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Geologic Application of thermal-inertia mapping from satellite

Type II Progesss Report
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Prepared for:
Goddard Space Flight Center
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A. Problems

The major problem is lack of adequate U2 and HCMM data. We have received predawn thermal U2 data over our Arizona site; however, Goddard is not able to process the corresponding daytime data. The HCMR malfunctioned on the U2 flights over our Wyoming site last August and had not been repaired in time for our field mission there in October. Therefore, we have no U2 data to work with from either site.

HCMM screening prints and transparencies have been received for four different days - two covering each site. On both sets of Wyoming data, clouds were present over most the site, and the data are not acceptable for thermal-inertia mapping. We have received good daytime visible data (CCT) over the Arizona site but the companion thermal data were garbled. Also received was a day visible transparency over Arizona of good quality.

B. Accomplishments

Approximately 400 miles of low altitude scanner data were acquired over the Powder River Basin between October 13-16. The areas covered were identical to those acquired last July. The Basin was reflown because the July data had noise problems and marginal weather conditions. The noise problems had been identified and corrected for the October flying. The weather conditons in October were ideal - clear and stable - for our aircraft flying; however, mostly cloudy conditions existed for the two HCMM overpasses bounding either side of our data acquisition days. The screening film from our RS-14 scanner indicates good data were acquired on all our aircraft flights.

An additional experiment to the normal data acquisitions was devised for looking at the sky radiance with the aircraft scanner on the

ground. An optical arrangement was designed to measure the radiation sky flux in the 7.9 to 12.5 μm region before and after every flight. These data will provide information on the magnitude and diurnal variation of sky radiation to make an emissivity correction.

The ground stations established in July were re-established for our October mission. Prior to the mission several days of July data from all three stations were examined. This data set indicated that information from the three stations correlated very closely and, therefore, could be considered as representative of the regional meteorological and radiometric conditions. The data acquired at the ground stations in October appear to be of good quality.

All of the meteorological and radiometric data from the July mission have been digitized. The radiometric data have been inputed into the computer and screening plots have been made. The meteorological data are ready for plotting. This July data set will be published as a U.S.G.S. open file report.

Good quality analog film prints have been made of the the thermal images from the Wyoming mission. These are now being closely examined to determine which scenes will be processed for thermal-intertia mapping.

Watson's linear Fourier series thermal model was extensively revised to a standardized Fortran format. The model will be made available to other users as an NTIS report.

The objectives planned for the next quarter include reducing the ground station data and preparation of special product images. The July and October data sets will both be processed as open file reports. Selected data from the October mission will be processed to produce

thermal-inertia and heat-flux images. As suitable HCMM products are made available, they will be included with this analysis.

C. Significant Results

The significant results from this reporting period are:

- Acquired approximately 400 miles of low altitude scanner data of good quality over the Powder River Basin between October 13-16, 1978.
- Acquired radeometiric and meteorological data from three ground stations in support of low altitude U.S.G.S. overflights.

For details of these results, see the accomplishments section.

D. Publications and Presentations

A comprehensive summary was submitted for the geology and mineral resources poster session at the Thirteenth International Symposium on Remote Sensing of Environment. The summary is titled "The use of thermal data to extend geologic reconnaissance from satellites" by Susanne H. Miller and Kenneth Watson. A copy of the summary is submitted with this report.

E. Recommendations

As of this date we have not received usable thermal CCT's (day or nite) of either of our two sites. We therefore recommend that at least film products of all thermal data of our sites be made available rapidly in order to plan the remainder of our investigation.

F. Funds Expended

Total expenditures to date: $60,180

G. Data Utility

No usable U2 data have been received. Most of the HCMM data

received has been cloud-covered and not suitable for analysis. No CCT's have been received of our test areas which contain thermal data. See problem section.

H. Erratum

On page 3 of the June-August quarterly report, it was erroneously stated that "the proportional fit will be satisfactory where low thermal-inertia differences are present." This should read "...where high thermal-inertia differences are present."

The use of thermal data to extend geologic reconnaissance from satellites

by

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Comprehensive Summary

Landsat multispectral data have become useful reconnaissance tools in mineral and energy resource evaluations and environmental studies. Now, the Heat Capacity Mapping Mission (HCMM) satellite has made thermal infrared information available to improve and extend these surveys. The purpose of our HCMM study is to develop and evaluate the use of thermal-inertia and heat-flux mapping techniques in areas of known and potential mineral and energy resources.

The two study areas selected were the Powder River Basin and environs in eastern Wyoming and the Cabeza Prieta Range in southwest Arizona. The Powder River Basin is the site of major uranium and petroleum exploration, and the Cabeza Prieta area is currently undergoing mineral resource appraisal. The specific geologic problems we proposed to examine were detection of mineralization, underground coal fires and the surface expressions of sedimentary facies changes, using thermal-inertia and heat-flux mapping techniques. The resulting image products should permit extrapolation from known areas to large regions that are less well explored.

In addition to the HCMM and Landsat satellite data, U.S. Geological

Survey multispectral aircraft data have been acquired from critical areas over both sites, and ground calibration data were gathered from three widely spaced stations in the Powder River Basin to characterize the regional meteorological and radiometric conditions. These data were necessary to calibrate the aircraft thermal-inertia and heat-flux images, and to evaluate the validity of extrapolations to the regional satellite information. Other data available to correlate with the thermal-inertia products included: (1) a sand/shale ratio map of the southern part of the Powder River Basin measured from hundreds of exploration drill-hole geophysical logs, (2) Landsat multispectral images of the Basin, specially processed to display vegetation density variations that reflect differences in the underlying sedimentary facies, and (3) multichannel gamma ray data of the eastern part of the Basin.

An important part of our investigation is a thermal-inertia model development and evaluation study. Thermal-inertia values can be determined on site by measuring the diurnal variation of surface temperature in response to the known driving functions of the solar and atmospheric fluxes. Because thermal data from satellite and aircraft are required only at discrete times in the diurnal cycle, a mathematical model is needed to relate the measurements to thermal inertia and to determine appropriate observation times. Our model assumed that the fluxes which determine the surface temperature are solar, atmospheric, ground emission, and ground conductive. In addition, the model was modified to include effects due to transient fluxes such as changing atmospheric conditions and implusive heating and cooling. Techniques for correcting topography were investigated as well as determining albedo from the single broadband Heat Capacity Mapping

Radiometer (HCMR) channel and from multiband measurements from aircraft and Landsat.

The application and limitations of using satellite and aircraft remotely sensed data for geologic reconnaissance were the subject of our investigation. The inclusion of a thermal channel on satellite payloads should also permit upgrading of some existing geologic maps, particularly in remote or poorly accessible parts of the world. As the resolutions of satellite scanners improve, small-scale thermal-inertia mapping will become a more valuable tool in mineral and energy resource evaluation.