URUK SULCUS REGION OF GANYMEDE: TECHNIQUES TO INVESTIGATE ORIENTATION AND SPACING OF GROOVES. Harald Hiesinger1, J.G. Patel1, J.W. Head III2, B. Giese1, R.T. Pappalardo3, and the Galileo Imaging Team. Department of Geological Sciences, Brown University, Providence, RI 02912, USA; 3DLR-Institute of Planetary Exploration, Berlin, Germany. Harald.Hiesinger@dlr.de

Introduction: The surface of the Galilean satellite Ganymede has been imaged by the two Voyager spacecraft and more recently by the Galileo mission. Uruk Sulcus, one of the bright regions of grooved terrain which is centered near 160°W and 5°N, separates two darker regions, Marius Regio and Galileo Regio, and was imaged at high resolutions by the Galileo spacecraft during its G1 and G2 encounters in 1996. Here we present results of our investigation of the orientations of grooves for the geological units identified in the investigated area and results of our Fourier analysis, as well as topographic profiles across a digital elevation model of a part of Uruk Sulcus.

Approach and description of the data base: The goal of our investigation is to compare different analytical techniques to describe the tectonics of grooved terrain. For this purpose we compare results of one-dimensional Fourier analysis, which provides the spacing of grooves, with the results obtained from our digital elevation model (DEM) and Voyager-based photoclinometric analysis [1]. We also compare results of two-dimensional Fourier analysis, which gives us the orientation of grooves, with results of rose diagrams for groove orientations which we performed for each unit. For our investigation we made use of the data obtained at the first two encounters of the Galileo spacecraft with Ganymede in 1996. The spatial resolution of the G1 Uruk Sulcus images is 75 m/pixel and 40 m/pixel for the G2 images. For the Fourier analysis, and the measurements of groove orientations, all images have been radiometrically corrected and map-projected. The image processing for the digital elevation model has been described elsewhere [2]. For our Fourier analysis, we assume that brightness variations approximately correlate to topography as has been shown by [3].

Results from rose diagrams: We digitized grooves for units which are comparable to the units described by [4] and plotted rose diagrams for each of them, respectively. From our study we learned that most of the units exhibit a clear preference for only one dominant orientation of the grooves. However, secondary orientations oblique to the dominant orientation occur in several units, such as CRT1, CRT2, EERT, PLT2, PMRT1, and ST3. In unit PMRT2 and ST3 we also observed secondary orientations which are orthogonal to the dominant orientation, respectively. Unit PLT3 does not show any preferred orientation, here it seems that 3 orientations are equally dominant. We also see that the dominant orientations of the grooves are not evenly distributed in the rose diagrams, but concentrate at about 0°, 45°, 90°, and 135°. For unit EERT we found that the orientation of the grooves is not exactly parallel to the borders of the unit but rotated slightly clockwise. We conclude that dextral shear was active after the formation of the grooves which is in agreement with the structural interpretation of [7].

Results from Fourier analysis: Preliminary results on the spacing of grooves in Uruk Sulcus have been presented by [5]. We performed several one-dimensional Fourier analysis profiles perpendicular to the groove orientation. From these profiles we see that the spacing of the grooves vary between approximately 0.8 km and 6 km, depending on the unit. A more detailed investigation of dominant wavelength information from Fourier analysis is given by [6]. From Fig. 1b and 1c it can be seen that results of one-dimensional Fourier analysis are in excellent agreement with the results derived from the DEM. For the profile on the G2 image as given in Fig. 1a, both techniques provide a short wavelength spacing of 1.6 km and a long wavelength spacing of 3.5 km and 3.6 km, respectively. As shown in Fig. 1d and 1e, two-dimensional Fourier analysis gives us the orientations of grooves in the investigated units and these results agree well with our rose diagrams. This demonstrates that two-dimensional Fourier analysis enables us to easily obtain orientation information for different areas of grooved terrain.

Results from digital elevation models: For the calculation of our digital elevation model we used two G1 images (s0349758939, s0349758978) and two G2 images (s0359945600, s0359945613). In the area covered by our DEM, which has already been presented by [2], we found differences in height of more than 1 km. The lowest point is located at the northern border of the DEM and lies 915 m below the reference. The highest area which is 272 m above the reference can be seen near the southern edge of our DEM. The DEM shows several large ridges which are separated by grooves which are several hundred meters deep. Due to the technique of DEM generation, the spatial resolution of the topography data is resampled to 200 m/pixel compared to the original images. Unfortunately only longwave structures can be identified in the DEM because the spatial resolution of our DEM is not sufficiently high enough to reveal the finer structure of the terrain as it can be observed in the Fourier analysis. According to our DEM the spacing of large-scale grooves in Uruk Sulcus is about 2-6 km [2]. These results are consistent with photoclinometric analysis of Voyager images performed by [1]. On the other hand DEMs have the advantage in that they provide quantitative as well as qualitative descriptions of surface features such as slopes and shapes of grooves. Preliminary morphologic descriptions of grooves have been presented by [2] and [7].

Conclusions: We find one-dimensional Fourier analysis and DEM to provide remarkably consistent results for the spacing of grooves in Uruk Sulcus. Compared to the DEM, one-dimensional Fourier analysis is able to detect both the short wavelength spacing of grooves as well as the long wavelength spacing. On the other hand, the DEM also gives additional information about the slope and morphology of the ridges. As [6] shows, one-dimensional Fourier analysis can reveal dominant wavelength trends not obvious in the image. Furthermore, Fourier analysis requires no stereo coverage and can be applied to a single image, thus enlarging the area for
which we can investigate the spacing and orientation of grooves directly. However, less dominant orientations are easier to pick out from rose diagrams rather than two-dimensional Fourier analysis. From our investigation, we conclude that Fourier analysis is a fast and powerful tool in order to describe the spacing and orientation of grooved terrain. The calculation of a DEM as well as the representation of grooves in rose diagrams is much more time consuming but can reveal additional information. Therefore all three methods can be used in a complementary way in order to completely describe the observed surface features.

Fig. 1: Comparison of results obtained by two-dimensional Fourier analysis (b) and a rose diagram of PRT2, a selected area of Uruk Sulcus (c) and comparison of results from one-dimensional Fourier analysis (d) and a digital elevation model (e) show excellent agreement. The image shows G1 and G2 coverage superimposed on Voyager imaging data (a). The white square represents the area for the two-dimensional Fourier analysis, and the black line shows the position of the DEM and the one-dimensional Fourier analysis profiles.