COLOR CLASSIFICATION OF THE MARTIAN SURFACE; E. Hauber, H. Hoffmann, M. Rauch, and G. Neukum, German Aerospace Research Establishment (DLR), Inst. for Optoelectronics, Planetary Remote Sensing Section; 8031 Oberpfaffenhofen, FRG

INTRODUCTION: The chemical and mineralogical composition of a planetary surface can be inferred from remotely sensed spectral data. Color scenes taken by the Viking-Orbiter cameras offer the opportunity to classify the martian surface with a variety of methods [1,2]. Unfortunately, the average resolution of these color scenes is relatively poor, typically being a few hundred m/pixel. At this scale, no detailed morphological analysis is possible. On the other hand, high-resolution images available in only one channel do not bear any spectral information. Hence, only the combination of these two data sets allows us to compare the results of color classification with morphology. Here, we describe a non-automatical interactive surface classification and its verification by high-resolution data.

DATA: Among the most interesting geologic features of Mars are the Valles Marineris and Olympus Mons. For this investigation we have chosen two color scenes, showing Candor Chasma in the eastern Valles Marineris and the northern slope of Olympus Mons, respectively (Image No.'s 586a02/06/08 and 614a52/56/58). Each scene consists of three color channels: red, green, and violet (592 nm, 530 nm, 444 nm). All images were photometrically corrected by Minnaert and geometrically registered. Images of orbits 079-081, 908-913, and 512 have been selected for high-resolution mosaics.

CLASSIFICATION: Plotting the pixel values of one image versus another geometrically identical image yields a two-dimensional histogram. These so-called scattergrams give clues about differences between the images, image correlation, and thematical information [3,4]. In a spectral scattergram, color units form distinct clusters of points which can be identified either automatically or by visual inspection (Fig. 1a). By marking clusters with polygon borders, color classes are defined. Subsequently, all pixels in the original color scene with combinations of values plotting inside one polygon can be grouped together as one spectral class (Fig. 1b).

In order to define color classes, we used combinations between all channels, i.e. red/violet, red/green, and green/violet. Furthermore, image ratios (red/violet, green/violet) were plotted versus each other. In ratios, color variations related to morphological and topographical features should be widely removed. These features are known to cause spectral variations by photometric effects and are responsible for variegations in an image not caused by chemistry and/or mineralogy. Consequently, by using ratios these photometrically induced artifacts should disappear.

Scattergrams of the martian surface are known to exhibit a V-like pattern. The separation of different classes, however, is difficult due to the low diversity. In order to obtain the maximum information from the scattergrams we varied the density of the points. This was achieved by plotting only points with a frequency greater than a variable threshold value. By this way, small *and* large clusters can be detected equally well. If all points in a scattergram lie within specified polygons, all pixels in the original color scene are assigned to a distinct cluster. Pseudo-coloring of the different classes in the original scene results in a color-coded classification map (Fig. 2).

These unit maps were geometrically coaligned with digital image mosaics made from high-resolution images. High-resolution classification maps were created by a HSI-transformation, where the spectral intensity component was replaced by the high-resolution mosaic. Hence, a synchronous interpretation of both the color map *and* the morphologic details has been possible. We tested the correlation between the two kinds of information and corrected obvious errors of the color classifications (e.g. color variations due to photometric effects). To support this step, we computed the statistical relevance of the specified clusters. Clusters which were distinguished subjectively by visual inspection, but could not be separated mathematically were object to special attention.

RESULTS: The classification of colors by means of visually supervised scattergrams yields reasonable results on Viking color scenes. As an example, dark spots in Coprates and Candor Chasmata interpreted from panchromatic images as possibly recent volcanites [5] are easily identified in the scattergram of spectral channels. They form a branch of points with relatively high violet/red ratios, corresponding to fresh, unoxidized mafic materials (Fig. 2).

However, identified color classes have to be verified by an independent method. This can either be a statistical test or a comparison with topographical and/or morphological details. The advantages of this kind of classification are its speed, its flexibility, and the simplicity of error corrections. Moreover, the experience of the scientist helps to exclude *a priori* some non-compositionally based clusters. Knowledge of the surface composition, of photometric effects, and of additional data avoids misinterpretation.

REFERENCES: [1] McCord, T.B. et al. (1982) *JGR*, vol. 87, 10129-10148. [2] Arvidson, R.E. et al. (1982) *JGR*, vol. 87, 10149-10157. [3] Göpfert, W. (1987) *Raumbezogene Informationssysteme*, 278 pp., Wichmann, Karlsruhe. [4] Castleman, K.R. (1979) *Digital Image Processing*, 429 pp., Prentice Hall, Englewood Cliffs. [5] Lucchitta, B.K. (1987) *Science*, **235**, pp. 565-567.

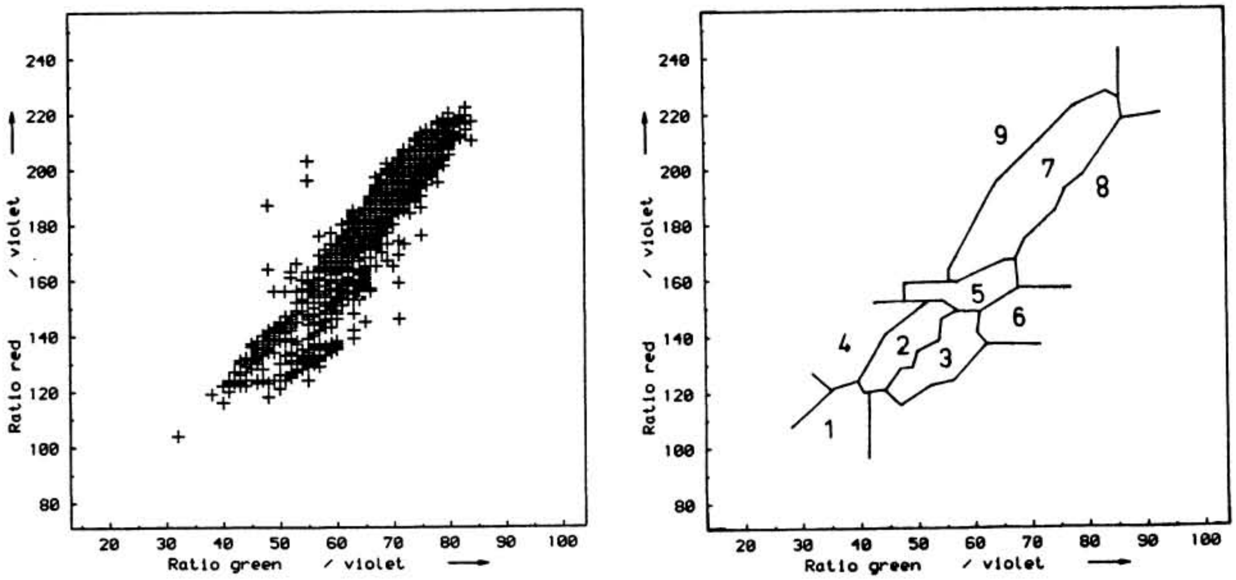

Figure 1. **a) Scattergram** *(Top left)* and b) **specified polygons** *(Top right)*; of ratios red/violet versus green/violet. Threshold frequency for scattergram is 15 (Candor Chasma region).

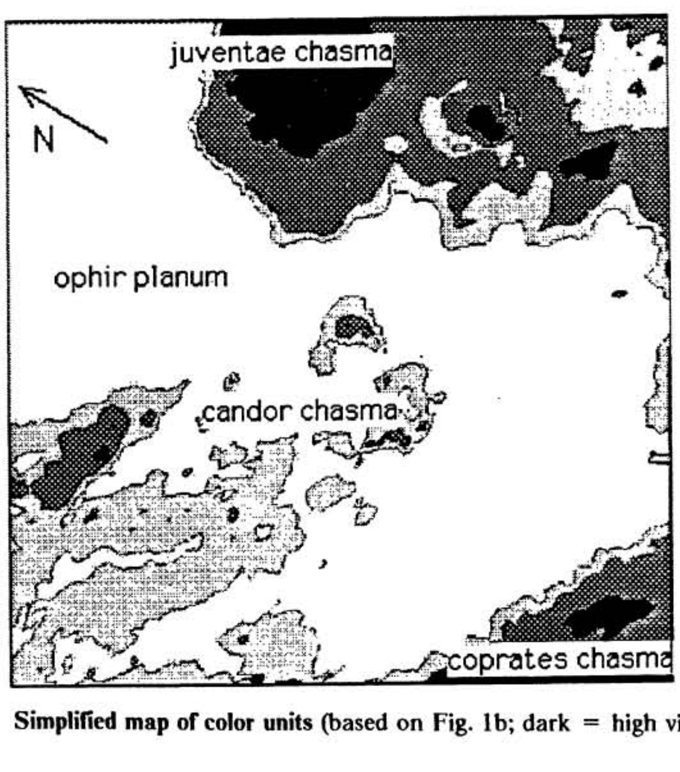

Figure 2. **Simplified map of color units** (based on Fig. 1b; dark = high violet/red-ratio).