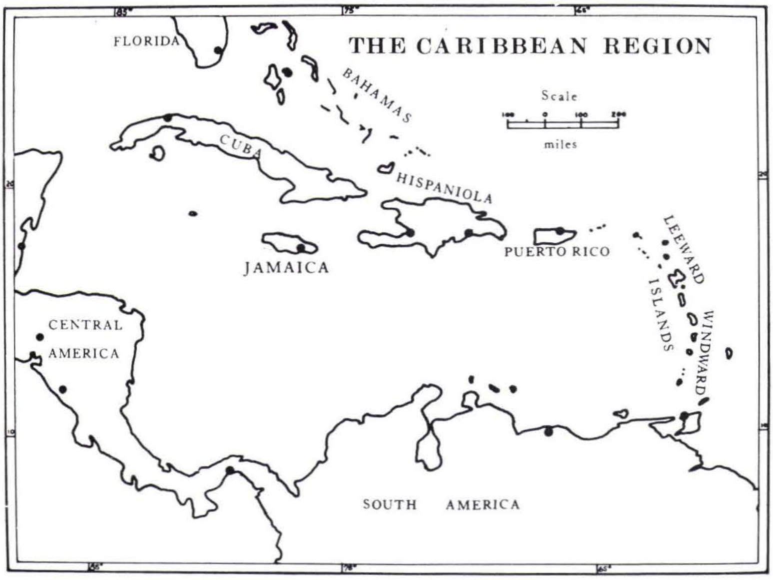

FIG. 1. The relationship of Jamaica to the Caribbean region.

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Geomorphology of Jamaica

Photographic interpretation is applied to an area in a humid tropical environment.

INTRODUCTION

IT IS THE INTENT of this paper to discuss the application of aerial photograph interpretation in the study of the geomorphology of an island exposed to what is essentially a humid tropical environment (Figure 1). It is not intended to be a short course in geomorphology, nor a review of the technique of aerial photograph interpretation. On the assumption, therefore, that most of those interested in the subject will be familiar with normal photo-interpretative procedures, only a brief summary of this phase will be presented.

Jamaica was selected as the subject of this discussion for a number of reasons, among the foremost of which are: the variability of the geologic foundation (Figure 2), the relative ease of access to most regions of the island, the availability of aerial photograph coverage, and the availability of an up-to-date series of topographic maps at a scale of 1:50,000. The geologic variability, in addition, has resulted in an equally wide variety of landforms and related geomorphologic processes.

PHASE I—PRELIMINARY STUDY

This phase, as is the case with most photo-interpretive studies, involves the evaluation of existing data. It is obviously desirable to learn as much as possible about the area of study before embarking on a program of detailed analysis. Where available, geologic

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reports, soils reports, vegetation descriptions, and similar materials should be acquired and reviewed. These reports and associated maps are usually the result of field studies conducted by specialists in the various disciplines and, therefore, may be utilized by the photo-interpreter as a source of such data, and/or then select the specific areas that they wish to assess in the field at a reconnaissance level. Others prefer to perform a field reconnaissance of the region to be studied in order to see as much of the area as possible and to evaluate from the ground its geologic characteristics, its general vegetative patterns,

ABSTRACT: *The application of the technique of aerial photograph interpretation to geomorphological investigations in Jamaica is discussed. Jamaica was selected because of its variable geologic foundation, its basically humid-tropical climatic regime, and the availability of supplementary data. Three different approaches to the study are reviewed: primary reconnaissance to develop the overall picture and to delineate major landform regions; regional analysis to determine the characteristics of forms, general processes, and chronology of these units; and detailed analysis of specific forms, specific processes, or anomalous features irrespective of their place in the regional picture. Some of the advantages and limitations of the photo-interpretive technique as applied to this field of investigation are mentioned.*

when personal field checking is not feasible. This preliminary phase provides a foundation for the subsequent geomorphologic investigation.

PHASE II—BASIC PROCEDURE

The decision as to whether field reconnaissance should be completed prior to the photo-interpretive study, or after a preliminary review of the photographs, is a matter of choice. Many photo interpreters prefer to select the aerial photographs of the area of study, carry out a rapid survey of these photographs, and and its landforms and processes. This technique provides the interpreter with a basic knowledge of the characteristics of the area which materially assists in the subsequent interpretation of the photographs.

Having completed the field reconnaissance, it is then necessary to survey the air photo coverage. The photographs selected as a result of this survey depend to a large extent on the specific type of geomorphic study to be undertaken.

If the intent is to conduct an island-wide reconnaissance geomorphologic study—map-

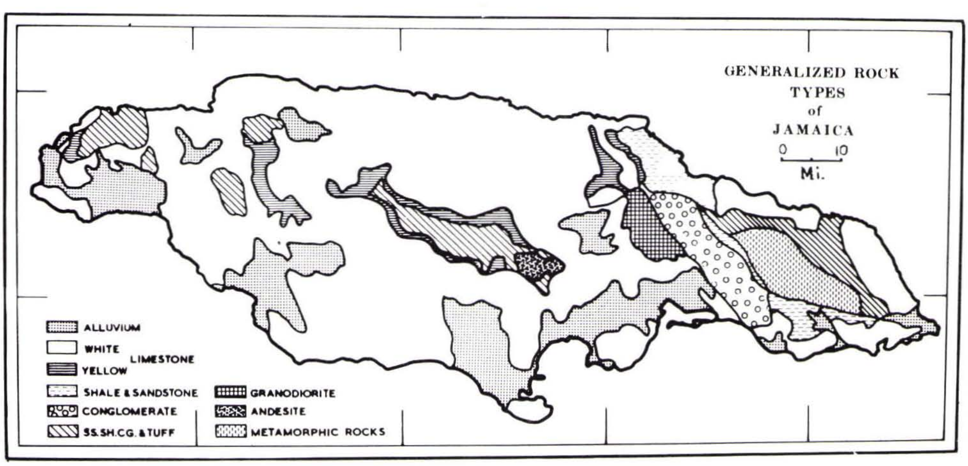

FIG. 2. Broadly generalized rock types of Jamaica. (After Zans, 1958.)

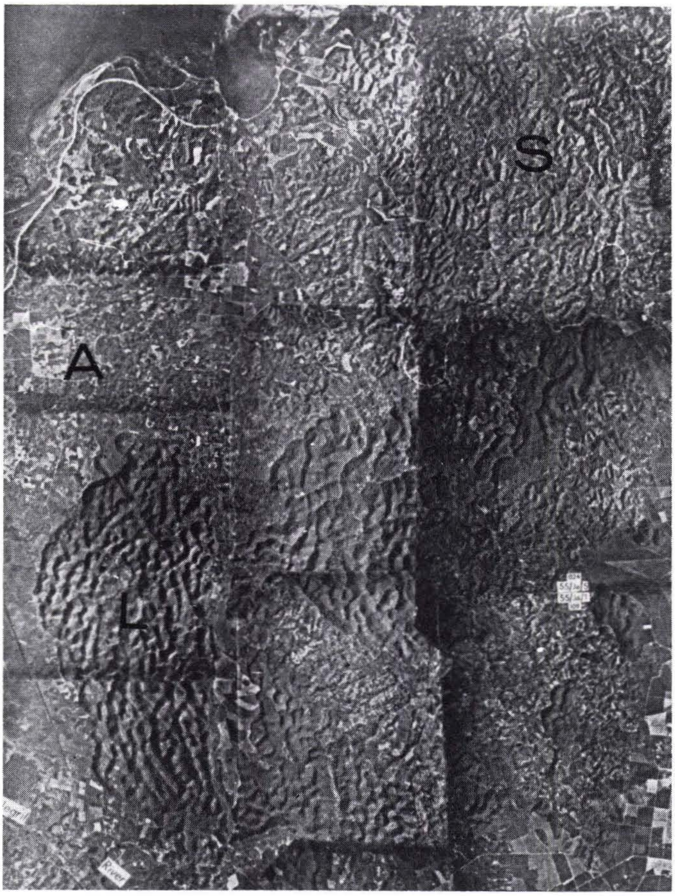

FIG. 3. Segment of air photo laydown index of Western Jamaica illustrating pattern variation with rock type: *L*—limestone, *A*—alluvium, *S*—sandstone, shale, conglomerate, and tuff complex.

ping features, and delineating regions and sub-regions—it may be necessary to obtain the entire coverage.

If the intent is to carry out a regional geomorphologic study, that is, a study of a specific area—such as the limestone region of the western part of the island, or the metamorphic region of the eastern, Blue Mountain part of the island—selected blocks of photographs may be required.

If the intent, however, is to complete a detailed geomorphologic study of a specific process—such as mass-wasting, or coastal marine erosion and deposition, or the control of limestone solution by lithology—the selection of the required photographic coverage may be much more complicated.

This aspect of the entire program necessitates a rather comprehensive review of the available photographic coverage and, in so doing, provides the geomorphologist with a regional picture of the island's features.

PHASE III—AERIAL PHOTOGRAPH INTERPRETATION AND THE GEOMORPHOLOGY OF JAMAICA

In the following sections the application of aerial photograph interpretation in the various types of geomorphologic study indicated above is discussed.

If a reconnaissance geomorphologic study of the entire island is desired, it will be necessary to delineate the regional characteristics and to describe these characteristics in relation to: the geologic foundation, the local climatic variations obtaining, and, where necessary, the pattern of land utilization or natural vegetation in existence. In this type of study, variation in landforms and their regional distribution may show up on the mosaics of the area (Figures 3 and 4).

The stereoscopic examination of photographs may then be used to evaluate differences in patterns, variations in local relief, the qualitative characteristics of individual

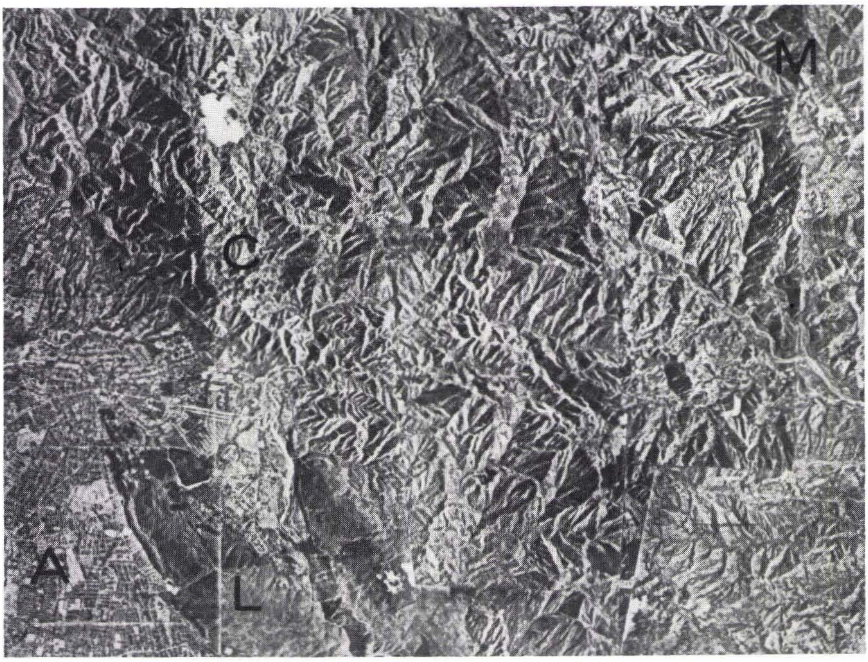

Fig. 4. Segment of air photo laydown index of the Kingston-Blue mountain area of Eastern Jamaica illustrating pattern variation with rock type: *L*—limestone, *A*—alluvium, *C*—conglomerate, shale, and sandstone, *M*—undifferentiated metamorphics.

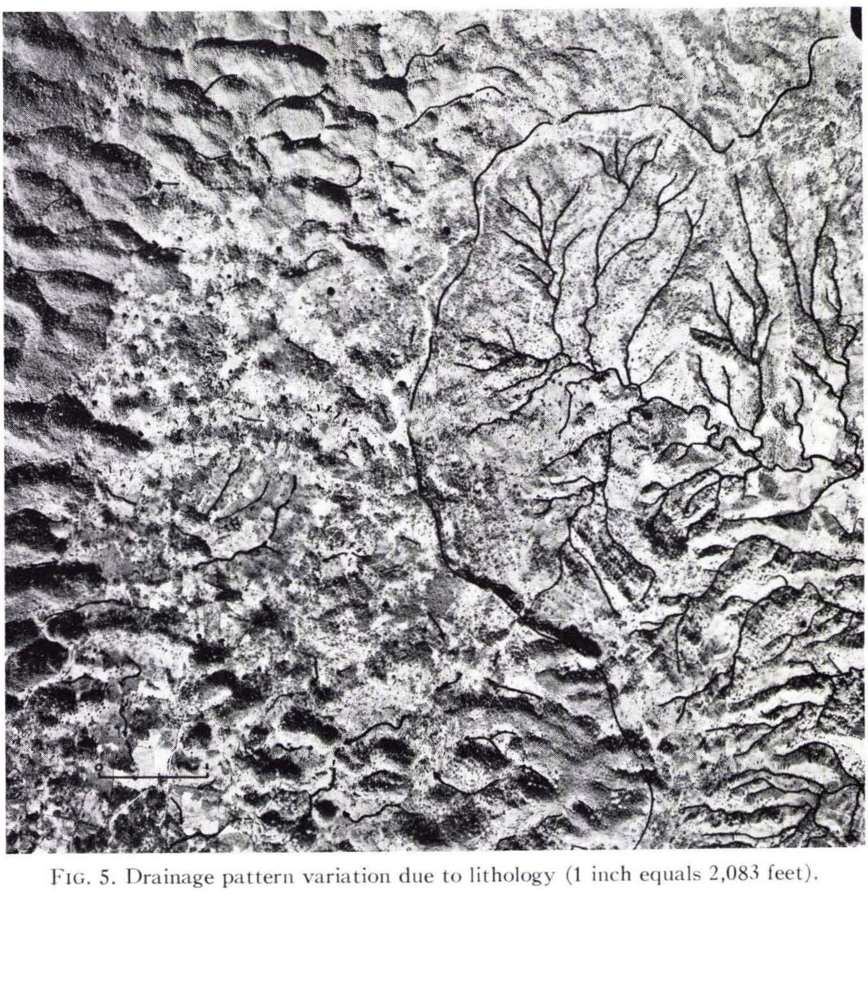

Fig. 5. Drainage pattern variation due to lithology (1 inch equals 2,083 feet).

FIG. 7. Forms developed by erosion of dominantly metamorphic rocks. Note remnants of possible erosion surface on spurs (1 inch equals 2,083 feet).

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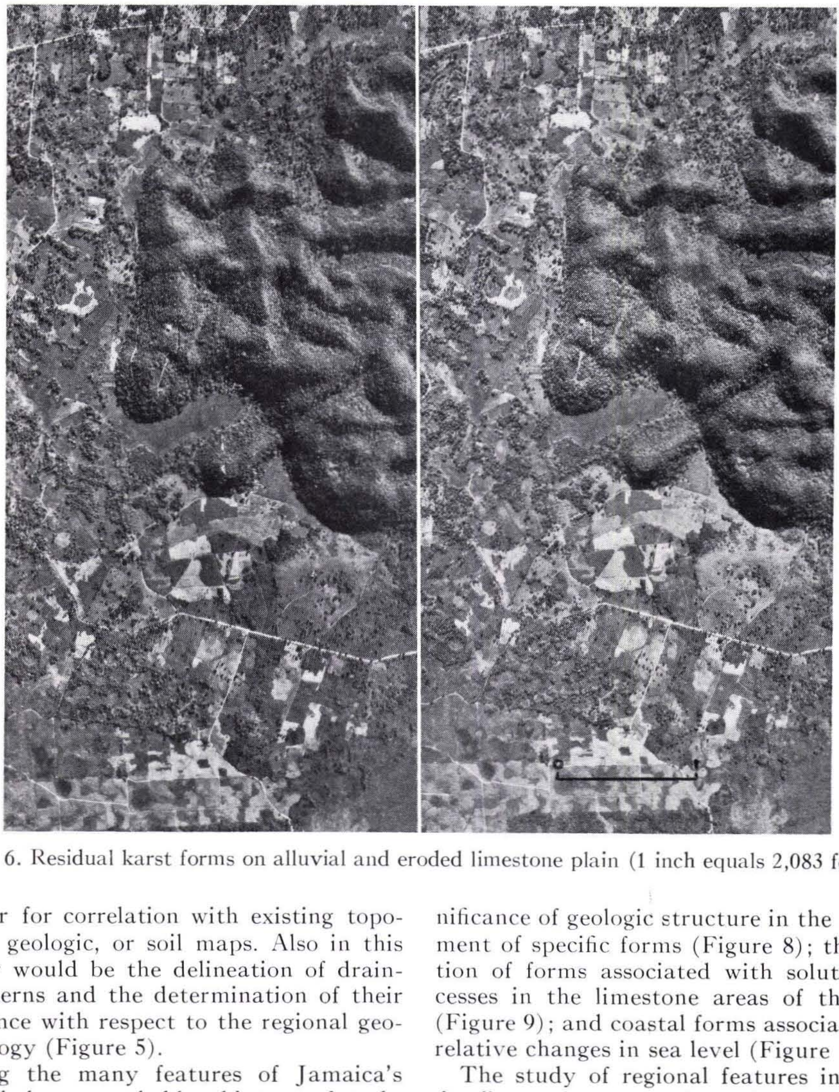

FIG. 6. Residual karst forms on alluvial and eroded limestone plain (1 inch equals 2,083 feet).

forms, or for correlation with existing topographic, geologic, or soil maps. Also in this category would be the delineation of drainage patterns and the determination of their significance with respect to the regional geomorphology (Figure 5).

Among the many features of Jamaica's geomorphology revealed by this type of study the following may be singled out as particularly interesting: the variation of basic form resulting from normal geomorphologic processes acting under the influence of a relatively uniform climatic regime, upon rocks of varying lithologies (Figures 6 and 7); the significance of geologic structure in the development of specific forms (Figure 8); the variation of forms associated with solution processes in the limestone areas of the island (Figure 9); and coastal forms associated with relative changes in sea level (Figure 10).

The study of regional features in greater detail may be centered on the metamorphic rocks of the Blue Mountains of Eastern Jamaica, the uptilted limestone strata surrounding this core, the broad limestone mass of Central and Western Jamaica, the association of shales, conglomerates, sandstones and tuffs of the Central Inlier, the scattered

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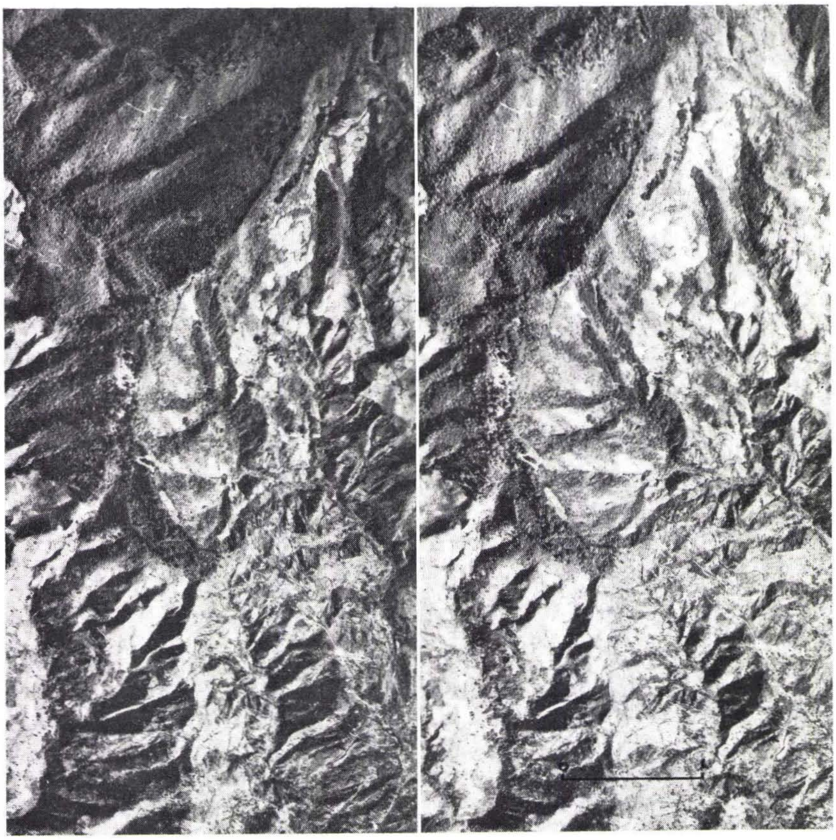
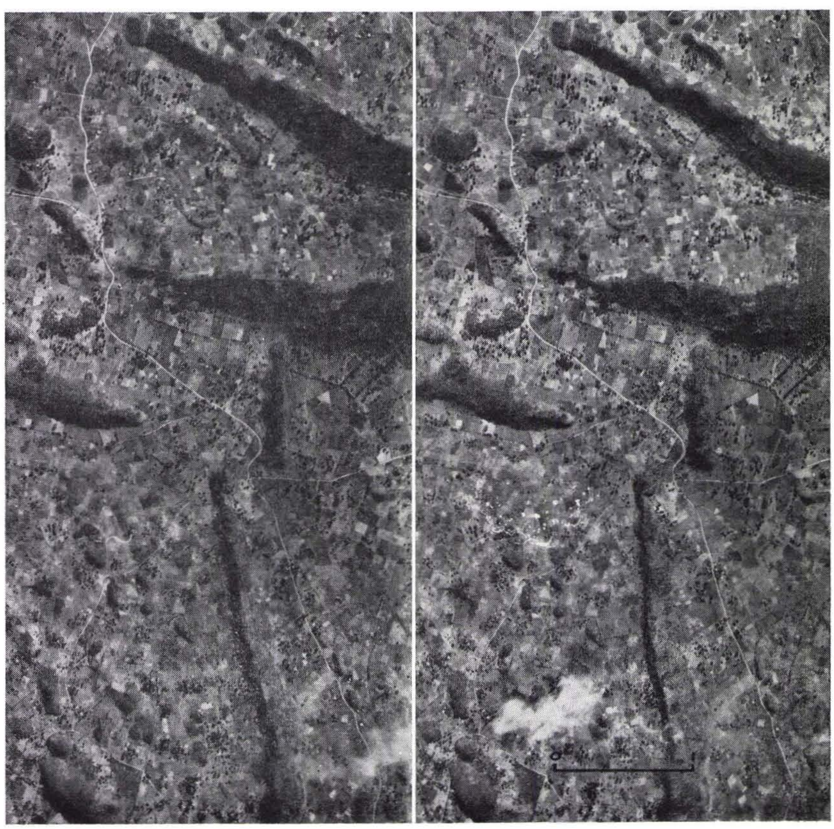
FIG. 8. Sequential faulting in limestone (1 inch equals 2,083 feet).





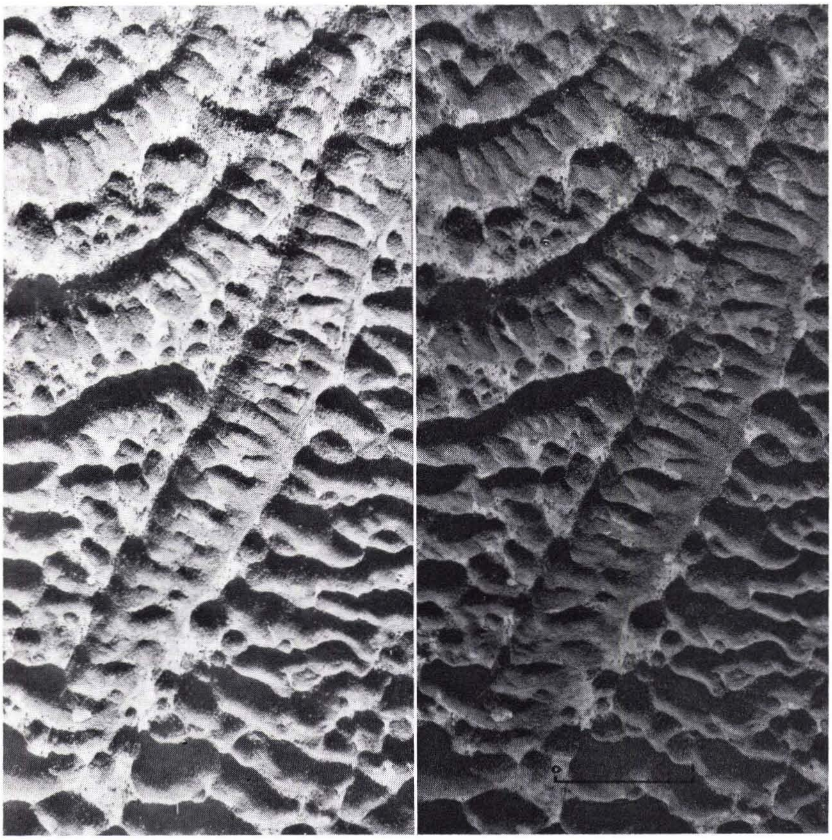


FIG. 9. Karst forms associated with geologic structure (1 inch equals 2,083 feet).

areas of intrusive and extrusive igneous rocks, the extensive belt of conglomerates, sandstones, and shales more or less separating the central and western part of the island from the eastern Blue Mountain region, the alluvial plains throughout the island, or the marine features of the coastal margin. In each instance, both qualitative and quantitative studies may be needed.

In the Blue Mountain region of metamorphic rocks, aerial photograph interpretation may be used to delineate the variation of drainage pattern with lithologies, the variation of valley characteristics from broad, open *V* cross-profiles, through steep *V*'s, into almost vertically sided gorge sections, the presence or absence of valley-in-valley profiles indicative of multicyclic development, the presence of flat-topped, interfluvial or ridge crest areas indicative of relict erosion surfaces, and the characteristics of slopes, both qualitative and quantitative. Details of processes active in the area may be indicative of the significance of the vegetative cover, of slope, of degree of weathering, or of the control exercised by rock type and structure. The significance of rainfall between the north-facing slopes of the Blue Mountains and the south-facing slopes, may also be determined by a study of these processes and the resulting forms.

In the limestone regions of the island, the interrupted pattern of drainage characteristic of karst development, may be studied on a regional basis, or, if necessary, in detail. It is even possible, in some areas, to trace the channel of a particular stream from the surface valley, through its underground counterpart, and back to the surface again (Figure 11). The characteristic form of the valleys associated with this type of drainage may also be studied specifically or in a more regional context (Figure 12). In the latter instance, the relationship of the valley form and its development to the lithologic characteristics of the particular limestone strata in which they are developed, may be determined.

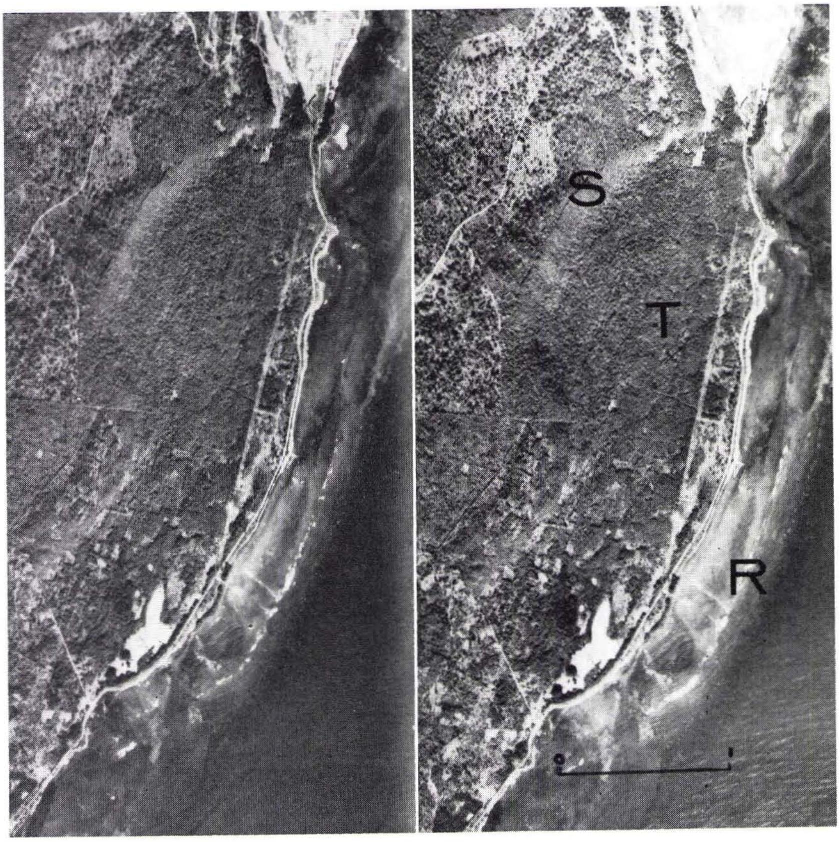


FIG. 10. Terrace *T*, and wave-cut scarp *S*, associated with relative changes in sea level. Present reef at *R* (1 inch equals 2,500 feet).

Using the aerial photographs it is not only easy to delineate the solution depressions, the sink holes and larger Poljes, but also the various stages of karst development and their areal distribution. In many cases, the characteristics of this solution morphology are subject to a much clearer analysis using this technique than is possible in the field. In the latter case, it is often very difficult to obtain a clear view of many of the features men-

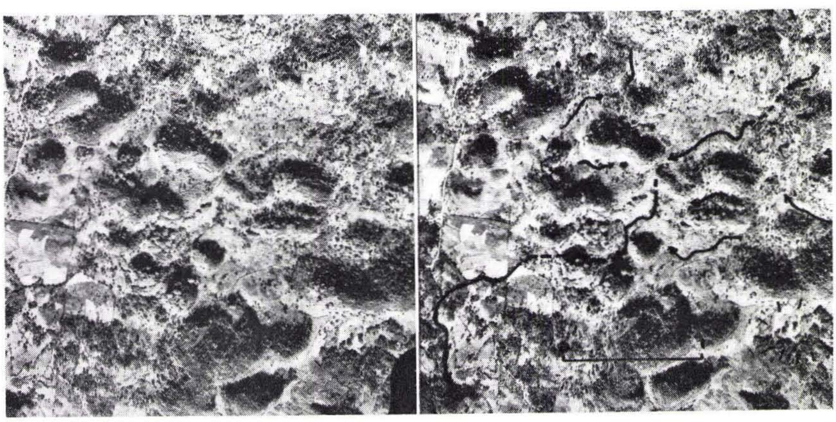


FIG. 11. Possible interpretation of path of stream; part on surface and part underground (1 inch equals 2,083 feet).

FIG. 14. Lithologic and structurally controlled patterns in karst area (1 inch equals 2,083 feet).

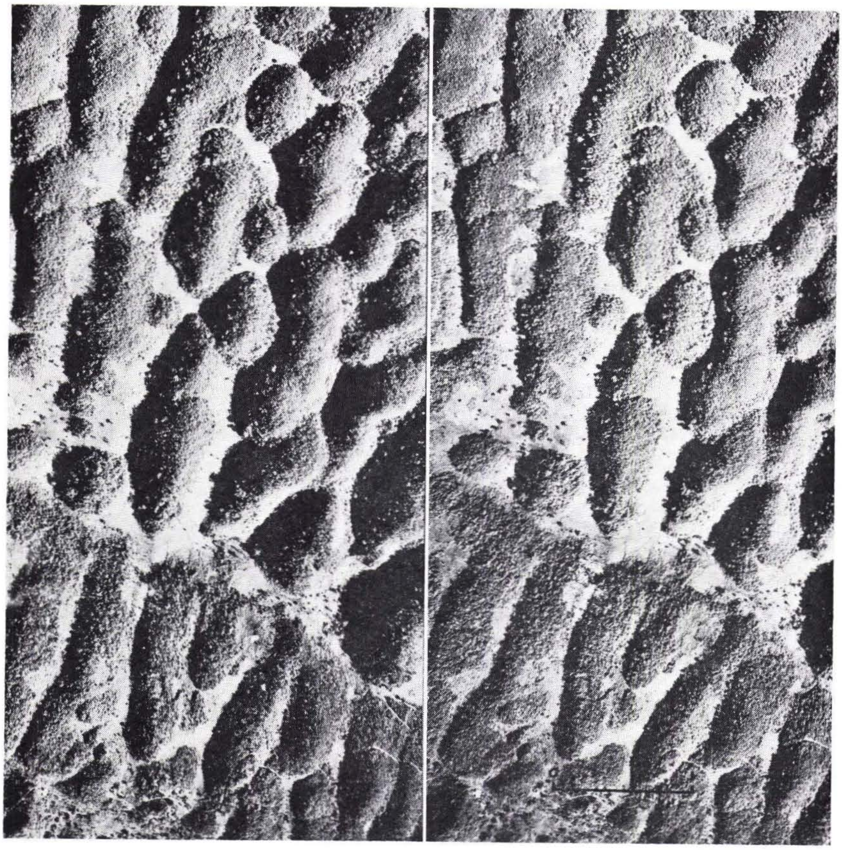


FIG. 12. Detail of karst forms and associated drainage (1 inch equals 1,167 feet).

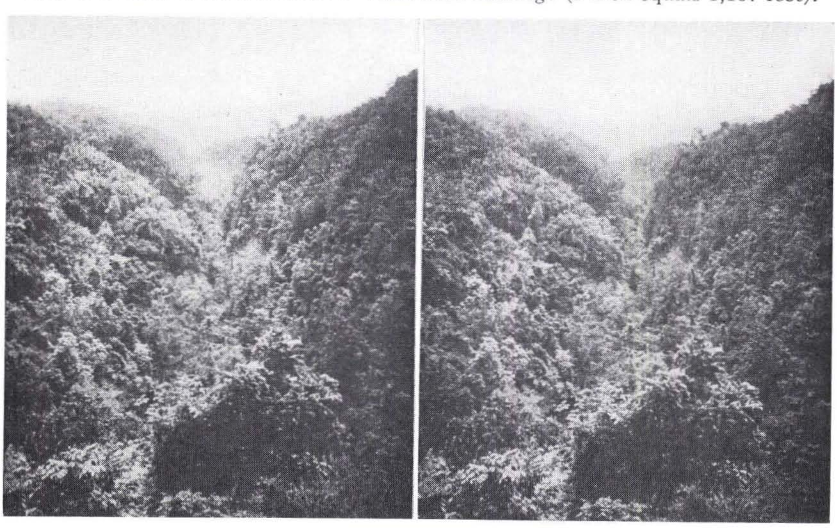
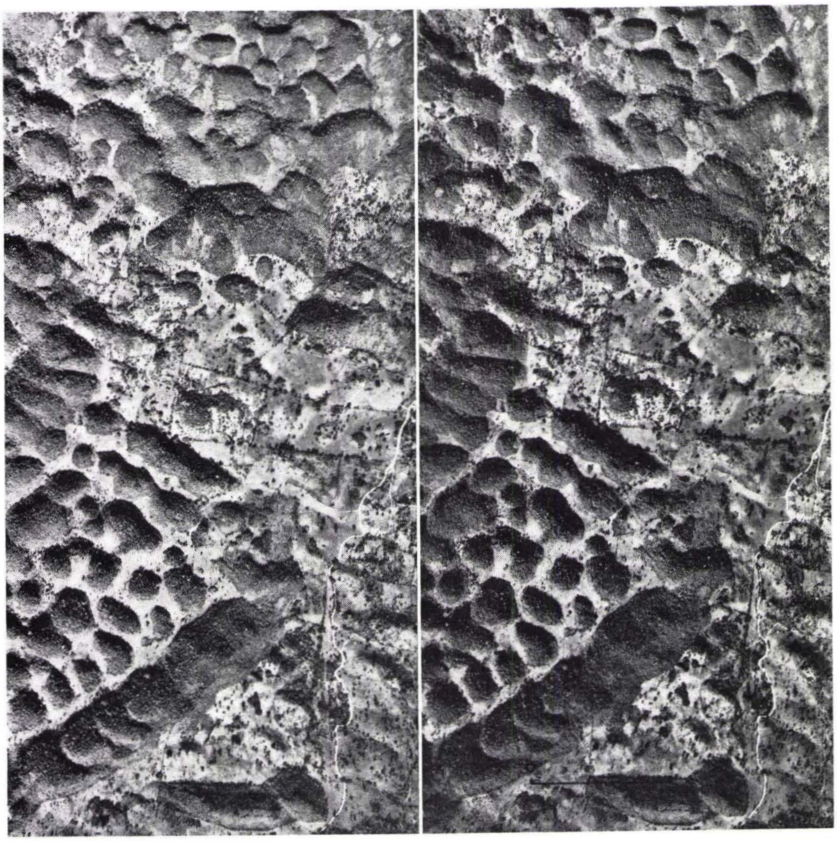
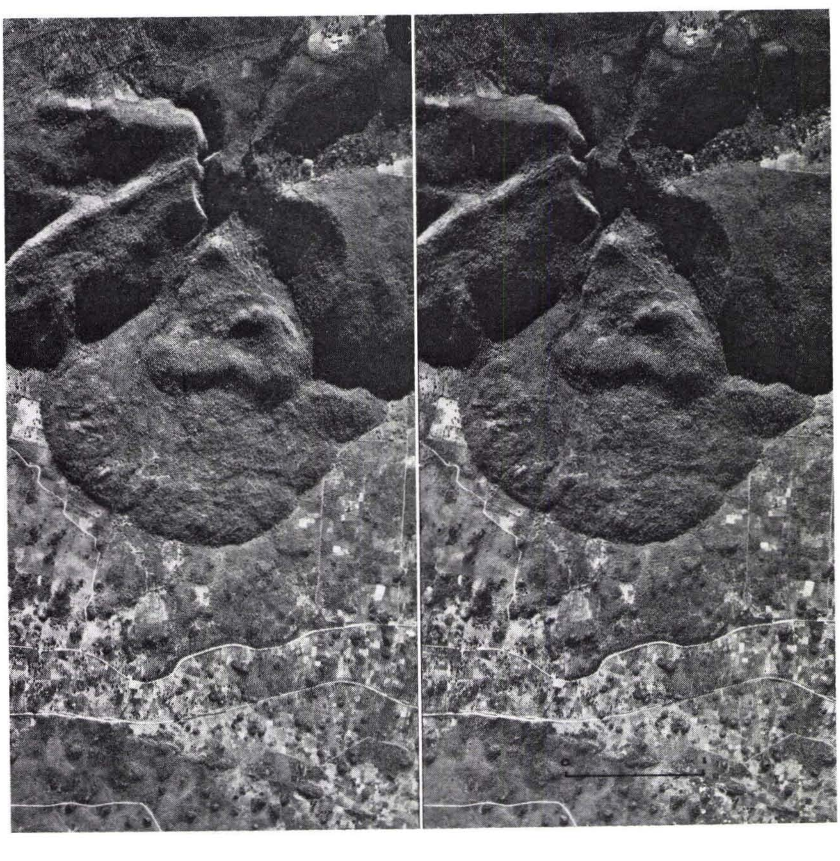


FIG. 13. Ground view of obscured valley in karst area.

FIG. 15. Major debris flow at fault, and variation in karst form due to lithology (1 inch equals 2,250 feet).





tioned, or because of dense vegetation, to carry out any significant quantitative measurement program (Figure 13).

The landforms of this region, although locally reflecting the nature and characteristics of the bedrock lithology, on a broader regional base, exhibit patterns which define the structural elements in a spectacular manner (Figure 14). Faulting and the resulting displacement of strata, and the attitude of bedding, are among those geologic features most clearly defined.

Many of the basic processes of weathering and erosion which may be interpreted on the aerial photographs, require detailed field investigation to determine specific characteristics. The presence of dense vegetation and the nature of the processes themselves are the controlling factors in this method of study. In the case of mass-wasting processes however, the aerial photographs are perhaps the most efficient method of evaluation. Soil flowage associated with faulting and rock slide/slump phenomena, are two such features most clearly illustrated (Figures 15 and 16).

The study of specific or unusual features and the processes responsible for their development, might be presented as a third type of geomorphologic investigation. Features of this type are usually encountered during the reconnaissance or regional studies discussed previously. As a rule they are indicative of specific processes acting on specific rock types or specific structures. In some cases such features may be related to tectonic activity, in the form of isostatic readjustment of land surfaces, to displacement of rocks as a result of faulting, to particular lithologic variations, or to eustatic changes in sea level. (Figure 17). In terms of geomorphologic processes, these features may be related to variations in the intensity of weathering, to the effectiveness of erosion, to the susceptibility of the rock foundation to mass-wasting, or to the effects of depositional activity in a number of different topographic environments. Changes in

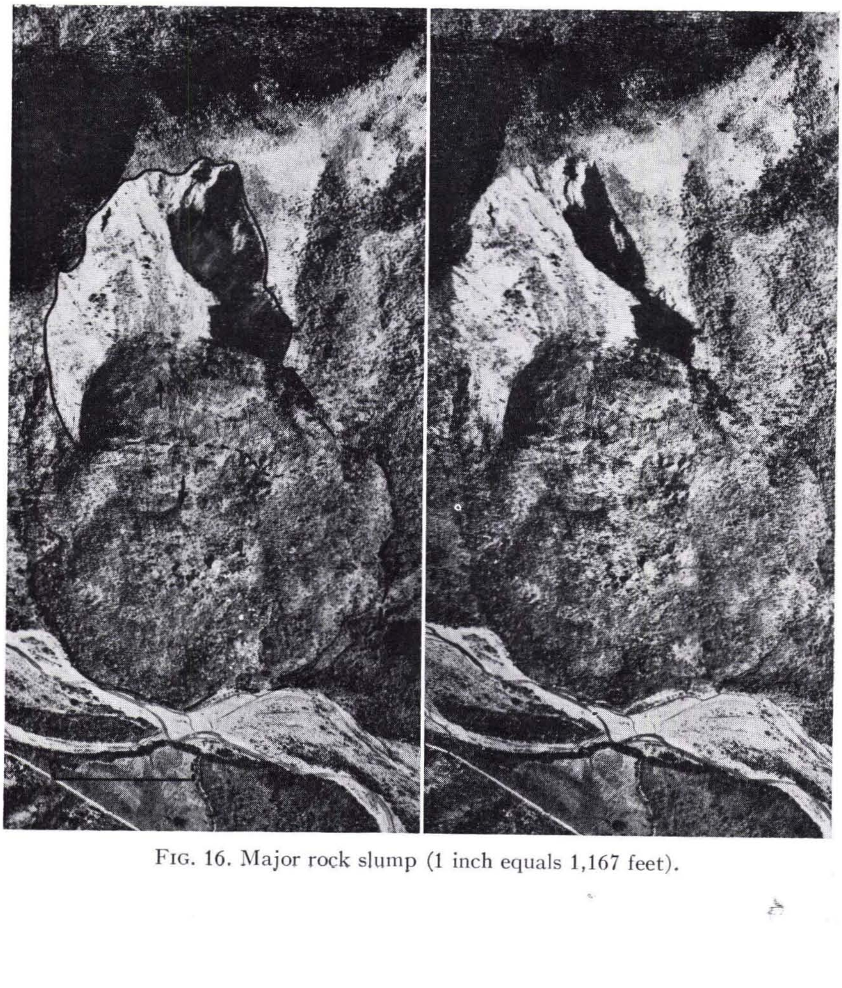


FIG. 16. Major rock slump (1 inch equals 1,167 feet).

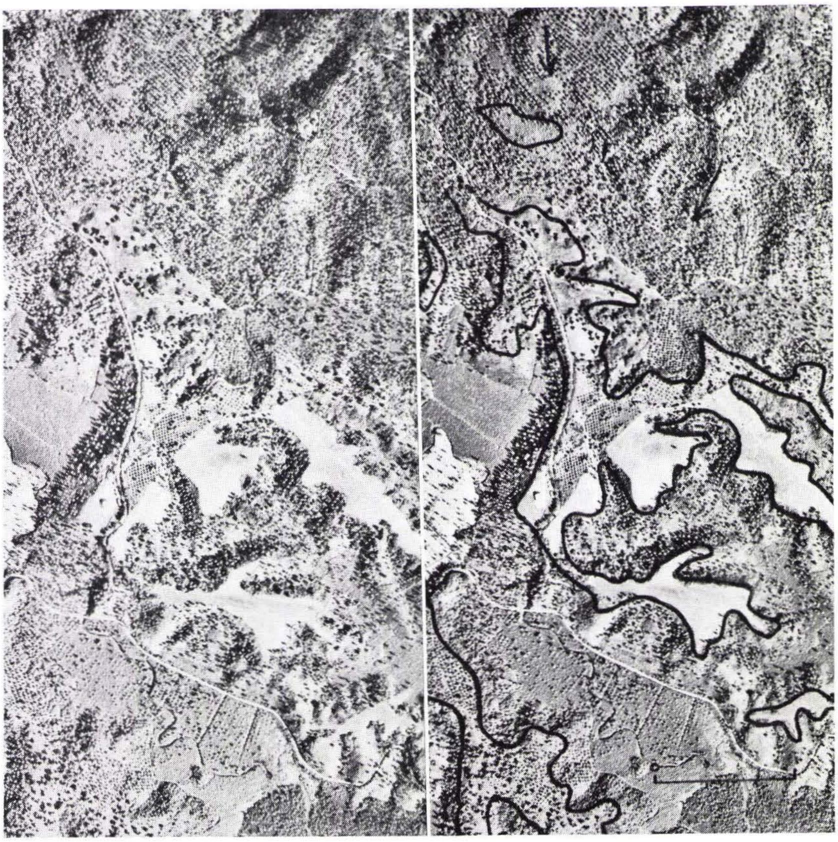


FIG. 17. Terraces probably related to a change in the elevation of the land with respect to the sea (1 inch equals 1,167 feet).

sea level, mentioned above, may affect virtually any or all of these processes in the related coastal areas. Finally, local climatic variations dependent on prevailing wind directions and orographic effects, may have a significant bearing on the processes active and the forms developed.

SUMMARY

In this paper, an attempt has been made to illustrate the effectiveness of aerial photograph interpretation in the field of geomorphologic investigation with special reference to the humid tropical environment as represented by the island of Jamaica. The stereoscopic pairs of aerial photograph segments were chosen primarily to support this objective rather than to depict the geomorphology of the island.

In view of the fact that a geomorphologist must study landforms, the processes active in the formation of these landforms, and the numerous factors influencing the effectiveness of these processes, it is not surprising that a technique which allows him to obtain an overall view of these features in three dimensions, to study in detail evidence of the activity of the processes mentioned, to evaluate the various factors affecting these processes, and to make relatively accurate quantitative measurements of the pertinent parameters, is so valuable. Anyone who has flown over an assemblage of landforms as striking as the cockpit country of Jamaica, knows the frustration of the transient nature of this passage. The aerial photograph and its ability to reproduce these assemblages in three dimensions, and to allow their study at leisure, is without doubt one of the most important tools that geomorphologists have to work with. When such a tool is combined with the opportunity for field investigation, the geomorphologist is indeed fortunate.

Finally some of the limitations of this technique in the field of geomorphological investigation, should be pointed out. Such limitations may be both qualitative and quantitative in nature. Dense vegetation may obscure surface features significant from the point of view of detailed studies of weathering and erosion. The scale of photography may, if it is too small, act in the same manner, or if it is too large, may prevent an overall or integrated view. In some instances the film-filter combination may influence tonal variations and the resulting interpretation.

Quantitatively, aerial photography may present problems in terms of accurate slope measurement, stream gradient determination, and relative relief classification, due to tip, tilt, or associated geometric distortion, lack of ground control, and/or many of the surface-obscuring factors mentioned above.

If however, the interpreter is aware of and familiar with these factors, and the many others not discussed, the loss in effectiveness of the technique may be kept to a minimum.