GEOLOGIC UTILITY OF IMPROVED ORBITAL MEASUREMENTS

A. R. Gillespie
Jet Propulsion Laboratory

From a geologist's viewpoint, the most important use of orbital cameras is probably to provide spatial or contextual information in remote areas. This information may be extracted even from broad-band, single-channel images ... provided that the spatial resolution is adequate for the problem at hand. Presently most of the globe has been recorded at 80 m/pixel (Landsat MSS); which is roughly equivalent to a scale of 1:125,000. This is clearly inadequate for some purposes; for example, Holocene or late Quaternary tectonic studies require the identification and measurement of fault-offset features as small as 10 m, or even less. In a recent study of the Red River Fault in southern China the Landsat MSS images were sufficient to locate the main trace of the strike-slip fault, to identify its sense of displacement, and even to measure its cumulative late Cenozoic offset (5-6 km). Using Landsat RBV and SIR-A (shuttle radar) images, with twice the resolution, it was possible to recognize that a minor trace of the fault, inconspicuous on the MSS data, was the one on which recent offset had occurred, and was the one which was seismically dangerous. Using 1:50,000 BW aerial photographs, (~ 2 m resolution) geomorphic features on this new fault were obvious--but even at this scale the smaller features (e.g., inflections in ravine walls) necessary to establish the level of activity were inconspicuous. Thus an increase of resolution of as much as two orders of magnitude could be used in tectonically active areas of the world--especially in China and Russia, where conventional aerial photographs are difficult to obtain.

The second most useful kind of information is topographic, usually provided by stereoscopic images. Most present-day orbital systems do not produce such data, but where stereo images are available they have proven valuable--even with the small base/height ratios of Landsat. Any future satellite system designed to satisfy general geologic requirements must be able to produce stereo images, preferably with large base/height ratios of 0.5 or more.

Stereoscopic images are sufficient for most geologic applications involving only photo-interpretation, but the geometry may not be adequately controlled for geodetic measurements without auxiliary information. During the design of Stereosat it was recognized that although subtle topographic relief could be detected during visual inspection of stereo pictures, it was difficult to measure (resolve). Thus an instrument such as a scanning laser ranger, which would permit accurate and precise measurements at elevations, would have considerable application to geologic studies. Of particular interest in remote sensing would be precise topographic slope information, necessary for the reduction of thermal images and for the removal of photometric effects from all images.

The Landsat program was designed to give periodic coverage of the same scenes at the same local time. This is advantageous for agricultural studies, but not for most geologic studies. For geologic purposes it would be useful to have coverage at different illumination geometries instead. Low sun angles are advantageous in regions of low relief where topography must be accentuated; high sun angles are desirable in areas of high relief or when multispectral data are to be collected. Thus for geologic studies, a different polar orbit than that of Landsat might be appropriate.

One of the main benefits of the remote sensing program to date has been the extended spectral sensitivity of electronic scanners. For geologists, this is important because it allows inferences of the composition of rocks in the scene to be drawn from the data directly, rather than from contextual clues. The current crop of sensors provides more channels and narrower spectral windows than those of the previous decade, and this welcome trend is likely to continue. Narrow-band sensors at 2.2 μm and multi-channel thermal scanners seem to be the most interesting at the moment. The former permit the recognition and distinction of different clays--an ability required in mineral exploration, but one which may also prove valuable in the relative dating of late Quaternary sediments. Multi-channel thermal images have been used to construct maps showing relative concentrations of silica at Tintic, Utah. This permits remote sensing to be used in the mapping of sedimentary facies as well as compositional variation in plutons, and may mark the advent of a new era of sophistication in geologic applications of remote sensing.

The need for data of high spatial and spectral resolution places a severe burden on the design and operation of the satellite. There are probably two useful approaches: (1) to fly numerous small, inexpensive, instruments designed for different special purposes; and (2) to fly a single complex instrument which may be programmed to select appropriate spectral channels and spatial characteristics. Such a flexible system could entail on-board data processing to minimize the transmission of unneeded data.