CHEMICAL COMPOSITION OF ANOTHER KREEP-RICH LUNAR REGOLITH BRECCIA YAMATO 983885. Y. Karouji[1], T. Arai [2], and M. Ebihara[1, 2], [1]Department of Chemistry, Tokyo Metropolitan University, Hachioji, Tokyo 193-0397, Japan (ebihara-mitsuru@c.metro-u.ac.jp). [2]National Institute of Polar Research, Tokyo 173-8515, Japan.

Introduction: Yamato (Y) 983885 is a recently found highland regolith breccia [1], which contains various lithic clasts, which are associated with KREEP, such as Mg-rich rocks and KREEPy basalt [2]. Its mineralogy in connection with KREEP led to an inference that Y-983885 be originated in close proximity to the Procellarum KREEP Terrain (PKT) [2]. Warren and Bridges [3] suggested that Y-983885 is similar to the KREEPy lunar meteorite Calcalong Creek regolith breccia, in terms of major elements and mafic-associated elements. Then, a possibility that there is relation to the source region of the KREEP-rich lunar meteorites Y-983885 and Calcalong Creek can be considered. In this study, we determined major, minor, and trace elements composition of Y-983885 by using several analytical methods, and aimed to characterize this meteorite in chemical and mineralogical compositions in comparison with those for other lunar meteorites and Apollo/Luna rocks, and propose its possible source region of this meteorite on the Moon.

Analytical methods: A total of 0.211g of the powdered Y-983885 specimen was allocated to us from the National Institute of Polar Research (NIPR). This sample was taken from a 1.264g powder of Y-983885,62 which was prepared by grinding it chunks in an agate mortar, suggesting that the specimen we used is representative of the meteorite in chemical composition. The sample was first analyzed by neutron-induced prompt gamma-ray analysis (PGA). Following PGA, instrumental neutron activation analysis (INAA) and instrumental photon activation analysis (IPAA) were performed. We also used inductively coupled plasma mass spectrometry (ICP-MS) for the determination of rare earth elements (REE), Th and U.

Results: Our data of bulk-chemical composition of Y-983885 (Table 1) were consistent with previously reported values (Kaiden and Kojima [1], Warren and Bridges [3], and Korotev et al. [4]). The major element compositions of bulk sample are in good agreement with those of a homogeneous impact glass spherule in a polished thin section (PTS) Y-983885,59-2 (Arai et al. [2], impact glass 1), except for Na_2O and K_2O. This indicates that Y-983885 is relatively mature regolith breccia in spite of inferred heterogeneity from the clast-rich macroscopic appearance [5].

Figure 1 shows that Y-983885 is a mixture of highland and mare components, predominantly composed of feldspathic materials. A low TiO_2 content indicate the mingled mare component is very low-Ti (VLT) basalt, which is consistent with the result of the mineralogical observation [2].

Y-983885 shows the third highest incompatible-trace-elements concentration among known lunar meteorites after SaU 169 [6] and Calcalong Creek [7]. Figure 2 shows chondrite-normalized REE abundance patterns for Y-983885, SaU 169, Calcalong Creek and Apollo/Luna soil and regolith breccia (S&RB). Because the KREEP materials are blended in these samples, the REE abundance patterns of these rocks are well alike.

Discussion: Arai et al. [2] reported that Y-983885 includes several KREEP-associated clasts. Because modal abundances of these clasts are very low (e.g., KREEP basalt = 0.28 vol%), it is probable that matrix of Y-983885 has higher Th content than other lunar feldspasthic lunar meteorites. We calculate the bulk chemical compositions using the modal abundances of the clasts identified in the PTS Y-983885,59-2 by Arai et al. [2] and the representative compositions for the each clast from the literatures. The modal abundances are, KREEP basalt: 0.28 vol%, high-Al basalt: 0.76 vol%, VLT basalt: 0.23 vol%, troctolite: 3.25 vol%, norite: 0.51 vol%, granulitic anorthosite: 0.38 vol%, and anorthite clast: 0.38 vol%. The chemical compositions of these clasts are represented by 15405, 14053, 70007,296, 76535, 77215, 60015 and 60015, respectively [8]. We evaluated which chemical compositions of Apollo/Luna S&RB or polymict breccia were suitable for the remaining matrix component (94.17 vol%). As a result, Apollo 16 S&RB was able to reproduce of chemical composition of Y-983885 best, except for FeO and Al_2O_3. The calculated composition is lower in FeO and high Al_2O_3 compared with chemical composition of Y-983885. A possible reason for such a discrepancy is that mafic components included in the matrix are more abundant than the estimated modal abundance of the clasts, considering that modal abundances are obtained only for comparatively large (> 300 micron across) clasts. Mafic components in the matrix need to be VLT basalts and/or Mg-rich rocks, because TiO_2 content of Y-983885 is relatively low.

Thereafter, there appears to be a similarity in chemical compositions between Y-983885 and Apollo 16 S&RB. In addition, because both high-Al basalt and Mg-rich rock clasts are included in Y-983885, a possibility of mixing of the terrane of Apollo 14 site is suggested. Thus, we tentatively assign somewhere in the middle point of Apollo 14 and Apollo 16 landing sites to the source region of Y-983885. However, there are several other regions where global map data of TiO_2, FeO and Th by Clementain and Lunar Prospector are consistent with their contents of Y-983885, like regions surrounding the PKT terrane on the near-side and the region near the SPA on the far-side. Although a possibility that Y-983885 originated from these regions cannot be completely denied, the mineral and chemical compositions of Y-983885 strongly support its affinity with such regions between Apollo 14 and Apollo 16 landing sites.

The chemical composition of Y-983885 shows a similarity to that of Calcalong Creek. As shown Figure 2, REE abundance and patterns of these meteorites are similar, although the absolute REE contents differ by a factor of two. The disparity of the REE abundances can be explained by the difference in quantity of KREEP materials between Calcalong Creek and Y-983885. Thus, we tentatively conclude source regions of Y-983885 and Calcalong Creek are closely connected with Apollo 14 and Apollo 16 sites, with the source region of Calcalong Creek being more proximate to the Apollo 14 site than that of Y-983885.

Table 1. Bulk chemical composition of KREEP-rich meteorites.

		Y-983885	Calcalong Creek*1	SaU169*2
SiO_2	(%)	45.8	47.18	45.15
TiO_2	(%)	0.531	0.84	2.21
Al_2O_3	(%)	22.6	20.83	15.88
Cr_2O_3	(%)	0.197	0.17	0.14
FeO	(%)	9.65	9.69	10.67
MnO	(%)	0.115	0.14	0.14
MgO	(%)	9.07	7.11	11.09
CaO	(%)	13.8	13.31	10.16
Na_2O	(%)	0.370	0.49	0.98
K_2O	(%)	0.166	0.24	0.54
P2O5	(%)			1.14
total	(%)	102	100	96.96
Th	(ppm)	2.37	4.280	32.7
U	(ppm)	0.697	1.18	8.6

*1 Hill et al. [7], *2 Gnos et al. [6].

References: [1] Kaiden H. and Kojima H. (2002) 27th *NIPR Symp. Ant. Met.*, 49-51. [2] Arai T. et al. (2005) *AMR* 18, 17-45. [3] Warren P. H. and Bridges J. C. (2004) 67th *Annual Meteoritical Society Meeting*, Abstract #5095. [4] Korotev R. L. et al. (2003) *GCA* 67, 4895-4923. [5] Kojima and Imae (2001) *Meteorite Newsletter* 10(2), 1 [6] Gnos E. et al. (2003) *Science* 305, 657-659. [7] Hill D. and Boynton W. V. (2003) *Meteoritics & Planet. Sci.* ,38, 595-626. [8] Heiken G. et al. (1991) *Lunar Source Book*.

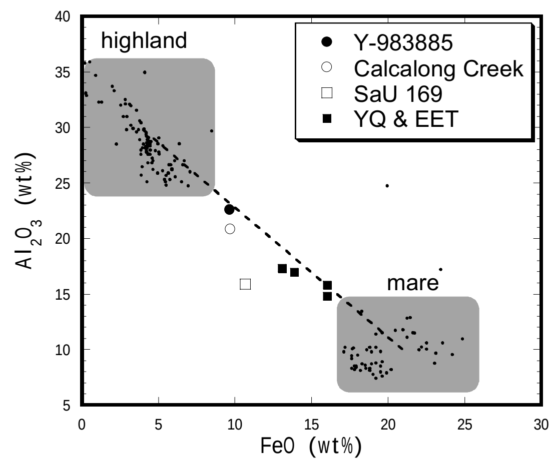

Fig. 1. FeO vs. Al2O3.Y-983885 is plotted on the mixing line of highland and mare components. Y-983885 is more feldspathic than YQ and EET.

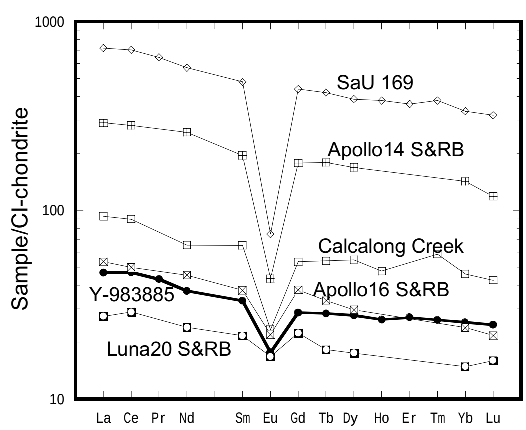

Fig. 2. Chondrite-normalized REE abundance pattern for Y-983885, SaU 169 [6], Calcalong Creek [7], averages of Apollo 14 S&RB and Luna 20S&RB [8], and intermediate values of Apollo16 S&RB [8].