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Transneptunian Objects' Surface Compositions

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Abstract

A Large Programme has been accomplished at ESO (VLT) and 40 transneptunian objects have been observed quasi-simultaneously with UT1, UT2 and UT4. The obtained results will be presented and the composition of the most significative/peculiar objects will be discussed in detail.

1. Introduction

The transneptunian objects (TNOs) are considered among the most primitive bodies of the Solar System and the investigation of their surface composition provides constraints on the formation processes of the early solar nebula, as well as on the formation processes of other planetary systems around young stars.

A large program has been carried out at ESO-VLT using almost simultaneously UT1, UT2 and UT4 telescopes (Cerro Paranal, Chile). The aim of this large program was to obtain as high as possible S/N simultaneous visible and near-IR spectroscopy (using FORS, ISAAC and SINFONI instruments) for almost all objects observable within the VLT capability. The program focused on high quality spectroscopy for objects selected among different dynamical groups. All these objects have also been observed by V, R, I, J, H and K photometry to determine the taxonomic classes.

For a few of them the rotational periods have been determined. The results relative to photometry will be presented by Perna et al. (this section). For eight objects, complementary polarimetric observations have been also carried out to better investigate the surface characteristics. The results relative to polarimetry will be presented by Belskaya et al. (this section).

2. Results

All the data have been analyzed and the surface composition of these remote objects has been investigated using Hapke and Shkuratov radiative codes. While some objects show no diagnostic spectral bands, others reveal surface deposits of ices of H_2O, CH_3OH, CH_4 etc. We computed the spectral slope for each object and searched for possible rotational inhomogeneity, observing a few objects several times.

For the spectral slope distribution of TNOs we collected all the visible spectral slopes obtained from spectroscopy available from the data collected during this large program and in the literature, obtaining a sample of 20 Centaurs and 53 TNOs (14 resonants, 29 classicals, 6 SDO and 4 detached objects, including the dwarf planet Eris). We find that there is a lack of very red objects in the classical population. Using a Spearman rank correlation we confirm a strong anticorrelation between spectral slope and orbital inclination for the classical population (Fornasier et al. 2009). Nevertheless, we do not observe a change (Fig. 1) in the slope distribution at $i = 5^o$, the boundary between the dynamically hot and cold populations, but we find that objects with $i < 12^o$ show no correlation between spectral slope and inclination, as already noticed by Peixinho et al. (2008) on the color – inclination relation for classical TNOs. A strong correlation is also found between the spectral slope and orbital eccentricity for resonant TNOs.

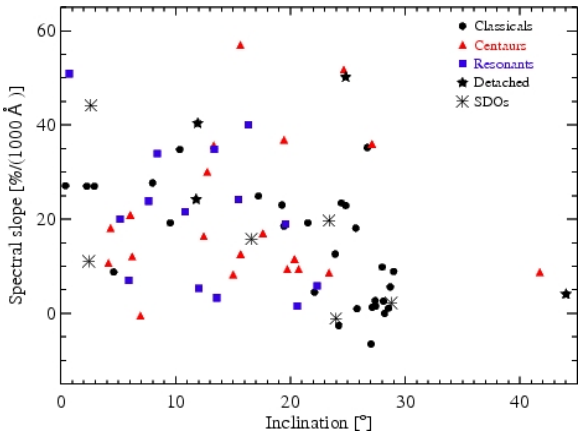

Figure 1: Spectral slope versus orbital inclination.

For each near infrared spectrum we measure the H_2O ice band depth at 2 μm and the spectral slope in the K band. Particular attention has been given to the four objects of our sample [(90377) Sedna, (90482) Orcus, (50000) Quaoar, and (136199) Eris] that are among the largest and have particular diagnostic features.

The dwarf planet *(90377) Sedna* (diameter of ~ 1300 km) is one of the most remote solar system objects accessible to investigations, and one of the reddest. Its surface is heterogeneous and the visible and near-infrared spectra have been modeled with organic materials (triton and titan tholin), serpentine, and H_2O ice in fairly significant amounts, and CH_4, N_2 and C_2H_6 in varying trace amounts.

(90482) Orcus (diameter of ~ 950 km) is a Plutino (3:2 resonance with Neptune). It has been observed several times and its surface appears homogeneous and has been modeled by H_2O ice (including both crystalline and amorphous ice), a neutrally absorbing blue component and probably NH_3 which could account for the weak signature present near 2.2 microns. DeMeo et al (2010) investigated also the limit on the possible presence of CH_4 and CO_2.

(50000) Quaoar is a classical TNO with a diameter of ~840 km. Its surface has been modeled, confirming previous results, with crystalline H_2O and CH_4 ices as well as C_2H_6 and organic materials. The addition of N_2 ice leads to a better fit with the obtained spectra.

The dwarf planet *(13699) Eris* (diameter of ~2400 km) is in the detached/scattered dynamical class of TNOs with an aphelion at 96 AU. The visible and near-infrared spectra are dominated by deep and broad methane features with small shifts. These observations suggest a stratification of the diluted CH_4 ice in N_2. The layer of diluted methane ice could be between two layers of pure methane ice.

For all the observed objects a surface model has been carried out using, when available, the Spitzer albedo. A global analysis of the observed objects has been carried out on the spectral slopes (in V and K bands), H_2O ice depths, and colors of the entire sample. A statistical analysis of the physical properties with respect to the size and dynamical classes has been performed.

In the presentation, we will summarize all our findings, particularly concerning the diversity of bulk composition.

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