Assessing different remote sensing techniques for geological mapping in complex impact structures, an example from the Central Rand Group in the Vredefort impact structure. Ch. Mielke[1], U. Riller[2], W.U. Reimold[1], [1]Museum of Natural History, Humboldt-University Berlin, Invalidenstrasse 43, 10115 Berlin, Germany (e-mail: christian.mielke@alice-dsl.de); [2]McMaster University, School of Geography and Earth Sciences, 1280 Main Street West, Hamilton, Ontario, Canada.

Introduction: Remote sensing is a powerful tool for mapping large-scale geological structures such as the Vredefort impact structure. High resolution data sets, such as Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), provide the opportunity to obtain multiple geological and morphological data to assess structure and lithology at various scales. This is demonstrated for a segment of the Central Rand Group from the so-called collar of the Vredefort Dome, the relic of the central uplift of the Vredefort impact structure [Fig. 1].

Fieldwork and remote sensing analysis: For the remote sensing part of our project, we used data from the ASTER sensor, Landsat 7, Shuttle Radar Topography Mission (SRTM), as well as anaglyphs from scanned stereopairs. Lithological and structural information inferred from remote sensing was checked by field geological mapping. Classification of different surface materials revealed that the spectral differences between the lithological units are relatively small in the available data sets. Therefore, it was necessary to also take morphological criteria [1, 2] into account, in order to identify different lithologies with remote sensing techniques.

Geological fieldwork and remote sensing analysis of fault traces revealed a major NW-SE strike trend of first-order faults in the study area [Fig. 2, 3]. However, two second-order trends, i.e., WNW-ESE and NNW-SSE, are also apparent in the data set. Although only few lineament trends deviate from the master trend, a complex fracture system that is perpendicular to the stratification of the collar rocks was identified by field geological mapping. This fracture system is interpreted as an interference pattern of impact-generated and non-impact related fractures.

Based on the definition by [1] and [2], two other lithologic units, the Johannesburg 1 and Turffontein 2 units, were found to be topographically "roughest" in the collar rocks. By contrast, the Johannesburg 2 unit is much smoother than the adjacent Johannesburg 1 and the Turffontein 1 units. Similarly, the Turffontein 2 unit is rougher than the Turffontein 3-5 units. This signal is caused by differences in mineralogical composition. In particular, quartzite beds and sandstones that are more resistant to erosion form topographic ridges, in contrast to argillaceous sandstones and conglomerate reefs that mark topographic depressions and are generally covered by often dense vegetation.

Since all of the exposed rock units are largely made up of quartz, it is almost impossible to distinguish them by spectral analysis. Moreover, various iron oxide crusts are often found within the same unit. Thus, compositionally similar rock units can only be mapped by textural analysis, i.e., occurrence and co-occurrence of filtering. However, following such data manipulation, manual data interpretation is needed to differentiate between different quartzite lithologies.

Conclusions: Our work shows that remote sensing techniques are very useful for geological mapping and structural interpretation in geological terrains, such as complex impact structures. However, different surface conditions, such as vegetation, agricultural activity and weathering crust, collectively, may mask the geological and structural signals. Thus, it is necessary to check the applicability of individual remote sensing tools carefully before interpreting such data in terms of lithology and structure. Finally, the scale of different structures should also be taken into consideration if work is carried out with data sets of variable spatial resolution.

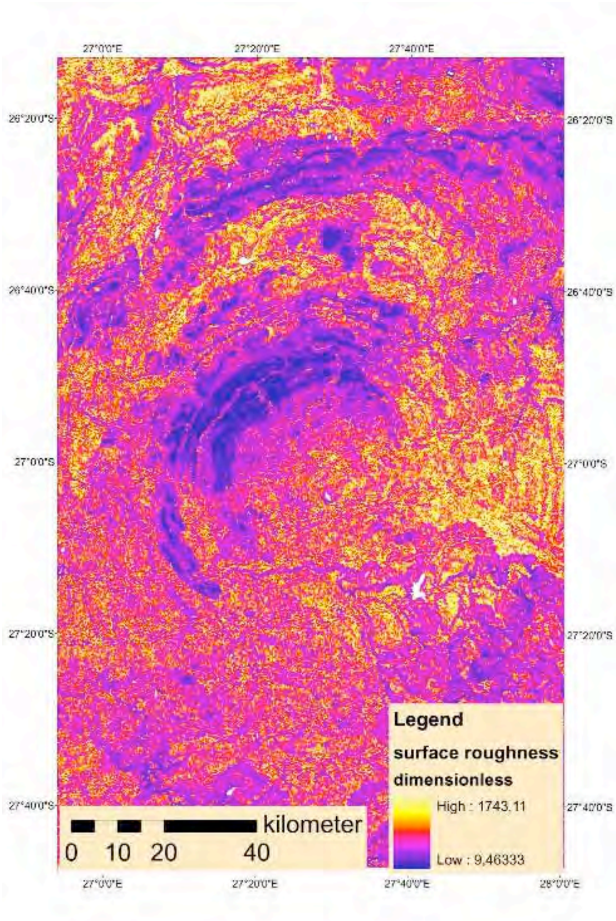

Fig. 1: Image of the Vredefort impact structure showing surface roughness inferred from SRTM data.

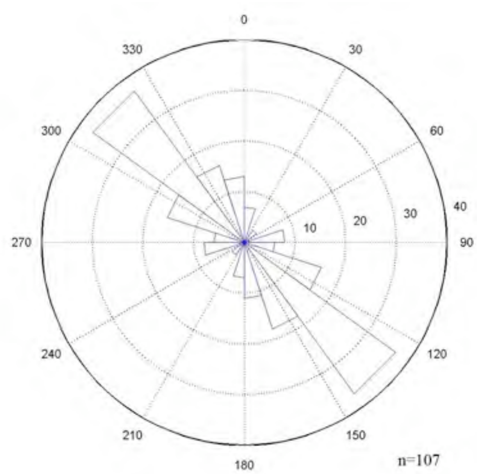

Fig. 2: Diagram showing traces of faults inferred from air photos.

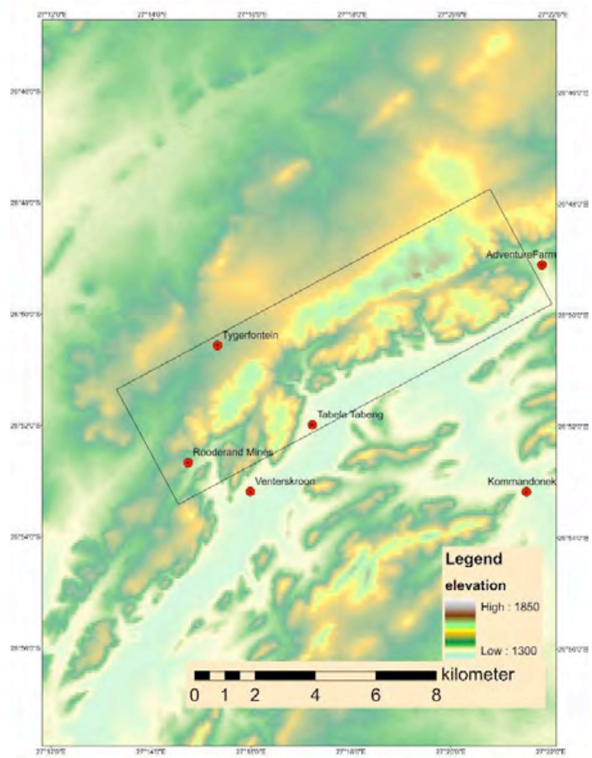

Fig. 3: SRTM relief showing the study area (rectangular box).

References:
[1] Grohmann C. H. et al., 2007, Comp. & Geosci., 33, 10-19; [2] Formento-Trigilio, M.L. and Pazzaglia, F.J., 1998, J. Geol., 106, 433-453.