ALGONQUIN CLASS ROCKS OF COLUMBIA HILLS IN THE GUSEV CRATER, MARS, AND THEIR RELATIONSHIP TO SNC METEORITES. G. Dreibus[1], J. Brückner[1], R. Gellert[2], E. Jagoutz[1], G. Klingelhöfer[3], M. E. Schmidt[4] and Athena Science Team[5], [1]Max-Planck-Institut f. Chemie, J.-J.-Becher-Weg 27, D-55128 Mainz, Germany (dreibus@mpch-mainz.mpg.de), [2]Dep. of Physics, Univ. of Guelph, Guelph, On, Canada, [3]Inst. Anorg. Analyt. Chemie, Joh. Gutenberg-Univ., Mainz, Germany, [4]Dep. Mineral Sci., National Museum of Natural History, Smithsonian Institution, Washington, D.C., [5]Cornell Univ., Ithaca, NY.

Introduction: The Mars Exploration Rover (MER) Spirit discovered the first ultramafic rocks on the surface of Mars as it descended the south flank of 'Husband Hill' (Columbia Hills). Data provided by the Alpha Particle X-Ray Spectrometer (APXS) showed the highest concentrations of Mg, Fe and the lowest contents of Al, K, Ca and Ti (Fig.1) of almost all rocks encountered so far [1] for two samples from the Algonquin Class, 'Algonquin Iroquet' and 'Comanche Palomino'. Among the SNC meteorites no such rock type is found. However, there is a close similarity of these two rocks (both brushed surfaces) to the Martian meteorites with respect to elemental compositions. Evidently, the Ni concentrations of the Algonquin Class rocks are higher than in SNCs. MER data discussed are for brushed (and abraded) surfaces, only.

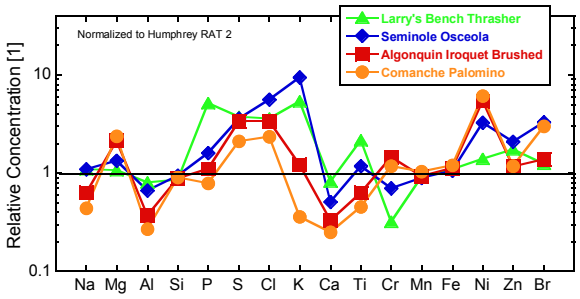

Figure 1 Relative concentrations of four related rocks (all brushed) at Husband Hill (see text). Values are normalized to Gusev plains rock 'Humphrey RAT2' [1].

Classification: The composition of 'Algonquin' and 'Comanche' with high Mg, low Na, Al, K, and Ca contents resemble to terrestrial picrites or komatiites.

There are considerable differences between Mars and Earth. The Martian mantle has more than twice the Fe content compared to the Earth's mantle. Therefore, the two ultramafic rocks encountered by the rover Spirit are with 22.3 and 24.8 wt % MgO not so magnesian as terrestrial samples, but richer in iron. For the Earth, the classification of high-magnesium volcanic rocks leads to MgO > 18 wt % for komatiites and > 12 wt % for picrites [2]. The total alkali content (Na_2O + K_2O) of the komatiites and picrites is between 1 and 2 wt % and between 2 and 3 wt %, respectively. The alkali content of Algonquin and Comanche is 1.7 and 1.1 wt %, respectively.

Chemical and mineralogical composition: At Husband Hill, a sequence of outcrop rocks was encountered and putatively called "Algonquin Class": 'Larry's Bench', 'Seminole', 'Algonquin' and 'Comanche'. The APXS and the Mössbauer (MB) spectra of these rocks indicate that the samples are relatively unaltered igneous rocks with high olivine content (also observed by Mini-TES [3]). Possibly, they could be derived from a primary magma as an olivine cumulate. A magmatic sequence of these four rocks becoming increasingly olivine-rich was postulated [4]. Among the SNCs the two chassignites contain mostly olivine and are thus classified as dunites.

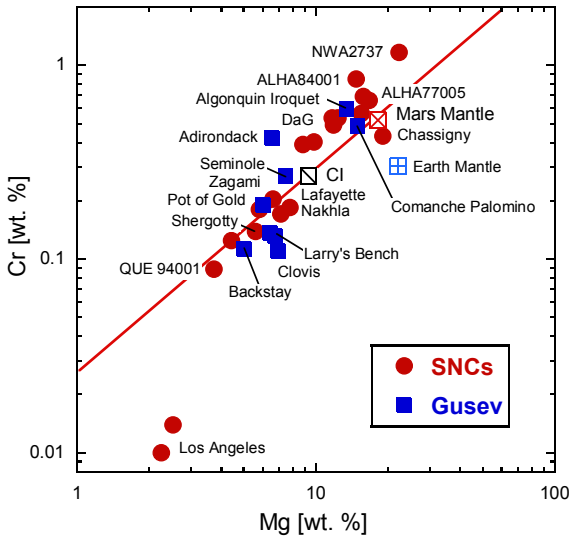

Figure 2 Cr versus Mg concentrations for SNC meteorites, Gusev rocks, Earth mantle, and carbonaceous chondrite CI.

Figure 2 shows the similarity of the brushed ultramafic Gusev rocks with the most unfractionated Martian meteorites, like Chassigny or the lherzolitic shergottites. Whereas the primitive basalt 'Adirondack' from the Gusev plains [1] does not fall on the chondritic (CI) Mg-Cr line, the Algonquin Class samples have a close to chondritic Mg-Cr ratio as postulated for the Martian mantle [5]. Furthermore, the ratio of the refractory elements Ca and Al of these rocks matches closely that of CI. This is a strong hint for (at least) a local, primitive magma source for potential volcanism beneath Gusev crater, similarly postulated

for alkaline volcanic rocks in Husband Hill by [6]. The Fe^{3+}/Fe_{total} ratios measured by MB on brushed surfaces of these rocks are 0.20 (Larry's Bench) 0.24 (Seminole), 0.11 (Algonquin), and 0.22 (Comanche), and illustrate that these outcrops are only weakly altered. However, compared to the SNCs with similar Fe contents their Mn contents are lower compared to SNCs resulting in an overall higher Fe-Mn ratio of 53 (Fig. 3). A similar trend can be observed for the olivine cumulate Chassigny.

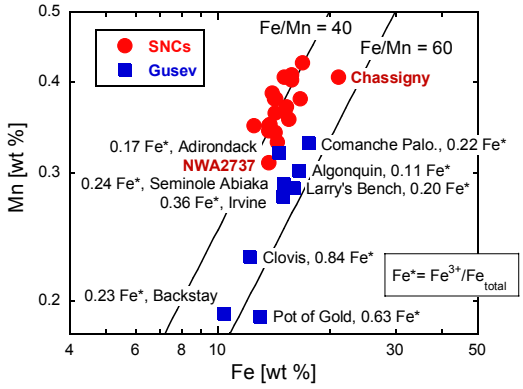

Figure 3 Fe-Mn ratios for SNCs and Gusev rocks.

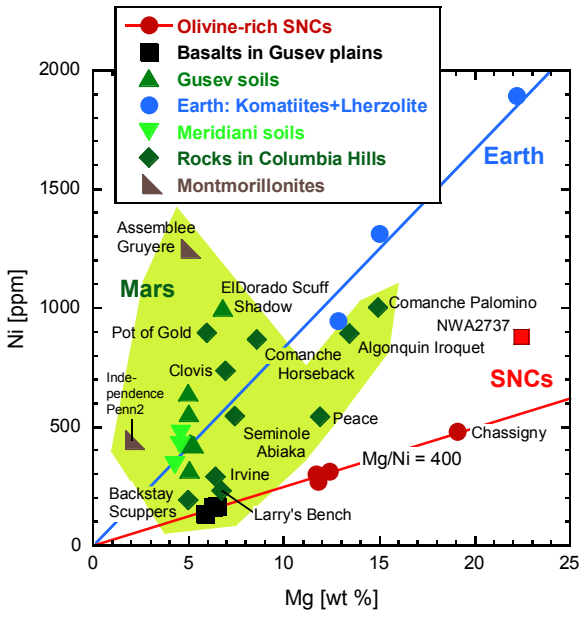

Figure 4 Nickel [ppm] versus Mg [weight %] of olivine-rich SNCs, NWA2737, Gusev rocks and soils, Meridiani soils, and terrestrial komatiites and lherzolites.

The Ni matter: Compared with the olivine-rich SNCs most of the Algonquin Class rocks have an extremely high Ni content. Only, a recently discovered chassignite, NWA2737, has with 875 ppm a similar Ni concentration.

The Ni contents of the Algonquin Class rocks, except for Larry's Bench, are also much higher than the primitive Gusev plains basalts [1]. A Ni enrichment of the Gusev soils relative to the plains basalts was explained by a meteoritic component that was admixed by impacts [1,7]. Most olivine-rich shergottites, Chassigny, and the Gusev plains basalts have an Mg/Ni of 400, except for NWA2737 with 250. All soils and the Columbia Hills rocks have even lower ratios (Fig. 4). The Ni/Mg scattering of all Gusev rocks is rather large and approaches the lower ratios of terrestrial rocks. While Ni/Mg in most SNCs and terrestrial ultramafics are strongly correlated, Ni in rocks at Gusev Crater might be mobilized by the acidic Martian environment.

Nickel is strongly partitioned into olivine. A weak correlation of Ni with the (calculated) olivine content of all Martian rocks exists (Fig. 5). Chassigny and the plains basalts plot along the SNC correlation line. However, most of the Algonquin Class rocks seem to follow a different correlation. Assuming olivine is the host mineral of Ni, the source region of the igneous Algonquin Class rocks must contain considerably higher Ni concentrations than derived for the Martian mantle based on the SNC compositions [5]. A fractional crystallization of the olivine cumulates could have changed their Ni content considerably, which would explain the apparent heterogeneity of the Martian mantle.

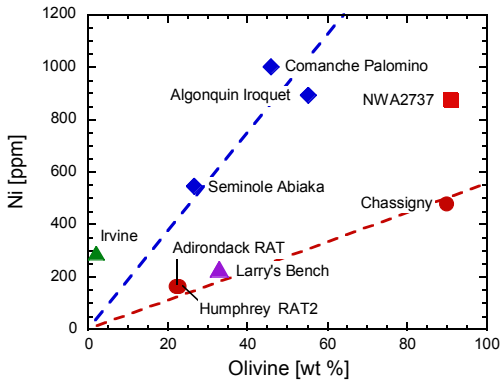

Figure 5 Nickel versus olivine for Gusev rocks, Chassigny, and NWA2737. The Gusev olivine content is based on the APXS data adjusted to 0.3 % S and 0 % Cl and the Fe^{3+}/Fe^{2+} ratio obtained by the Mössbauer data [6] and this work.

References: [1] Gellert R. et al. (2006) *JGR, 111*, E02S05. [2] LeBas H.J., (2000) *J. Petr., 41*, 1467. [3] Ruff S.W. et al. (2006) *LPSC 37*, #1989. [4] Mittlefehldt D.W. et al. (2006) *LPSC 37*, #1505. [5] Wänke H. a. Dreibus G. (1988) Phil. Trans. R. Soc. Lond. A 325, 545. [6] McSween H.Y. et al. (2006) *JGR, 111*, E09S91. [7] Yen A.S. et al. (2006) *JGR, 111*, E12S11.