DARKENING IN GAS-RICH ORDINARY CHONDRITES: SPECTRAL MODELLING AND IMPLICATIONS FOR THE REGOLITHS OF ORDINARY CHONDRITE PARENT BODIES. D.T. Britt and C.M. Pieters. Dept. of Geological Sciences, Brown Univ., Providence, RI 02912.

Introduction: The connection between asteroids and meteorites is based, in part, on the strong similarities between remotely sensed telescopic spectra and laboratory spectral data that have linked most of the major meteorite types with asteroid spectral types [1]. However, the major exception to this link is the failure to unequivocally identify any main asteroid belt parent bodies for the most numerous type of meteorite, the ordinary chondrites. Important clues to the identification of ordinary chondrite parent bodies may be found in the dark matrix material of gas-rich ordinary chondrites. The dark portions of gas-rich ordinary chondrites contain high levels of solar wind implanted gases and solar flare tracks strongly indicating that this material was exposed on asteroidal surfaces [2]. The implication is that the dark material represents samples of the regolith soil of ordinary chondrite parent bodies. The spectra of the dark material is altered from that of normal ordinary chondrites [3,4]. Not only is the reflectance lowered, but the diagnostic spectral absorption bands are shallowed and subdued. This would suggest that the regolith soil of ordinary chondrite parent bodies is also spectrally altered. Isolating the cause of the spectral darkening in of gas-rich chondrites may provide insight on the spectral characteristics of the regolith soil and, by implication, the spectral characteristics of the elusive ordinary chondrite parent bodies.

Spectral Mixture Modelling: The preferred way of examining the optical properties of the opaque fraction in gas-rich chondrites is to analyze the spectra of a sample of pure gas-rich dark matrix material. However such samples are extremely rare due to the intimate mixture between the dark matrix and the light clasts. The "dark" matrix of gas-rich chondrites is typically a fine grained mass of light clasts and fragments mixed with smaller amount of dark, gas-rich grains. It is simply impossible to separate grains with a particle sizes as small as a few tens of microns that are mixed on a scale of tens of microns and produce enough material for a laboratory bidirectional reflectance measurements. All the gas-rich samples used in this spectral study had a substantial fraction of light clast material mixed with the dark matrix. It is possible, however, to use an intimate mixing model based on the bidirectional reflectance theory of Hapke [5] to simulate the spectral mixing of light clast material with dark matrix material. The dark matrix material has an opaque morphology similar to that of black chondrites [6]. Photomicrographs and SEM images show that the particle size and distribution of metal and troilite is very similar to that in black chondrites. Counts show that the density of opaques and attenuation of photon path length is also well within the range seen in black chondrites [6]. If we assume that the "pure" dark matrix material has a spectrum similar to that of black chondrites, the intimate mixing technique can be used to test this assumption by examining how a mix of black chondrite and light clast spectra can replicate the spectrum of the dark area of a gas-rich chondrite. The first simulation uses the spectra of the light portion of the gas-rich chondrite Dwaleni (H6) and black chondrite Jackalsfontein (L6) as end-members. Point counts of a thin section of Dwaleni show that the dark component contains approximately 65% light clast material and about 35% dark grains. Shown in **Figure 1** are the spectra of the light and dark components of Dwaleni and the simulated spectrum with a mix of 65% light component and 35% black chondrite based on the point count data. The close match between the simulated and actual dark area spectra show that there are strong spectral similarities between the "pure" dark matrix material in gas-rich chondrites and black chondrites. Shown in **Figure 2** is a similar mixing experiment using the light portion of the gas-rich chondrite Fayetteville (H4-6) and the black chondrite Novosibirsk (H5-6). Once again a mix of these components in fractions corresponding to observed light/dark components replicates with great accuracy the spectrum of the dark area.

Simulations were also run to test the optical effects of the other opaque fractions in gas-rich ordinary chondrites. Two in particular, magnetite and carbon, have been suggested as optically important [7,8]. The results of these simulations are shown in **Figure 3**. Using the observed mass fractions and particle size distribution, both magnetite and carbon failed to produce anything close to the required optical alteration. This is not to say that chromite, magnetite, ilmenite and carbon are not contributing to the optical darkening seen in black chondrites. Clearly all the opaques in the meteorite contribute to the overall effect. However, the relatively large particle size, limited distribution, and the very small mass fraction of these minor opaques makes their contribution minor. Metal and troilite are so much more abundant that their effects swamp the contributions of other opaque fractions.

The Cause of Darkening in Gas-rich Ordinary Chondrites: The dark fine-grained matrix of gas-rich ordinary chondrites replicates many of the physical, morphological, and spectral characteristics of the highly shocked and optically altered black chondrites. Spectral mixture modelling shows that the darkening and spectral attenuation seen in the dark matrix can be simulated with realistic mass fractions of light host material and black chondritic material. All these factors point to the conclusion that the dark matrix of gas-rich ordinary chondrites is dark due to the same processes that darkens black chondrites, shock-distributed small particle size FeNi metal and troilite. Because the darkening is not seen in any of the non-gas-rich light portions and is only seen in the gas-rich grains of the meteorite, the shock-darkening would have to occur as part of the matrix's exposure to regolith processes. Since all gas-rich grains are darkened, it follows that darkening is not only common, but pervasive in asteroidal regoliths. These results imply that the upper, optically active layer of an ordinary chondrite parent body should have the spectral characteristics of a black chondrite, which are a dark, relatively featureless spectrum with modest red slope in the infrared. These are the characteristics of spectral type C asteroids [1].

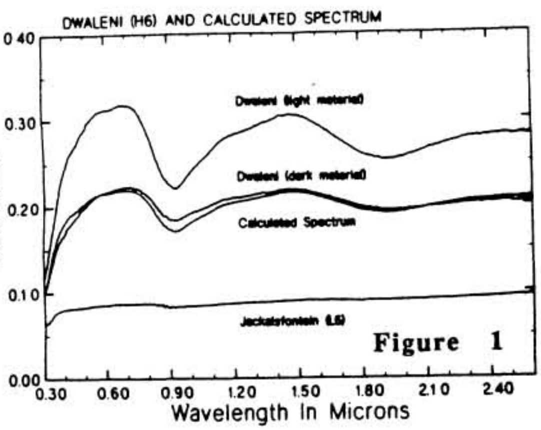

Figure 1

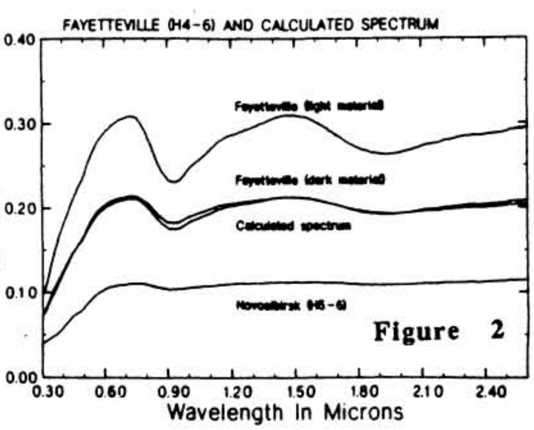

Figure 2

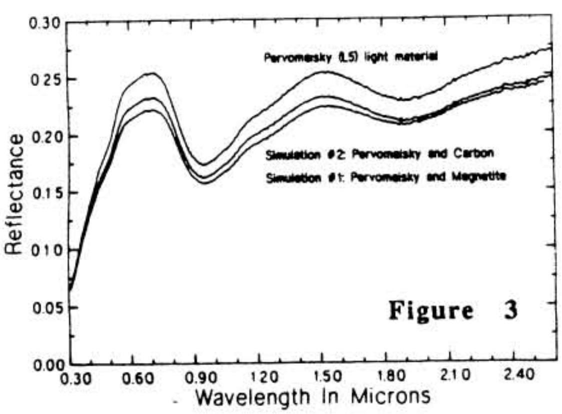

Figure 3

References: [1] Bell J.F. et al. (1989) Asteroids II, 921-945 [2] Bell J.F. and Keil K. (1988) *Proc. 18th*, 573-580 [3] Fredriksson K. and Keil K. (1963) *G & C Acta, 27*, 717-739. [4] Britt D.T. and Pieters C.M. (1991) This volume. [5] Hapke (1981) *JGR, 86*, 3039-3054. [6] Britt D.T. and Pieters C.M. (1991) In preparation. [7] Rubin et al., (1983) *Proc. 13th, JGR 88*, A741-A754. [8] Keil K. (1982) LPI tech. rept. 82-02, 65-83.