DUST FROM PLANET FORMATION IN DEBRIS DISKS: A COMPARISON WITH PLANETARY MATERIALS. A. Morlok[1,2,3], M. Anand[3], C.M. Lisse[4], A.B.Mason[5], E.S. Bullock[6], M. M. Grady[2,3]. [1]Department of Mineralogy, The Natural History Museum, Cromwell Road, London SW7 5BD, UK (morlokan@uni-muenster.de), [2]Institut für Planetologie, Wilhelm-Klemm-Strasse 10, 48149 Münster, Germany, [3]Department of Physical Sciences, The Open University, Walton Hall, MK7 6AA Milton Keynes, UK, [4]Johns Hopkins University-APL, 11100 Johns Hopkins Road, Laurel, MD 20723, USA, [5]Finnish Centre for Astronomy with ESO (FINCA), University of Turku, Tuorla Observatory, Väisäläntie 20, FI-21500 PIIKKIÖ, Finland, [6]National Museum of Natural History, Smithsonian Institution, Washington, D.C, 20560 USA.

Introduction: Similar to our own Earth, exoplanets form in a circumstellar gas and dust disk around a young star. After a short transitional stage, the debris disk follows after < 10 Myr. At this stage, already-formed bodies grow by collision with other bodies and accrete into larger planetesimals, and finally planets. Evidence for such events such as giant collisions during planetary growth in our Solar System include the formation of the Moon after collision of proto-Earth with another planetary body [1]. Astronomical infrared spectra of the dust produced in such processes provide mineralogical information about the bodies involved [e.g. 2].

For the identification of mineral phases in the observed dust, we need laboratory absorption infrared data for comparison. A number of absorbance/transmission studies have been carried out on specific minerals in recent years [e.g. 3,4]. Transmission/absorption studies of bulk planetary materials were made by [5-11]. Studies with the specific aim of using differentiated solar system materials in order to characterize these exoplanets in debris disks have been rare [11-14].

The aims of this study are: (a) to present mid-infrared dust absorbance spectra for a representative suite of rocks from highly differentiated, terrestrial-type planetary bodies; (b) to identify spectral features characteristic for such materials that allow the identification in astronomical infrared observations; (c) compare the spectra with astronomical observations of dust in debris disks.

Sample Selection and Techniques: We selected typical crustal (e.g. granite, basalt) and mantle rocks (e.g. peridotite) as representatives for Earth. This includes impact glasses as analogues for molten crustal materials (tektites). Furthermore, we also used samples of the whole range of Martian meteorites (Shergottites, Nakhlites and Chassigny). The rocks samples analysed in this study are from the collections of the Natural History Museum in London. Additional data (obsidian, SiO_2 glass) were provided by [4].

We mixed 2-3 mg of powdered sample with 300 mg of powdered KBr. The mixture was ground in an agate mortar, and afterwards pressed in an evacuated pellet press into a pellet at 10 tons/cm^2. To avoid water bands due to absorbed water, the pellets were dried in an oven at 100 °C for three days.

The analyses were carried out at the Natural History Museum in London, using a Perkin Elmer Spectrum One workbench. A spectrum from each pellet was obtained from 2.5 to 40 µm, with a spectral resolution of 4 cm^{-1}, adding 50 scans for each sample. The results are presented in terms of absorbance (A) and normalized to the same intensity (Fig.1).

Results: Most astronomical spectra of debris disks can be divided into two groups based on their characteristic mid-infrared features.

Group A (Fig.1) has a strong band between 9.0-9.3 µm and another between 18-21 µm. For example, dust in the inner system of ~100 Ma old F6V star HD23514 [15] shows similarity to the features of SiO_2-rich crustal materials such as tektites or obsidian. Also, heavily shocked Martian meteorite Los Angeles and mesosiderites [11], samples from impact or collisional events, show similarity in band positions to this group. In an earlier study, one of the systems in group A, debris disk HD172555, was identified to probably have produced SiO_2-rich melt and gas in a collision [13].

Group B (Fig.1) is characterized by two strong bands at ~ 10 and ~ 11 µm with varying intensity. Further bands are at ~ 19 µm, ~ 16 µm and ~ 23 µm. These are the features of olivine-rich dust [16,17]. Examples are the 100 Ma old F9 system P1121 [18] and 3-10 Gyr old K0V system HD69830 [2].

The olivine-rich chassigny Martian meteorite and terrestrial mantle materials — especially the features of dunites and harzburgites at ~ 10.2 µm and ~ 11.3 µm bands, and the strong band in the 23 - 24 µm area — are similar.

Dust in debris disks of this group already have been shown to be similar to differentiated bodies e.g. ureilites [12,14]. However, the olivine-rich composition of group B member HD 69830 for example, has also been shown to be similar to carbonaceous chondrite materials [2].

Discussion: Comparisons of band positions indicate a similarity between differentiated planetary materials from terrestrial bodies and dust in many debris disks. However, in the interpretation of the results, the actual processes which form the dust debris have to be taken into account.

In most cases, we expect mixing of both bodies (projectile and target). Only tidal disruption of a projectile [19,20] or ejecta from a large planetary impact [21] can produce dust material with a composition based predominantly on the projectile.

Material of group A could be explained by grazing-type collisons [19] in hit-and-run encounters, or large planetary impacts [21]. This could procuce dust with a high 'crustal' component.The olivine-rich dust of group B could confirm the 'lost mantle' hypothesis about the loss of the olivine-rich crust and mantle of most planetesimals in collisions and impacts in the early Solar System [22].In the presentation, we will investigate the various models for collisions [e.g. 19, 20] between planetesimals and proto-planets and how they could help to interpret the dust compositions in debris disks.

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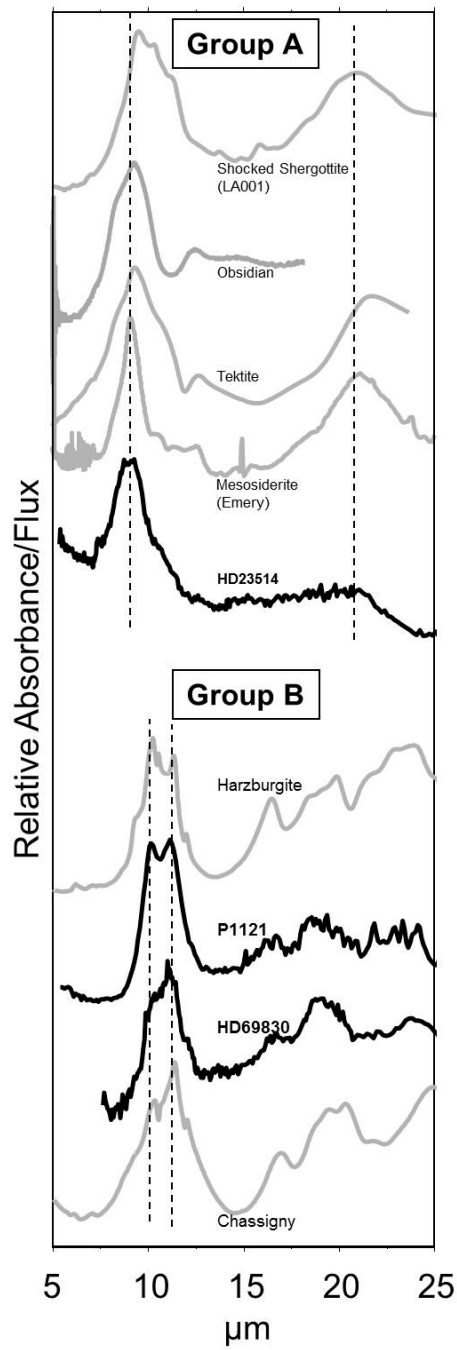

Figure 1: Examples of laboratory spectra and astronomical spectra of group A, with a characteristic feature between 9.0 and 9.3 µm, and group B with characteristic bands at ~10 and ~11 µm. In Absorbance (laboratory spectra) or Flux (astronomical spectra).