Radiometric Studies, Bay of Fundy*

JOHN F. CRONIN
Air Force Cambridge Research Laboratories, Bedford, Massachusetts

Introduction

The absorption, reflection, and polarization of solar, sky and terrestrial radiation by a lithospheric surface through a planetary atmosphere is a complex, wavelength-dependent process. On earth the lithospheric surface is a nonhomogeneous reflector of radiation whose mineralogical and petrologic components, altered and unaltered, demonstrate a wide range of spectral characteristics. To gain some insight into these interrelated optical properties of lithosphere and atmosphere, a variety of geologic sites in a variety of atmospheric environments have been chosen for detailed field radiometric studies.

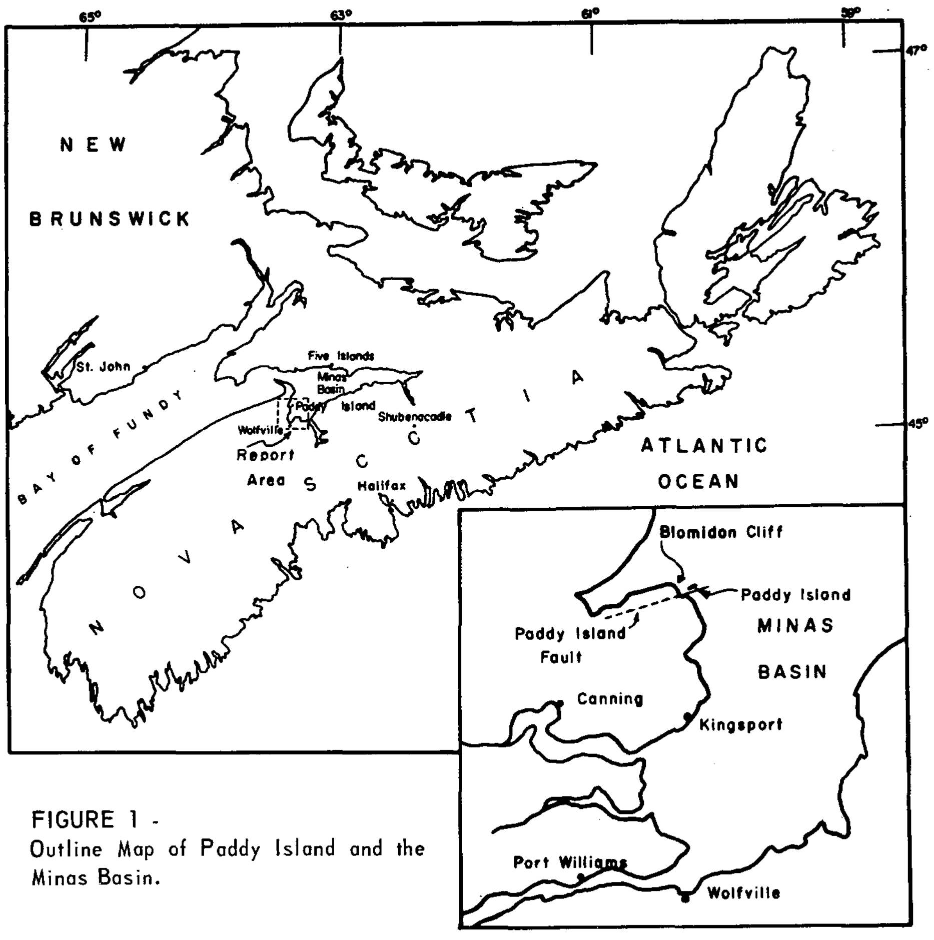

FIGURE 1 - Outline Map of Paddy Island and the Minas Basin.

At the suggestion of the late Prof. H. L. Cameron of Acadia University we were led to perform our first experiment along the shore of Minas Basin, just north of Kingsport, Nova Scotia, at a spot called Paddy Island (Fig. 1). It was a fortuitous choice largely due to Prof. Cameron's understanding of our goals and his pioneering interest in the application of remote sensor techniques to geology and the terrestrial sciences.

Initial efforts at Paddy Island were limited to the measurement of reflection and polarization, and to the spectrophotography of variegated Triassic sedimentary beds using rather elementary spectral photometric and photographic methods. By means of selected narrow-band filters and films the photographic spectrum was separated into discrete and contiguous bandwidths of wavelength.

* Manuscript received February 16, 1970.

Site

Paddy Island is a small erosional stack about 500 feet offshore. At low tide the island is completely exposed, and at high tide about half submerged. Each end is capped by a knob of resistant red beds.

One of the reasons the site is of interest is that two generally similar yet distinguishable sedimentary suites are exposed in the same environmental setting. Both suites consist of red-bed units of the Fundy group of the Triassic. The underlying beds are of the Wolfville formation and the upper beds of the Blomidon; both are of continental origin. Geological interpretation of the area was taken largely from a paper by Klein (1962). Prof. George D. Brown, Jr. and Dennis W. O'Leary of Boston College, Chestnut Hill, Massachusetts provided local descriptions and columnar sections.

Method

To measure the radiometric properties of the Paddy Island exposures, a Pritchard photometer with an S-11 photocathode photomultiplier tube was employed. The spectrum of the photometer extended from 4000-6600 Å and was divided, by the choice of filters, into five contiguous bandwidths. Interchangeable horizontal and vertical polarizers were inserted at one bandwidth only. Spectrophotography of the site was made at bandwidths which were, with one exception, comparable to those of the photometer (Fig. 2).

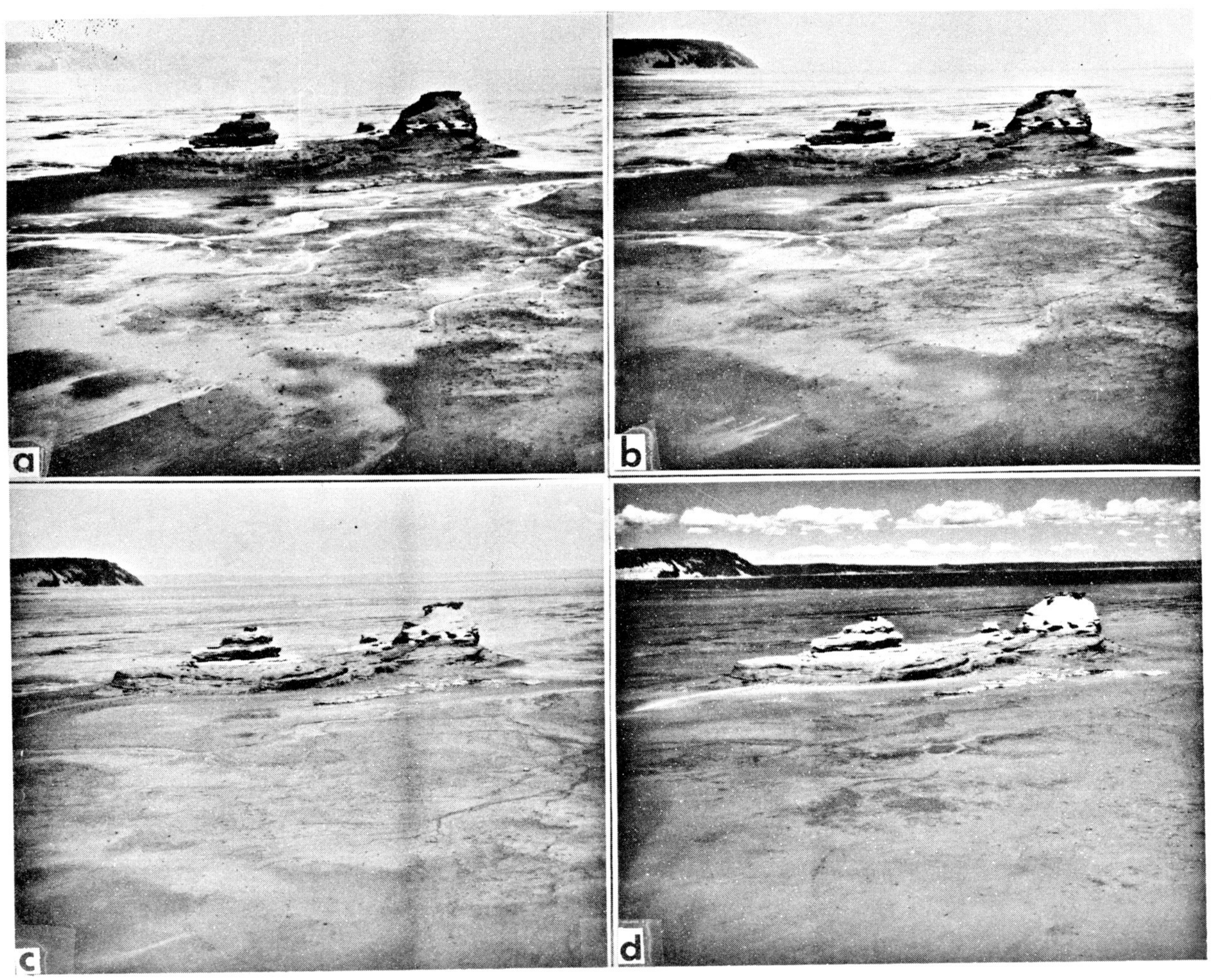

FIGURE 2 - Spectrophotography of Paddy Island. a - 385 - 445 mu b .485 - 545 mu c - 540 - 615 mu d 645 - 690 mu

FIGURE 3 - Enlargement of Figure 2a. Symbol indicates anomalous reflectivity of lithologic unit.

Observations

As expected the wet tidal flat was most reflective at the shorter wavelengths (Fig. 2a), and the Triassic red-beds exposed on the island were most reflective at the longer wavelengths (Fig. 2d). However, one lithologic unit appears to be quite reflective at all wavelengths (Fig. 3). Although this unit is more indurated than adjacent units, is an orange-red rather than the deeper red of the other units, and contains considerably more calcite (25% as compared to the 8% average), it is believed that the maritime environment of the Bay of Fundy plays the more significant role in the unit's greater reflectivity. For some undetermined reason this unit receives a denser encrustation of salts than any of the other lithologic units exposed on the island or on the nearby Blomidon Cliff. This anomalous reflectivity resulting from increased salt deposition was seldom detectable visually. However, spectrophotography and spectral photometry in the field always revealed its presence.

The processes of evaporation and condensation of chemical substances from the sea to the air and finally to a terrestrial feature (in this case, the emission of dissolved salts, which are believed to be halides, into the air by sea spray, and the subsequent deposition of these solids so that they encrust selectively a specific lithologic surface) is, undoubtedly, an important aspect of the interaction processes occurring at any sea-air-terrestrial boundary. To date, the subject has received little attention from environmental scientists. However, Sugawara (1948) and others have noted that there is a preferential escape of volatile sea-salt components into the air, but, as yet, there is nothing known, to the writer at least, that indicates a like preferential deposition of sea-salt components on a lithospheric element. At present it is not certain that the selective deposition at Paddy Island is simply the result of any local ephemeral environmental process. However it is certain that neither the manner of sample collection, nor transport, nor the technique of analysis in the laboratory is, in any way, responsible for these apparent zonal differences in photometric response.

Another aspect of interest is the complex micrometeorology of the Minas Basin. There is a continuous change in moisture flux and evaporation from the unconsolidated sediments, from the exposed strata, and from the sea surface. The variations must, at times, be exceedingly large.

Figure 4 illustrates another observation of interest. Near the base of Paddy Island occurred an enclosed pocket of rippled, fine grained sand that appeared to be derived from the Triassic units exposed on the island. In contrast to the underlying consolidated bed, these orange-red, well sorted sands exhibited a pronounced increase in reflection in the near infra-red spectrum. Unconsolidated lithic materials commonly exhibit a wavelength dependent increase of reflection, but seldom is it quite so dramatic a change. The spectrophotometry of these rocks and derived sediments will be shown in the appropriate journals.

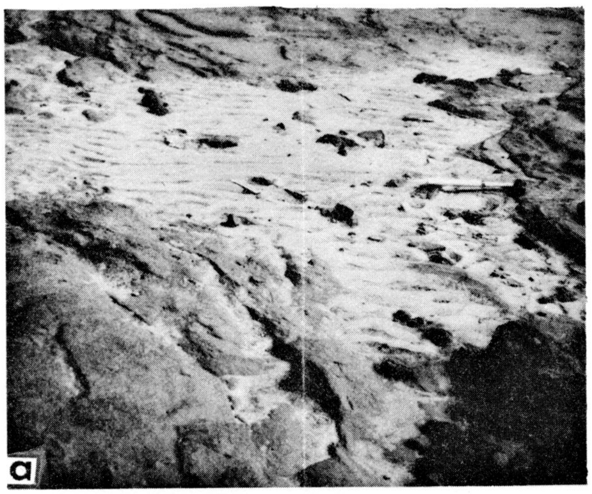

FIGURE 4 - Spectrophotography of Beach Sand Ripples

a 645 - 690 mu

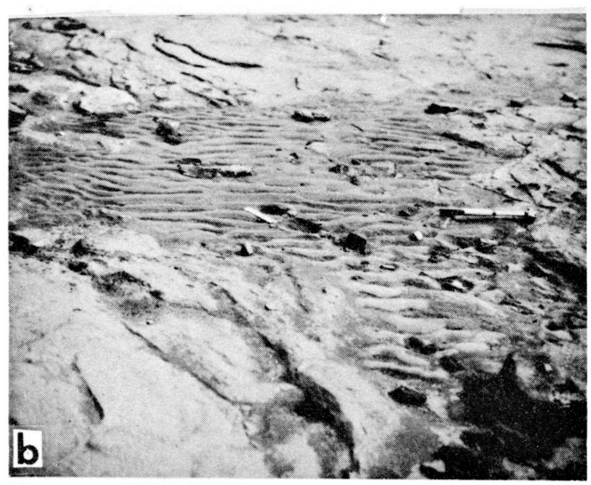

FIGURE 4- Spectrophotography of Beach Sand Ripples

b 385 - 445 mu

Comments

The goals attained in this study were, first, the establishment of a correlative laboratory and field technique for the measurement of radiometric data, and second, an indication of an environmental basis for the interpretation of terrestrial radiometry. The field technique is being developed further at sites in California and St. Croix. The need for greater reliability and sensitivity in field instrumentation was fulfilled recently by the acquisition of a triradiometric system designed by the author and specially built for the task by the Steward Observatory, University of Arizona. We plan to return to Paddy Island with the new instrumentation to continue this research, and also plan to initiate programs of terrestrial radiometry measurement at one or two other northern latitude sites of differing environment.

References cited

KLEIN, G. DeV., 1962, Triassic sedimentation, Maritime Provinces, Canada, Geol. Soc. American Bull., v. 73, p. 1127-1146.

SUGAWARA, K., 1948, Kagaku, v. 18, p. 458-492.