VISIBLE AND NEAR-INFRARED REFLECTANCE SPECTRA OF RUMURUTI. J. Berlin, C. M. Lingemann, and D. Stöffler. Institut für Mineralogie, Museum für Naturkunde, Invalidenstrasse 43, D-10115 Berlin, Germany. e-mail: jana.berlin@museum.hu-berlin.de

Introduction: Visible and near-infrared (VNIR) reflectance spectra of meteorites help us to constrain genetic relationships to potential parent asteroids [1-3]. We present measurements in the range of 0.5-2.5 µm for Rumuruti after which a new chondrite group was named in 1994 [4]. Rumuruti is the only fall among the R chondrites and as an unweathered meteorite it is ideal for reflectance spectroscopy. R-chondrites have highly oxidized mineral assemblages [4,5] and contain, with decreasing abundance, olivine, plagioclase, Ca-rich pyroxene, low-Ca pyroxene, minor phases such as pyrrhotite, pentlandite, chromian spinel, and traces of metallic FeNi. Most R-chondrites are light/dark structured regolith breccias consisting of highly recrystallized fragments as well as unequilibrated lithologies and contain solar-wind-implanted rare gases [6]. As of today, there is only one VNIR-reflectance measurement on Rumuruti powder [7].

Samples and methods: We conducted non-destructive measurements on raw saw-cut surfaces of two chips of Rumuruti (Fig. 1) using the technique of [8] and [9]. Therefore, we were able to set the elliptical beam spot on three characteristic lithologies resulting in three different, well-defined spectra: (a) a light clast of petrologic type 5/6, (b) a shocked dark, nearly opaque lithology ("shock-blackened"), and (c) a typical region within the clastic matrix of the breccia (Fig. 1). The mineralogical compositions of these lithologies are well known from electron microprobe analyses of comparable regions in thin sections of this meteorite.

Experimental: The biconical reflectance spectra were acquired using an FTIR-spectrometer (Bruker IFS 88) with a Seagull™ variable angle reflectance accessory at the German Aerospace Center (DLR) in Berlin. For all measurements the incidence and emergence angles were 20°. Spot sizes were 2 mm for the light clast and dark lithology, and 3 mm for the clastic matrix. During NIR measurements the analysis chamber was purged with dried air. We used a Si-detector for the wavelength range of 0.5 to 1.1 µm and a LN_2-cooled InSb-detector for 0.9 to 2.7 µm. The laboratory reflectance standards applied are Spectralon™ and Au-evaporated sandpaper, respectively; and the reflectance spectra are represented by the ratio of the samples' signals to the standards' signals. The angular scattering properties of both laboratory reflectance standards are not known. Therefore, our spectra do not describe the accurate bidirectional reflectance but can be referred to as a "relative reflectance" [10]. To obtain the spectrum of the sample over the entire wavelength region, the spectra obtained with the two detectors were merged scaling the reflectance spectrum of the longer wavelength region to the value of the spectrum of the lower wavelength region at 1 µm.

Results: On the basis of petrographic and microprobe studies, the three sample types can be characterized as follows:

(a) Light type 5/6 clast. Metamorphosed light fragments in Rumuruti mainly consist of equilibrated olivine (Fa_{39-40}). Smaller crystals of Ca-rich pyroxene are less equilibrated ($Fs_{10-19}Wo_{36-46}$) and no low-Ca pyroxene was observed. Interstitial plagioclases have a composition of $Ab_{80-87}An_{8-17}Or_{3-5}$. Opaque phases (mostly sulfides) are found in individual grains that vary largely in size. The modal abundances of minerals were determined in a comparable light clast in one of the thin sections of Rumuruti: olivine = 72.6 vol.%, plagioclase = 12.0 vol.%, Ca-rich pyroxene = 11.7 vol.%, and opaque phases = 3.7 vol.%.

(b) Shocked dark lithology ("shock-blackened"). The dark appearence of these regions is due to a fine network of sulfide-filled veins found along grain boundaries and in fractures of olivine and pyroxene. As Fe-(Ni-)sulfides have a low liquidus temperature, they can be readily melted and dispersed by shock heating. This is commonly referred to as "shock blackening" [11]. The sulfide-coated olivine and pyroxene grains have similar compositions to those found in the light clasts. Plagioclase is also a common phase.

(c) Clastic matrix. The matrix of Rumuruti outside the lithic fragments was classified as petrologic subtype 3.8 [5] because of relatively heterogeneous olivine and pyroxene compositional distributions. It contains zoned olivine crystals (Fa_{7-44}) as well as homogeneous olivine grains (Fa_{39}), Ca-rich pyroxene ($Fs_{9-18}Wo_{33-48}$), low Ca-pyroxene ($Fs_{2-32}Wo_{0.3-11}$), a few chondrules and chondrule fragments consisting of the latter minerals, sulfide grains up to 300 µm in size, and albitic feldspar intergrowths. In general, the matrix is more fine-grained than the light clasts.

The reflectance spectra of the light type 5/6 clast, the shocked dark lithology, and the clastic matrix are shown in Fig. 2. Since olivine is the dominant phase in Rumuruti, both the spectra of the light clast and the matrix are particularly similar to a pure olivine spectrum [*e.g.*, 12]. The center of the olivine absorption feature is shifted because of higher Fe contents [2] to 1.06 µm and 1.07 µm for the light clast and the matrix, respectively. Due to the existence of pyroxene and plagioclase, the reflectivity of boths spectra decreases towards 1.6 µm compared to the spectrum of pure olivine. The light clast, as it is of higher metamorphic grade than the matrix, shows typically stronger absorption features [12]. The spectrum of the shocked dark lithology shows a weak band center at 1.02 µm, but it is flat and reddish because of the dispersion of shock-induced sulfides.

Discussion: The visible and near-infrared reflectance spectra of Rumuruti´s light clast and matrix show some similarities to spectra of LL chondrites [12]. The spectrum of the shocked dark lithology is comparable to "black chondrites" [13]. Recent cuts showed that darkened regions are more common in Rumuruti than previously thought [4,5]. Their shock origin may make them a more important surface constituent of the parent asteroid. Therefore, the reflectance spectrum of Rumuruti´s parent body may be a composite of the three types of measured spectra, notwithstanding the effects of space weathering and roughness of the real surface. This composite is obviously similar to the spectrum of the clastic matrix representing approximately the asteroid's surface properties. Our results confirm the observation that Rumuruti plots within the olivine region in a diagram of band area ratios versus Band I centers, which was made by Burbine et al. [7]. This region corresponds to S1 asteroids [14].

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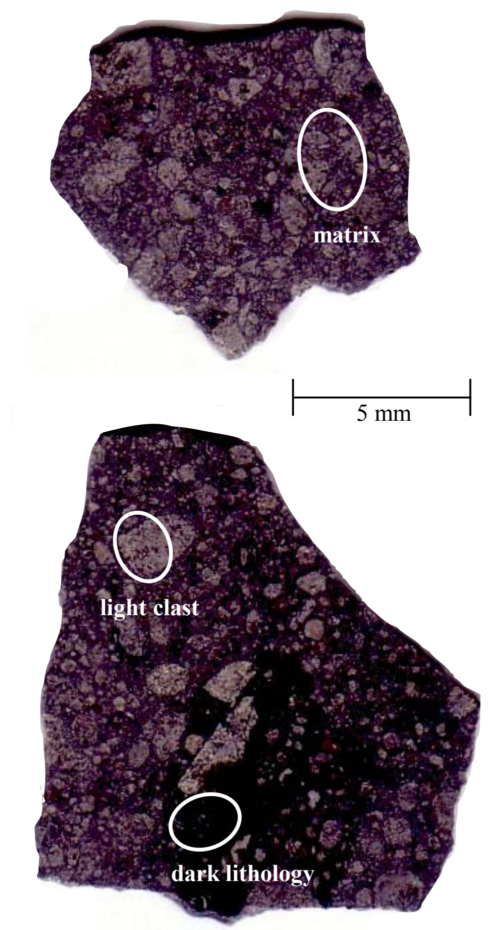

Fig. 1: Sawed chips of Rumuruti (thickness: 0.6 mm). The white ellipses show the locations of analyzed spots.

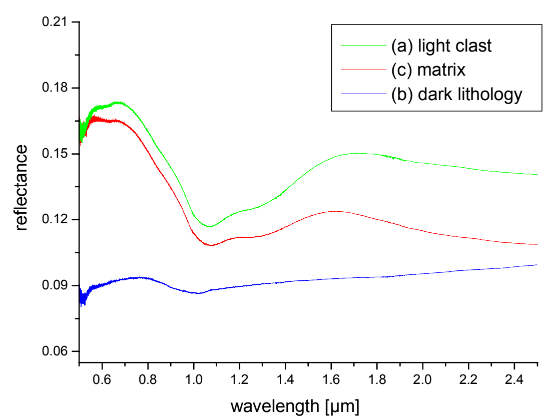

Fig. 2: Reflectance spectra of three different lithologies of the chondritic breccia Rumuruti.