
Terrestrial impact craters are the only varieties for which detailed ground-truth data are available (i.e., geophysics, geochemistry, drilling) [1]. Because of the efficacy of terrestrial erosion processes as well as the dynamics of Earth tectonism, many terrestrial impact craters expose deep interior structures which result in surface expression of highly shocked and shock-melted materials. In spite of the wealth of field data available for many of the most significant impact events in recent Earth history, little if any attention has been given to the application of state-of-the-art remote sensing techniques to study of these landforms. This is in contrast to the major advances in cratering accomplished by means of remote sensing of impact features on the Moon, Mars, Mercury, and Venus [2]. The aim of this report is to summarize preliminary results of multispectral and radar imaging studies of a set of terrestrial impact craters which span the range of morphologies and levels of degradation currently recognized on Earth. Included in this study are analyses of Landsat Thematic Mapper (TM) and SPOT Multispectral (XS) data for Meteor Crater (AZ), Zhamanshin (USSR), Bosumtwi (Ghana), Goat Paddock (Australia), Gosses Bluff (Australia), Elgygytgyn (USSR), Bigatch (USSR), Ries (FRG), Tin Bider (Algeria), Wanapitei (Canada), Roter Kamm (Namibia), and a suspected impact landmark in NW Saudi Arabia (Al Madafi). Quaternary structures such as Meteor, Zhamanshin, and Bosumtwi, as well as Australian features are the focus of this report. In addition, an analysis of the suspected Al Madafi structure in comparison with known craters of an equivalent size (e.g. Goat Paddock and Tin Bider) is presented. The final outcome of this continuing study will be relevant to future multispectral imaging data analysis of fresh craters on Mars and the Moon.

Our approach has been to use various image analysis techniques to identify spectral disruption patterns possibly associated with surficial impactites. For several of our study sites (e.g. Meteor, Zhamanshin, and Gosses Bluff), detailed maps of the spatial distribution of impact-related materials (allogenic breccias, melt, suevite, ejecta) are available and have been used to evaluate the identified anomaly regions. Both principal components deconvolution (PC) and hue-intensity-saturation (HIS) algorithms have been used in our analysis [3,4]. In addition, color composite band ratio images (in particular a TM combination of (3/2,5/7,3/7) as RGB) have been constructed to discriminate possible impact melt or suevite deposits in arid regions.

For Meteor Crater, the band ratio image (3/2,5/7,3/7 as RGB) indicates a “unit” which strongly correlates with the mapped distribution of shocked Coconino sandstone and allogenic breccias [5]. The PC images (PC1,2,3 as RGB) also yield spatial patterns which correlate well with the exposed part of the Kaibab ejecta. Analysis is underway of a thermal IR imaging dataset for Meteor Crater acquired in Sept. 1987 by the TIMS instrument; parallel laboratory spectral reflectance studies in the 8-12 um region indicate a total loss of the ~8.6 um quartz restrahlen feature in shocked Coconino sandstone [6]. Analysis of thermal IR imaging data for surficial sandstone breccias at Gosses Bluff using a GEOSCAN airborne scanner dataset allows mapping of these deposits on the basis of the intensity of the 8.5 um band.

Analysis of Landsat TM band ratio and PC images of Zhamanshin crater have demonstrated that there is an extremely high correlation between spectrally anomalous regions and the well-exposed allogenic breccias which cap the small hills that define the inner ring of the structure. In fact, detailed mapping of Zhamanshin from the enhanced TM images corroborates the existence of breccia deposits as far as 13 km for the crater center, which lends additional credence to recent work by Feldman et al. [7] that suggests Zhamanshin has an outer ring diameter of ~13.5 km and an offset inner ring due to the effects of oblique impact. Figure 1 is an enhanced TM image which illustrates the "butterfly"-like pattern of impactites which define the outer annulus of
Zhamanshin; the isolated dark regions within the butterfly are the allogenic breccia hills. Impactites such as these have also been identified from TM images at Goat Paddock and Gosses Bluff. Comparison of the spectral patterns observed from TM data for Goat Paddock with those at the suspected AL Madafi ring (NW Saudi Arabia) suggests that the Saudi Arabian feature is most consistent with an impact origin; it may represent the deeply eroded inner ring structure of a Mesozoic-age impact crater larger than 10 km diameter. The empirical analyses summarized above are continuing in conjunction with laboratory spectral reflectance studies. Attention to GEOSCAN airborne scanner data for well-exposed Australian impact features as well as to TIMS data to be collected for an Australian crater will be the near-term focus of this effort. (We gratefully acknowledge the support of NASA/Goddard DDF grant 88-4 which was made possible by G. Soffen and J. Townsend; the assistance of J. Warner, C. Evans, M. Emmons, and the encouragement of L. Stuart are also appreciated).


Fig. 1: Edge enhanced TM (bands 3,5,4 as RGB) image of the entire Zhamanshin structure; the original color-composite was converted to B&W for display here. The scene is 20 km by 20 km in dimensions. Observe the 5 "flower-petals" of dark impactites which define the outer annulus of the crater. Dark "blobs" represent breccias which cap inner ring hills.