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SMALL-SCALE GEOMORPHOLOGICAL MAPPING OF P.D.R. YEMEN: AN APPROACH TO LANDSCAPE EVALUATION (**)

Abstract: VILLWOCK G., *Small-scale geomorphological mapping of P.D.R. of Yemen: an approach to landscape evaluation.*

The first attempt at landscape evaluation of South Yemen utilises small-scale (1:1 million) geomorphological mapping, depicting macrorelief units 10 to 1000 km in size. Morphographic, lithological and morphostructural characteristics are identified. The mapping is based on remote sensing, field observations in selected areas, and data from geological maps. Evaluation of natural resources and geomorphological hazards is based on analysis of the relief in combination with climatic and soil data.

KEY WORDS: Geomorphological mapping, Small-scale maps, Remote sensing, P.D.R. Yemen.

Riassunto: VILLWOCK G., *Cartografia geomorfologica a piccola scala della Repubblica Popolare dello Yemen: un approccio all'esplorazione del territorio.*

In relazione a un primo rilevamento a piccola scala del territorio della Repubblica Popolare dello Yemen è stata eseguita una carta geomorfologica sintetica alla scala 1:1 milione, nella quale sono rappresentate le unità morfologiche con dimensioni lineari da 10 a 1000 Km (macroforme). Esse sono contraddistinte da caratteristici lineamenti fisiografici, litologici e morfostrutturali. La tecnica cartografica comprende l'uso di dati da telerilevamento, da carte geologiche e osservazioni originali di zone selezionate. La conoscenza delle condizioni del rilievo con l'aggiunta delle carte climatiche e pedologiche conduce ad un primo tentativo di valutazione delle risorse territoriali e dei rischi naturali della Repubblica Popolare dello Yemen.

TERMINI CHIAVE: Cartografia geomorfologica, Carta a piccola scala, Telerilevamento, P.D.R. Yemen.

In an area which is relatively poorly known, assessment of resources and identification of natural hazards can in the first instance begin with analysis of the relief. The methodology for such surveys has been pioneered by such organisations as the CSIRO (the land systems approach) and the ITC (geomorphological mapping in combination with remote sensing). In South Yemen, a developing country in the south-west of Arabia, mapping of the relief through remote sensing has enabled the first systematic assessment of resources and natural hazards to be made.

The relief and structure of South Yemen are the result of Tertiary and Quaternary morphogenesis under climatic conditions that have varied from marginal tropical and semi-humid in the early Tertiary, to semi-arid or arid in the Neogene and Quaternary. The position of the area in relation to the Arabian Shield and the Arabian Shelf, and its proximity to the Gulf of Aden rift zone, have strongly conditioned the distribution of basement and sedimentary rocks, and also the tectonic style of the area.

Previous geomorphological investigations have been very limited. WISSMANN & LEIDLMAIR produced the first accounts of the structure and of the evolution of the relief. Subsequently, there were more detailed studies in the southern and coastal regions, but vast areas of the East and North remain largely unexplored.

METHODOLOGY OF SMALL-SCALE RELIEF ANALYSIS AND GEOMORPHOLOGICAL MAPPING

The research programme has attempted to compile a synthetic geomorphological map on scales from 1:1 million to 1:2 million, representing relief units from 10 to 1000 km in size. These units comprise heterogeneous associations of landforms whose recognition and characterisation are based on macroforms (mountains, plateaus, plains, etc.), mesoforms of subordinate scale (such as valleys, gorges, terraces, etc.) and on the main morphogenetic features. In devising a legend for the mapping, the relief units are first of all arranged in three main morphogenetic groups: forms of denudation, forms of accumulation and volcanic forms. Further subdivision of the first (denudational) category depends on relief amplitude, stage of dissection, lithology and structure. Forms of accumulation are subdivided according to their relief features and their origin (e.g. fluvial, alluvial fan or eolian deposits).

The following data sources are utilised:

LANDSAT-1 imagery, with a ground resolution of about 80 m;

aerial photography on scales from 1:50000 to 1:90000 for selected areas;

outline geological maps (1:250000 to 1:1 million);

topographic maps for selected areas; and

field observations and mapping in selected areas.

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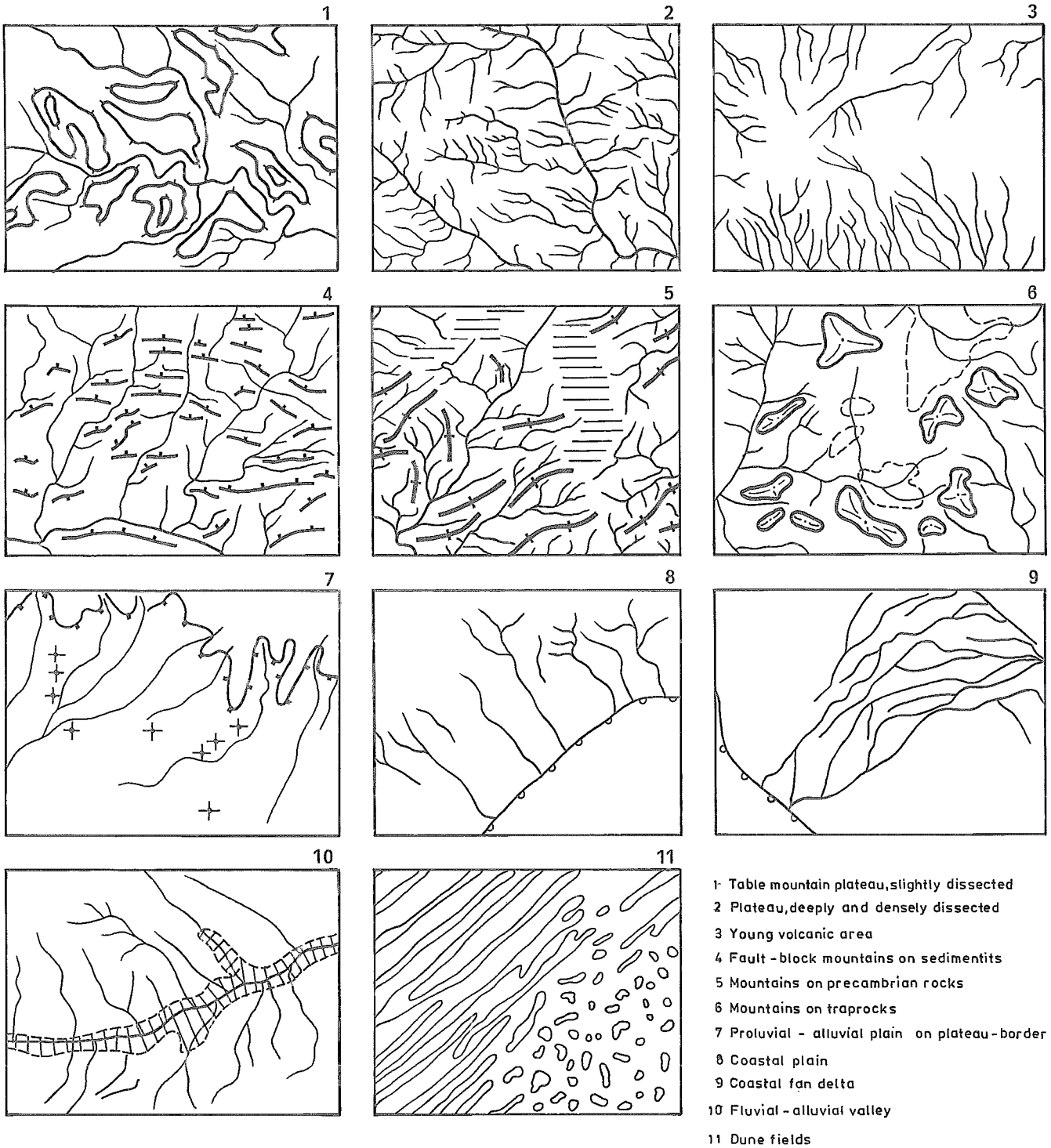

FIG. 1 - Image pattern of relieftypes of P.D.R. Yemen.

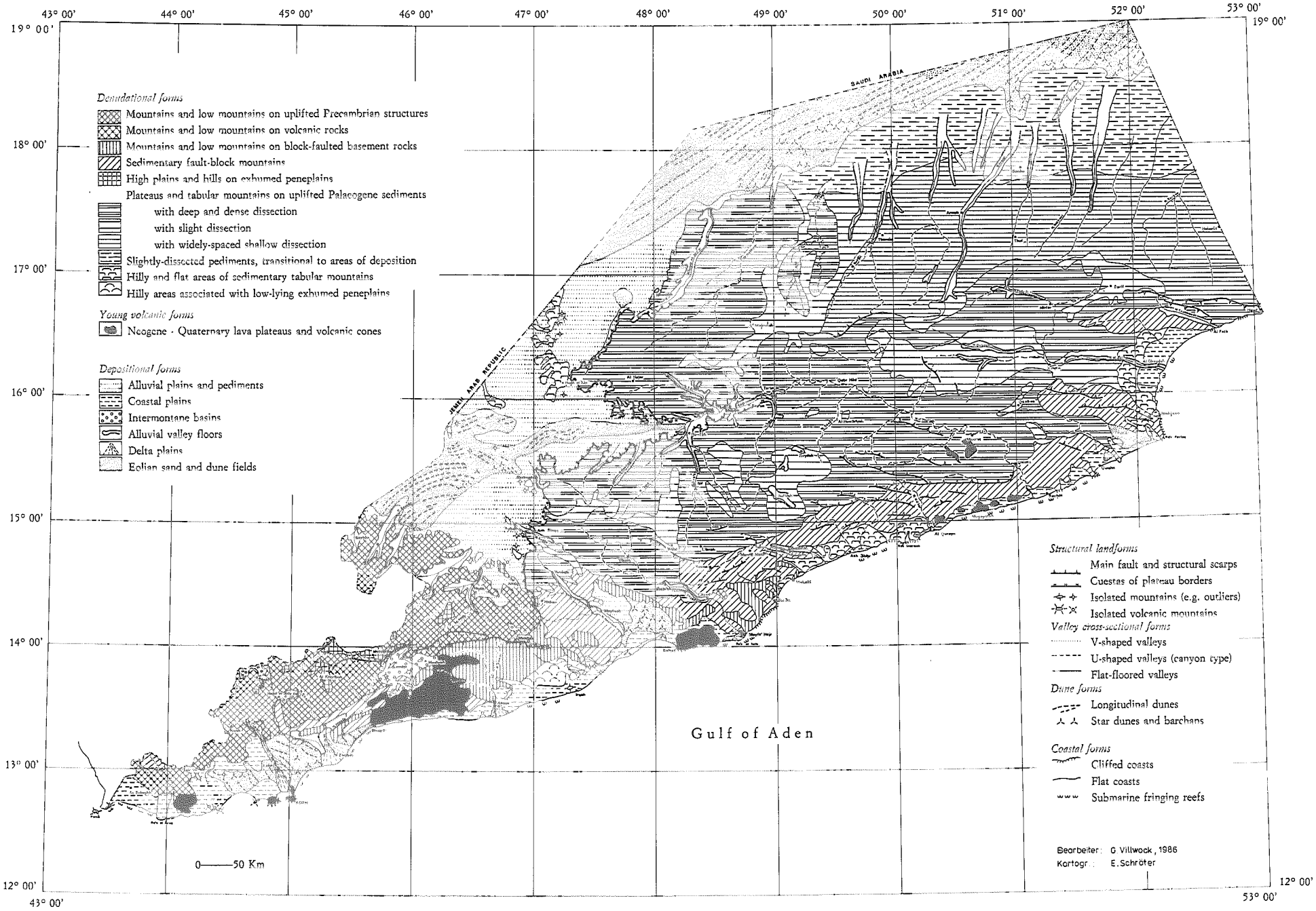

FIG. 2 - Geomorphological map of South Yemen.

The main step consists of visual interpretation of the remote-sensing imagery, together with stereoscopic study of the aerial photographs. Analysis starts with a selection of representative sub-areas whose relief characteristics have already been established from field observations and aerial photographs. These sub-areas then serve as models for extension of the interpretation to other areas and for establishing types of relief pattern (fig. 1). The patterns are strongly influenced by the valley network and such other features as scarps, ridges and tabular mountains. The tonal range of the images can provide some indications of lithology.

The patterns of the denudational forms also reveal the strong tectonic control in many areas, especially the intensively faulted northern border area of the Gulf of Aden rift zone, and also in areas with older exhumed tectonic lineaments (see blocks 4 and 5 on fig. 1). On the other hand, areas of unfaulted sediments show patterns closely linked to variations in lithology and folding. Depositional forms are particularly characterised by valley networks lacking structural control; and sediments types can be interpreted from the light tonal range. Their position with respect to other relief units (e.g. bordering mountains or plateaus) is also critical in interpretation.

Following analysis in the selected model areas, it is then possible, using the image patterns and the tonal characteristics, to complete the survey of macroforms for the whole area, delimiting both major relief units and the subordinate forms. The latter, ranging in size from 0.1 to 10 km, include, for example, scarps, cuestas, single mountains, main valleys, dunes and coastal forms. Generalised profiles are added to the map to show the relationships of relief and structure (fig. 2).

FURTHER USE OF THE GEOMORPHOLOGICAL MAPPING

a) *Geomorphological regionalisation*. Grouping areas according to similarities in macrorelief has enabled the area to be divided into 13 major regions. These have been further sub-divided into 42 sub-regions based on associations of relief types.

b) *Land systems*, soils and agricultural potential. The results from the small-scale geomorphological mapping, together with geological and climatic data, provide a basis for establishing a hierarchy of land systems based on geomorphological, lithological and climatic characteristics. Combined with soil data and water availability, this approach has been used to provide the first estimates of the agricultural potential of South Yemen.

c) *Geomorphological hazards*. South Yemen forms a part of the «Dry zone with an arid morphodynamic system» according to MENSCHING (1983). Rainfall is highly variable, intense and episodic in character. Occasional violent rainstorms, mostly in spring or autumn, can reach an intensity of 150 mm in a day, promoting sudden and rapid fluvial response in valleys and coastal deltas. The scanty vegetation cover provides little or no interception and surface runoff develops rapidly. The high transporting and erosional capacity of these flash floods presents great dangers for cultivated areas, settlements, roads, reservoirs and so on. Recent catastrophic rainstorms and floods occurred in spring 1989, and previously in 1982 and 1977. The spatial incidence of rainstorms is highly variable, affecting different parts of the country at different times.

The sand plains of coastal and interior areas with rainfall below 100 mm a year have little vegetation and are dominated by eolian processes. Dust and sand storms and advancing dunes can present hazards to cultivated areas, which can become covered with loose sand, and to roads, as well as causing soil loss in other areas. MCKEE (1979) has estimated the eolian drift potential at 10 to 30 m^3/m/year, comparable with estimates from the Sahara.

TABLE 1

MORPHODYNAMIC CHARACTERISTICS ASSOCIATED WITH THE MAIN RELIEF TYPES IN SOUTH YEMEN

Relief type	Morphological processes and hazards
Plateaus and tabular mountains	Sheet erosion; episodic fluvial erosion in valleys
Mountains, low mountains, western Yemen	Linear erosion, strong slope dissection, considerable risk of soil erosion for terraced arable systems
Sedimentary fault-block mountains	Slope dissection and rockfalls on scarps; intense episodic erosion in valleys
Main valley floors	Lateral erosion and gullying of arable lands by episodic floods
Alluvial, coastal and interior plains	Sheet erosion; lateral erosion in shallow valleys; subordinate deflation processes
Mobile sand areas	Eolian transport and deposition, migrating dunes
Slightly dissection sediments of the north-eastern plateaus	Combined fluvial and eolian activity

Table 1 presents a summary of the main morphological processes and hazards associated with the principal relief types determined from the small-scale mapping (fig. 2).

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