REFRACTORY AND SEMI-VOLATILES ORGANICS AT THE SURFACE OF COMET 67P/CHURYUMOV-GERASIMENKO. E. Quirico[1] L. V. Moroz[2,3], B. Schmitt[1], G. Arnold[3], M. Faure[1], P. Beck[1], L. Bonal[1], M. Ciarniello[4], F. Capaccioni[4], G. Filacchione[4], S. Erard[5], C. Leyrat[5], D. Bockelée-Morvan[5], A. Zinzi[4], E. Palomba[4], P. Drossart[5], F. Tosi[4], M. T. Capria[4], M. C. De Sanctis[4], A. Raponi[4], S. Fonti[6], F. Mancarella[6], V. Orofino[6], A. Barucci[5], M. I. Blecka[7], R. Carlson[8], D. Despan[5], A. Faure[1], Fornasier[5] S., M. S. Gudipati[8], A. Longobardo[4], K. Markus[3], V. Menella[9], F. Merlin[5], G. Piccioni[4], B. Rousseau[5], F. Taylor[10], and the Rosetta VIRTIS team. (1) Université Grenoble Alpes, CNRS, IPAG, Grenoble France (2) University of Postdam, Germany (3) DLR, Berlin, Germany (4) IAPS-INAF, Rome, Italy (5) LESIA, Observatoire de Paris-Meudon, France (6) Università del Salento, Lecce, Italy (7) Space Research Centre, Polish Academy of Sciences, Warsaw, Poland (8) NASA JPL, Pasadena, USA (9) INAF Napoli, Italy. (10) Oxford University, Oxford, UK

The VIRTIS instrument onboard the Rosetta spacecraft has provided extensive spectral mapping of the surface of comet 67P/Churyumov-Gerasimenko, in the range 0.3-5 μm. The reflectance spectra collected across the surface display a low reflectance factor through the whole spectral range, two spectral slopes in the visible and the near-infrared ranges, and a broad band centered at 3.2 μm. The first two of these characteristics are typical of dark small bodies of the Solar System, and in this respect their interpretation in terms of composition is difficult. Solar wind irradiation may modify the structure and composition of surface materials, and there is no univocal assignment for those spectra devoid of vibrational bands. In order to circumvent these problems, we developed an analysis by constraining the nature of cometary materials from the study of cometary grains analyzed in the laboratory and by considering results on surface rejuvenation and solar wind processing provided by the OSIRIS and ROSINA instruments, respectively. Our results show that (1) The low albedo of comet 67P/CG is accounted for by a dark refractory polyaromatic carbonaceous component mixed up with opaque minerals. VIRTIS data do not provide direct insights into the nature of these opaque minerals. (2) A semi-volatile component, consisting of a complex mix of low weight molecular species not volatilized at T~220 K, is likely a major carrier of the 3.2 μm band. Water ice has a significant contribution to this feature in the neck region, but not in other regions of the comet. COOH in carboxylic acids is the only chemical group that encompasses the broad width of this feature. It appears as a highly plausible candidate, along with the NH_4^+ ion. (3) Photolytic/thermal residues, produced in the laboratory from interstellar ice analogs, appear as potential interesting spectral analogs. (4) No hydrated minerals were identified and our data support the lack of generic links with the CI, CR and CM primitive chondrites. This concerns in particular the Orgueil chondrite, which had been suspected to have a cometary origin. (5) The comparison between fresh and aged terrains revealed no effect of solar wind irradiation on the 3.2 μm band. This is consistent with the presence of efficient resurfacing processes, such as dust transport from the interior to the surface as revealed by the OSIRIS camera.

ISOTOPIC EVIDENCE FOR PRIMORDIAL MOLECULAR CLOUD MATTER IN METAL-RICH CARBONACEOUS CHONDRITES. E. Van Kooten[1], D. Wielandt[1], M. Schiller[1], K. Nagashima, A. Thomen, K. Larsen[1], M. Olsen[1], Å. Nordlund[1], A. Krot[1,2] and M. Bizzarro[1], [1]Centre for Star and Planet Formation, University of Copenhagen, Copenhagen, Denmark, [2]HIGP, University of Hawai'i at Manoa, Honolulu, USA.

The short-lived ^{26}Al radionuclide is thought to have been admixed into the initially ^{26}Al-poor protosolar molecular cloud prior to or contemporaneously with its collapse. Bulk inner solar system reservoirs record positively correlated variability in mass-independent ^{54}Cr and ^{26}Mg*, the decay product of the short-lived ^{26}Al radionuclide. This correlation is interpreted as reflecting progressive thermal processing of in-falling ^{26}Al-rich molecular cloud material [1, 2]. Planetesimals formed in the outer solar system could have accreted a significant fraction of primordial and, hence, thermally unprocessed molecular cloud matter. This material reflects the nucleosynthetic make-up of the molecular cloud prior to the last addition of stellar-derived ^{26}Al. Therefore, unlike inner solar system objects, the isotopic signature of the thermally unprocessed and ^{26}Al-poor primordial molecular cloud matter is expected to show a decoupling between their ^{26}Mg* and ^{54}Cr compositions.

To search for the signature of primordial molecular cloud material, we analyzed the magnesium and chromium isotope composition of metal-rich carbonaceous chondrites (CH, CB and CR) and their components, including 3 bulk samples, 13 chondrules and 5 hydrated lithic clasts. Several observations suggest that metal-rich chondrites may have incorporated primordial molecular cloud material of possible outer solar system origin, including enrichment in ^{15}N, high abundance of presolar grains and the presence of ^{26}Al-poor CAIs. Our results show that CH, CB and CR chondrites and their components have a unique ^{26}Mg* and ^{54}Cr isotope signature, falling off the solar system correlation line. Our samples defined an array extending from the composition of CM chondrites to that expected for thermally-unprocessed and ^{26}Al-free molecular cloud material (μ^{54}Cr = 160 ppm and μ^{26}Mg*= –16 ppm). This requires the presence of significant amount (25-50%) of primordial molecular cloud material in bulk metal-rich chondrites. Given that such high fractions of primordial molecular cloud material are expected to survive only in the outer Solar System, we infer that, similarly to cometary bodies, metal-rich carbonaceous chondrites are samples of planetesimals that accreted beyond the orbits of the gas giants. The presence of chondrules in CR, CH and CB chondrites with an isotopic signature requiring the incorporation ^{26}Al-poor primordial molecular cloud component suggests that chondrule formation was not limited to the inner Solar System, indicating that chondrules present in cometary bodies such as Wild2 may be locally derived. The lack of isotopic evidence for primordial molecular cloud material in other chondrite groups requires isolation from the outer Solar System, possibly by the opening of disk gaps from the early formation of gas giants.

[1] K.K. Larsen *et al*. (2011) *Astrophys. J.* **735**, L37. [2] M. Schiller *et al*. (2015) *Geochim Cosmo Acta* **148**, 88.