Selected Comparisons of Aircraft-Borne and Orbital Imaging Radar Data and their Geologic Significance

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Editor's Note: Dr. Feder has been fascinated by the use of radar from his days as an officer in the Navy, and is considered the father of radar geology, having played an important role in the development of radar as an exploration tool. He is one of the principal scientists in his company, Aero Service Division of Western Geophysical Company of America, 8100 West Park Drive, Houston, Texas 77063.

INTRODUCTION

Some geologists, who would never think of equating Landsat imagery with aerial photography, might tend to make a “one for one” comparison of aircraft-borne and orbital radar terrain imagery. Such an equating is not justified. Two distinct types of remote sensing systems are involved. Their prime connection is that both system types employ radar principles and electronics. We will first briefly examine this commonality and its significance to us, as geologists.

Background of Radar Geology

Radar, the acronym for radio detection and ranging, was first demonstrated in the 1930’s, and underwent explosive development during World War II. Its first known employment for distinctly nonmilitary and nonnavigation purposes took place in 1950-51 (Aeronautical Chart and Information Center, 1951). One of the first appreciations of radar’s potential for geologic purposes is believed to date from early 1957 (Feder, 1957), with pioneering research being performed shortly thereafter (Feder, 1960; Scheps, 1962).

Possibly the first use of the term “radar geology” and a description of that technology took place in 1957 (Feder, 1957). The description included, of course, radar’s capacity for imaging through cloud cover and around the clock, but concentrated on radar imagery lending itself to structural mapping with great facility, and an ability to provide selected indications of terrain composition and condition. Let’s look at some of these attributes in terms of radar performance.

Radar Geology Principles

Radar is analogous to holding a flashlight over your right shoulder and illuminating an object held at arm’s length in your left hand. If the object is a mirror, it will be a specular reflector. That is, when held horizontally, the mirror will reflect the energy away from you. As you progressively tilt the mirror to vertical, it will progressively reflect more energy back to you. The mirror contrasts with a piece of crumbled tissue, a diffuse reflector, which will return a large amount of energy to you regardless of the illuminating geometry. It is the comparison of diffuse and specular reflectors of broadcast radar energy, for given aspects, that permits us to interpret their nature.

Figure 1 is an X-band (3 cm wavelength) synthetic aperture radar image of an arid environment in Arizona. The radar, responding to surface cover texture and geometry, shows brightest return signals from the bare rock mountain peaks and talus. The return signals decrease progressively downslope, through the bajada slopes, and on into the Bolson plains, with their possible playa features, which are totally specular. That is, they reflect the illuminating energy away from, rather than back to the receiver. These “dark” signals are from the finest materials in the area, probably clays and silts.

In the Bolson plain are seen stringers of bright signals. These are probably from coarse sands and gravels and represent the braided courses of the highest velocity streams entering the area.

Thus, radar in this sense is useful in exploring for