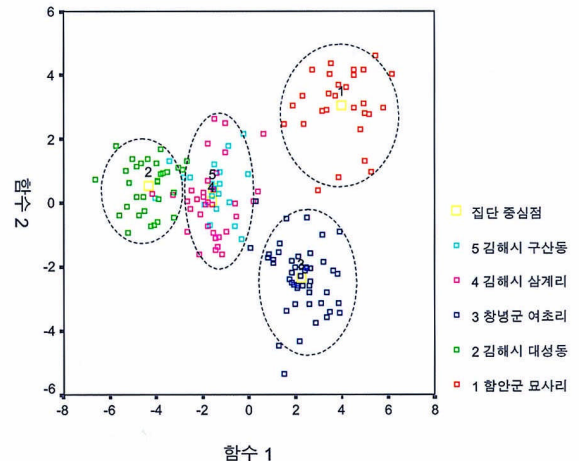


Fig. 3.

			Wilks			
1	9.081	0.949	0.005	790	64	0.000
2	3.434	0.880	0.051	445	45	0.000
3	1.797	0.802	0.226	222	28	0.000
4	0.581	0.606	0.632	68	13	0.000

Table 6.

1	4.014	-4.345	2.253	-1.618	-1.542
2	3.038	0.519	-2.346	0.059	0.473

Table 7.

		1 (%)	2 (%)	3 (%)	4 (%)	5 (%)
	28	27(96.4%)	0	1(3.6%)	0	0
	31	0	31(100%)	0	0	0
	48	0	0	47(97.9%)	1(2.1%)	0
	34	0	0	0	29(85.3%)	5(14.7%)
	20	0	0	0	1(5%)	19(95%)

Table 8.

* (Hit Ratio) = 95 %

가

4

가

161

1. X Quartz Feldspar,
Quartz Feldspar

Mullite Feldspar가

Tridymite Mullite가 , Cristobalite

Mullite가

X ,

Quartz Feldspar

가 가 Cristobalite Mullite가

가 1200 가 가

2. , CaO-Sr

Sm, Cs, Sc, Eu, Hf 5 가

3. ,
4 , , ,
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4. ,
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가
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