Composition of comet 67p/Churyumov-Gerasimenko refractory crust as inferred from VIRTIS/Rosetta

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The Visible InfraRed Thermal Imaging Spectrometer VIRTIS instrument onboard ESA's Rosetta orbiter has completed extensive mapping campaigns of the 67P/Churyumov-Gerasimenko comet (67P/CG) nucleus in August-September 2014. Reflectance spectra were collected within the 0.4-5 μm range and reveal a dark surface (normal albedo ~6 %), positive (red) near-infrared spectral slop, steeper red visible slope, and a broad feature that peaks at 3.2 μm. The reflectance spectra are fairly similar to those of other comets (Borelly, Temple1 and Hartley 2), and share similarities with those of D-type asteroids (except the 3.2 μm band). They are significantly different than reflectance spectra of CI, CM and CR carbonaceous chondrites collected in laboratory. This might imply that any of those carbonaceous chondrites are linked to comets, challenging the asteroid-comet continuum. Insights into surface rejuvenation after perihelion are however required to get robust conclusions. The reflectance factor in the visible and the near-infrared up to 2.7 μm points to a carbon-rich surface mixed with opaque minerals (likely ~ FeS sulphides, with possibly Fe-Ni alloys). The 3.2 μm is observed for the first time in a comet. This broad band can be assigned to OH, CH, H_2O, NH/NH_2 and NH^{4+} chemical groups, molecules or ions. The nucleus temperature of 220 K renders negligible a significant contribution from water ice, which is marginally detected in area of the nucleus just emerging from shadow. The most plausible candidates are alcohol (terminating -OH) and carboxylic groups (-COOH), as well as the ion NH_4^+. These species could be relicts of sublimated ices and not linked to the dark refractory carbonaceous material that account for the very low reflectance. A thorough investigation of the structure of this 3.2 μm band, and its variation across the surface, should help constrain further this assignment.