MINERAL CHEMISTRY OF LUNAR METEORITE DAR AL GANI 400.

Antonina S. Semenova[1], Mikhail A. Nazarov[1,2], Natasha N. Kononkova[1], Allan Patchen[2], Lawrence A. Taylor[2], [1]Institute of Geochemistry and Analytical Chemistry, Moscow 117975, Russia (nazarov@geokhi.ru), [2]Planetary Geosciences Institute, University of Tennessee, Knoxville, TN 37996, USA (lataylor@utk.edu).

Introduction: Dar Al Gani 400 (DG 400) is the second lunar meteorite to be discovered in the Sahara and the largest lunar meteorite to be found on Earth. This meteorite has been described as a highland regolith breccia [1,2,3]. No mare and/or KREEP components have been reported previously. In the present study, we examined the petrography and mineral chemistries of three thin sections of DG 400 from the Russian meteorite collection. This meteorite is dominated largely by a ferroan anorthosite (FAN) component. However, DG 400 also contains minor Mg-suite lithologies and rare mare basalt (?) mineral fragments related to VLT basalts and, possibly, to the Apollo 14 rock suite. In addition, DG 400 contains an unusual feldspar component enriched in Ba/K. It is speculated that this meteorite was derived from a highland area, possibly of the lunar farside.

Results: DG 400 is a clast-rich-matrix, melt breccia that is composed of lithic clasts (80%) and mineral fragments (10%), set within a glassy matrix (10%). Lithic clasts are mainly fragmental glassy melt breccias. Only one clast of a rock with an ophitic (igneous ?) texture was found. Based upon mineral compositions, the lithic clasts can be subdivided into (1) anorthosites; and (2) anorthositic norites and troctolites. **Anorthosites** comprise 95% of the lithic clast population. They are up to 2.5 mm in size and consist of about 95% plagioclase (or maskelinite). **Anorthositic norites and troctolites** are minor components. These clasts are 0.1-0.25 mm in size and contain 20-40% of olivine and/or pyroxene. One small clast (0.3 mm size) of spinel troctolite was identified. It consists of Mg-Al-rich spinel, along with plagioclase and olivine, embedded in a glassy matrix. The most abundant discrete **mineral fragments** imbedded in the matrix are olivine, pyroxene, and feldspar.

As shown in Fig.1, **plagioclase** compositions in all lithologies range from An94 to An98. Only one small lithic fragment (0.1 mm in size) containing more sodic feldspar was discovered. It consists of plagioclase (An81, Or3.4) and silica. This feldspar is Ba-rich (BaO 0.6-0.9 wt.%), but it is relatively low in K (K_2O 0.5 wt.%). **Olivine** (Fig.1) in anorthosites is distinctly lower in Fo (72-66) compared to that in anortositic norites and troctolites (Fo85-70). Olivine fragments vary from F086 to Fo64. Among the mineral fragments, olivines of the ferroan anorthosite lithology are most abundant. **Pyroxene** shows extensive variation in chemistry (Fig. 2). Orthopyroxenes, pigeonites, and augites are present. As to be expected, pyroxenes of FANs are more ferrous compared to those in anorthositic norites and troctolites. Pyroxene mineral fragments are compositionally similar to pyroxenes of lithic clasts. However, **mare-basalt** fragments of Fe-rich augites and pigeonites occur, but are absent in the lithic clasts. One of them is ferroaugite (Wo37-40, Fs49-51) with small inclusions of silica, which may be a portion of the breakdown product of pyroxferroite. Another one is a zoned pigeonite with a core of Wo16Fs38 and rim compositions of Wo10Fs41. In the rim of this pigeonite, there are inclusions of Fe-rich olivine (Fo45), Fe metal (Ni 0.5, Co 0.7 %), and Cr-rich ulvöspinel. The Fe-rich pyroxenes have a higher Ti/Al ratio compared to those of lithic clasts and could be derived from a mare rock.

The Mg-Al **spinel** of the spinel troctolite is similar in composition to that of other lunar troctolites (Fig.3). Spinel fragments of this composition also occur in the matrix. In addition, a grain of Cr-pleonaste, previously described only in Apollo 14 nonmare rocks [4], was found. Other accessory minerals identified in the matrix include Mg-rich ilmenite (MgO 6%), troilite, FeNi metal (Ni 12-19, Co 0.6-1.7 %), and Ti-Al chromite. The ilmenite is probably of highland origin, whereas, Ti-Al chromite could be related to **mare basalts** (Fig. 3). The matrix **glass** and glass fragments have largely anorthositic compositions (Fig. 4). However, some glass fragments are relatively high in Fe, Ca/Al ratio, and Ti (up to 3 wt.% of TiO_2) and may well contain a **basalt** component similar to Apollo 14053 and 14063 feldspatic basalts. The bulk composition of DG400 measured by broad beam technique is SiO_2 43.4, TiO_2 0.23, Al_2O_3 29.16, Cr_2O_3 0.3, FeO 3.52, MnO 0.06, MgO 3.8, CaO 18.68, Na_2O 0.33, K_2O 0.1 (wt.%).

Discussion: The major lithology resent in DG 400 is similar in mineral chemistry to the ferroan anorthosite suite (FAN) in lunar highland rocks (Fig.5). This meteorite possesses the highest amount of FAN material compared to other lunar meteorites (Fig. 4). The minor noritic and troctolitic lithologies are distinctly richer in Mg/Fe and corresponds in mineral chemistry to a mixture of FAN and the Mg-Suite of highland's rocks (Fig.5). All lithologies in DG 400 appear to be enriched in Ca-rich pyroxene. In fact, the bulk DAG400 is slightly higher in Ca/Al ratio when compared to the highland lunar crust and the most of lunar highland meteorites. Mare basaltic material, although of minor abundance in DG 400, is certainly detectable from the chemistry of mineral fragments. The pyroxene, olivine and chromite compositions suggests that the mare component could be related to VLT basalts, known to be a main mare constituent of lunar meteorites [5,6].

There could be also some unusual components in DG 400. The Cr-pleonaste and a Ti-rich glass points to a possible presence of a component derived from the Fra Mauro formation sampled by Apollo 14 mission. The intergrowth of silica and Ba-rich feldspar assumes that a unique material with highly fractionated Ba/K ratio could be sampled by DG400. It has been demonstrated that DG400 as well as DG262 are enriched in Ba [3,7]. The enrichment was explained by terrestrial contamination. However the Ba-rich feldspar fragment cannot be of terrestrial origin and, therefore, points to unusual Ba-K fractionation in some kinds of lunar rocks.

In **Summary**, we conclude that the lunar source area for the DG 400 meteorite is a highland's terrain rich in FANs, with minor Mg-suite components and mare basalts. These less abundant lithologies are known to dominate on the lunar nearside, with relatively little representation from FANs. But, the lunar farside is believed to be rich in ferroan anorthosites [8], and this is a likely source area for DG 400.

References: [1] Zipfel J. et al. (1998) *MAPS*, ***33***, A171. [2] Cohen B.A. et al. (1999) *MAPS*, ***34***, A26. [3] Bukovanska M. et al. (1999) *MAPS*, ***34***, A21. [4] Haggerty S.E. (1972) *PLSC* ***3d***, 305–332. [5] Koeberl C. et al. (1991) *GCA*, ***55***, 3073-3087. [6] Warren P.H. (1990) *15th Symp. On Antarctic Meteorites*, 131-133. [7] Bischoff A. et al. (1998) *MAPS*, ***33***, 1243-1257. [8] Peterson C.A. et al. (1999) *LPI Contribution No* ***980***, 46-47. [9] Palme H. et al. (1991) *GCA*, ***55***, 3105-3122. [10] Taylor S.R. (1982) *Planetary Science - A lunar perspective*. Lunar Planet. Inst.