SIMULATED LUNAR HIGH LAND ROCKS USING JAPANESE IGNEOUS ROCKS. H. Ii[1] and H. Kanamori[2], [1]Wakayama University (930 Sakaedani, Wakayama city, Wakayama prefecture, Japan and hiro@center.wakayama-u.ac.jp), [2]Japan Aerospace Exploration Agency (3-1-1 Yoshinodai, Chuou-ku, Sagamihara city, Kanagawa prefecture, Japan and kanamori.hiroshi@jaxa.jp).

Introduction: Most petrologists distinguish three major classes of pristine igneous lunar highland rocks are ferroan anorthosites, Mg-rich rocks, and KREEP rocks [1]. The ferroan anorthosites and Mg-rich rocks are rarely found as plutonic (coarsely crystalline) rocks, though most occur as monomict breccias. Volumetrically, KREEP rocks are far less important than ferroan anorthosites and Mg-rich rocks. The precise compositional range of the Mg-rich rock group is not well defined. Rocks in this group range from olivine-rich rocks (dunite) all the way to rocks composed of pyroxene and Na-rich plagioclase. Then, in order to make a simulated lunar highland rock, the best method is to prepare each simulated rock, the ferroan anorthosites, Mg-rich rocks, and KREEP rocks and then mix them. The mixing ratios change according to simulated place or condition. The simulated rock was determined by mineralogy and main chemical composition.

Method: The mineralogy and main chemical composition of ferroan anorthosites, Mg-rich rocks, and KREEP rocks are compared with those of Japanese igneous rocks. The possibility of digging the candidate rocks was confirmed in the field as for amount of volume.

Results: The maximum, minimum and average chemical compositions of these three types rocks [2] are compared with Japanese candidate rocks as shown in Table 1, 2, and 3.

Ferroan anorthosites. From the modal mineral composition of the ferroan anorthosites [2], plagioclase content varies 34 to 99 % and are over 90 % for the most of rocks. Modal olivine and pyroxene contents of the ferroan anorthosites very low, 0 to several %. Anorthite content of plagioclase in the ferroan anorthosites is very high and 96 to 98 %. Anorthite crystal is thought to be candidate as the simulated rock for the ferroan anorthosites although olivine and pyroxene crystal are added as spice. Japanese basalt and andesite rocks contain sometimes big anorthite crystals (high Ca plagioclase) as phenocrysts. Generally anorthite phenocrysts in basalt or andesite are surrounded with groundmass and it is very difficult to distinguish phenocrysts from groundmass. However, anorthite crystals in Miyakejima and Fugoppe are isolated from surrounding rock. Anorthite phenocrysts in Miyakejima basalt is volcanic bombs and reach over 3 cm in size. It is covered with thin basaltic lava and includes olivine crystals. Anorthite content of plagioclase phenocrysts in Miyakejima is 94 to 98 % [3] as shown in Table 1 and coincides with those in the ferroan anorthosites. Anorthite phenocrysts in Miyakejima basalt is easy to pick up around the volcanic cone and to keep several kg is possible.

Anorthite phenocrysts in Fugoppe are included in andesite tuff and reach over 2 cm in size. It is easy separate crystals from tuff because of softness for tuff and are covered with pyroxene crystals. Anorthite content of plagioclase phenocrysts in Fugoppe is 92 to 95 % [4] as shown in Table 1 and coincides with those in the anorthite in Miyakejima. Anorthite phenocrysts in Fugoppe are taken from cliffs located in the forest and are not easy to pick up. Anorthoite phenocrysts in Miyakejima and Fugoppe are good coincidance with the ferroan anor-thositic rocks excluding high Al_2O_3. On the other hand, anorthoite phenocrysts with olivine inclusion and lava cover in Miyakejima also coincided with the ferroan anor-thositic rocks excluding high low SiO_2. Therefore, mixing of anorthoite phenocrysts with olivine inclusion and lava cover in Miyakejima and pure anorthoite phenocrysts in Fugoppe is best candidate rocks for the ferroan anorthosites.

Table 1 Chemical composition (%) of Ferroan anorthosites and anorthite phenocryst in Miyakejima and Fugoppe

	anorthite phenocryst average values			ferroan anor-thositic rocks	
	Miyakejima		Fugo ppe	Minu-nu-mum value	Max-imum value
	With lava, oli-vine	No lava			
SiO_2	41.25	43.66	43.41	41.90	48.00
TiO_2	0.03	n.d.	0.12	0.01	1.36
Al_2O_3	33.20	36.00	36.17	11.10	35.60
Fe_2O_3	2.83	0.70	0.56		
FeO	0.72	0.43	n.d.	0.15	15.70
MnO	0.04	n.d.	0.01	0.00	0.24
MgO	3.59	0.17	0.09	0.14	10.10
CaO	18.34	19.38	19.27	13.00	20.40
Na_2O	0.48	0.46	0.50	0.18	0.57
K_2O	0.01	0.04	0.03	0.01	0.11
P2O5	0.00	n.d.	0.00	0.01	0.05

Mg-rich rocks. Mg-rich rocks are various, olivine rich, pyroxene and Na-rich plagioclase rocks and various ultrabasic rocks. Then, peridotite and gabbro were selected for simulated as Mg-rich rocks. The Horoma area in the south of Hokkaido, Japan is a famous for peridotite, in particular, various kinds of peridotite and gabbroic rocks and then rocks in Horoma area were thought to cover with most kinds of Mg-rick rocks. Table 2 shows chemistry of representative gabbroic rocks and peridotitre [5]. Both rocks were sampled at the lower stream of Horoma River. white gabbro and green gabbro are devided by color. white gabbro is composed of mainly plagioclase and green gabbro is mainly composed of pyroxene. Plagioclase and pyroxene grains are coarse and the plagioclase and pyroxene content is widely changeable. Then, the chemistry for gabbroic rocks is separately analyzed. As a result, chemistry of plagioclase, pyroxene and olivine rich rocks were analyzed. All values coincide with those of Mg-rich in highland excluding MgO in Dunite. Actual highland rocks on the moon were changeable and to adjust mixing ratio of the prepared three rocks enable to coincide with chemistry for each Mg-rich rocks.

KREEP rocks. The KREEP rocks are named for their high content of incompatible elements, especially K, rare earth elements (REE), and P. Comparing with Japanese basalt, K and P contents are not too high from Table 3. As anorthite phenocryst in Miyakejima is a candidate for the simulated ferroan anorthosites, effectiveness of basalt in Miyakejima is also checked and basalt chemistry at some places in Miyakejima is suitable for as a simulated KREEP basalt from Table 3. Basalt in Miyakejima widely contains olivines and pyroxenes however, the olivines in KREEP basalt are rare but pyroxenes are common and show a characteristically wide range in composition. Precise simulation for the KREEP is difficult for both element and mineral compositions. However volumetrically, KREEP rocks are far less important than ferroan anorthosites and Mg-rich rocks and basalt in Miyakejima is selected.

Table 2 shows chemistry of representative gabbroic rocks and peridotite and Mg-rich rocks in Highland.

	White Gabbro	Green Gabbro	Dunite	Mg-rich rocks In highland	
	Horoman area in Hokkaido			Minimum	Maximum
SiO_2	46.27	41.31	41.20	37.50	52.00
TiO_2	0.11	0.03	n.d..	0.03	1.03
Al_2O_3	27.83	14.69	1.31	1.30	28.70
Fe_2O_3	2.63	10.38	0.86		
FeO	0.99	6.20	4.13	2.25	17.10
MnO	0.05	0.16	0.38	0.03	0.20
MgO	4.73	22.30	48.81	6.90	45.40
CaO	13.77	6.62	1.96	1.10	15.90
Na_2O	2.69	1.11	n.d.	0.02	0.91
K_2O	0.16	0.08	n.d.	0.00	0.23
P_2O_5	0.01	0.00	n.d.	0.03	0.11
Cr_2O_3	0.06	0.04	0.46	0.02	0.38

Table 3 Chemical composition of basalt in Miyakejima and KREEP rocks

	Basalt in Miyakejima			KREEP rocks	
	Ako	Benkenemisaki	Imasaki	Minimum	Maximum
SiO_2	49.90	50.76	51.80	48.00	52.80
TiO_2	1.14	1.23	1.42	1.03	2.23
Al_2O_3	15.63	15.55	14.51	13.30	16.40
Fe_2O_3	2.97	2.59	3.40		
FeO	10.76	10.19	10.64	9.20	15.50
MnO	0.27	0.25	0.25	0.14	0.23
MgO	5.26	5.43	4.42	6.80	10.50
CaO	11.27	10.73	10.09	7.10	11.10
Na_2O	2.04	2.16	2.42	0.29	0.89
K_2O	0.24	0.38	0.42	0.25	0.67
P_2O_5	0.07	0.16	0.20	0.46	0.70

Conclusion: Anorthite phenocrysts in Miyakejima and Fugoppe were simulated as ferroan anorthosites. Ultrabasic rocks in Horoma area were simulated as the Mg-rich rocks. Basalts in Miyakejima also were simulated as KREEP rocks. The simulated lunar highland rocks were composed of a mixture of simulated ferroan anorthosites, Mg-rich rocks and simulated KREEP rocks.

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