GEOLOGICAL MAPPING FOR THE PURPOSE OF LAND-USE PLANNING ALONG THE MEDITERRANEAN COAST OF ISRAEL

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Introduction

The Mediterranean shoreline of Israel has long been recognized as one of the country's most valuable land assets. Although not rich in mineral deposits and topographically not complicated, it is the seaward border of the country's most densely populated and most rapidly developing area. It serves as substrate to both rural and municipal settlement, contains vital outlets for regional drainage and local sewage, includes the obligatory sites for ports, central power plants and other major coastal installations, and is the state's most intensively used recreational facility.

Beside these functions, which converge heavily on a narrow strip of shore and hinterland, the area has a unique faunal and floral aspect, and preserves the ruins of many historical settlements and human remains, down to the dawn of prehistory. Some of these sites are today submerged, or raised to levels other than their original position, and may testify to recent land – sea changes (Neev *et al*, 1973).

All of this indicates that without timely interference of a national planning agency, the state may incur irrepairable damage through unsuitable or conflicting land use, as well as lose landscape resources, historical heritage, and potential for future development.

In order to forestall these possible harmful trends and to facilitate planning, a land-use program is being prepared through the coordination of the Environmental Protection Service (Interior Ministry), under whose general project the Geological Survey is to provide geological and geomorphological base data on the Mediterranean shoreline. Previous projects of the GSI have contributed to the regulation of the exploitation of raw materials in the coastal area (Bakler, 1976; Hall and Bakler, 1975), as a result of which the harmful quarrying of kurkar rock and marine beach and dune sand has practically ceased.

The present project aims at producing an outcrop map to be plotted on the existing 1:10,000 topocadastric series, as well as geomorphological documentation based on high detail oblique aerial photography of the coastal area. Data relating to special environmental problems, such as offshore processes, coastal cliff stability, sand movement, seasonal drainage, etc., will be specially documented in order to enable monitoring and qualitative research. A map and report were prepared for the coastal section north of Haifa Bay. Work is now in progress on the section south of Haifa. The following is a summary of the results obtained, and an outline of the environmental geology problems to be met.

Geological Mapping

Rosh Haniqra – Akko

A geological map showing rock outcrops along 20 km of coastal strip (up to ½ Km wide) at a scale of between 1:6,600 and 1:6,700 was prepared based on rock units chosen on geotechnical rather than stratigraphic grounds. They include:

Loose sand	Calcarenite
Beachrock	Soils and clays
Kurkar	Fill and rubble

Main landscape-forming components are a low, discontinuous kurkar (calcareous sandstone) ridge (8-10 m elevation), parallel to the shore, 10-15 m from the water line. The crest of the ridge has been planed down in the past by littoral processes (Late Pleistocene?), and its western (sea-facing) slope is marked by ledges, a sign of past water lines. Abrasion platforms are observed at some localities at the nearshore foot of the ridge, and similar abrasion platforms form submerged offshore shoals. Rocky shores are often indented by small, wedge-shaped baylets formed by abrasional widening of fissures in the kurkar ridge. These may form compound embayments. Spouters and boomers occur at some localities. Shore hummocks (3-6 m), remnants of the wave-abraded kurkar ridge, occur in places at the water line, forming small but conspicuous promontories. Several canals and seasonal river beds cut through gaps in the kurkar ridge, but have little or no influence on the nature of the beach and swash zone.

A maritime plain, composed of clays and soils, borders the ridge on its landward side and covers its eastern slope, leaving a locally poorly drained strip where the flattened kurkar crest forms a barrier. This maritime plain is fully cultivated and in places quite densely settled. Windblown sand is draped against parts of the ridge's seaward slope. These aprons flatten into beach sands, possibly burying some abrasion platforms at shallow depths. Offshore, sand is seasonally brought and removed on the rocky shoals and in the baylets. Sparse dunes are blown inland onto the maritime plain along gap-facing stretches. In the same stretches, algal calcarenite is found, forming sizeable deposits in the areas of the Betseth, Keziv and Beit Ha'emeq river end courses.

Human activites (quarrying, canaling, roadbuilding, offshore construction) over the last centuries are the strongest landscape-forming factor to shape the coastal strip in the mapped area.

On the basis of geomorphological generalities, the strip was divided into 9 sections:

Rosh Haniqra – Misrefot Yam (~1.2 km).
Sandy shore; outlet of Betseth River (~1.4 km).
Rocky shore; north of Akhziv (~1.9 km).
Akhziv shore (3 subsections) (~1.25 km).
Isasbest – Nahariya (~3.5 km).
Ga'aton River outlet – Beit Ha'emeq River outlet (~2.5 km).
Beit Ha'emeq River outlet – Yasif River outlet (~3 km).
Bustan Hagalil shore (~1.6 km).
Akko city shore (~2.8 km).

Haifa – Ziqim

This stretch of coast, which is to be mapped on the basis of aerial photographs, has to date been only generally surveyed. The map rock units are the same used in the area north of Akko, but they are here further divided:

Loose sand, includes here, mobile dune and stabilized dune;

Soils and clay also include fossil deposits (paleosols) which are mapped as Hamra (sandy to clayey, brown to reddish loams).

The landscape forming components include rocky shoals and nearshore islets; abrasion platforms and terraces; swash zone (mostly sandy, rarely rocky); sand berms; shore escarpment or truncated shore ridge; shore hillocks; crescentic baylets; river gaps; maritime plain (often with a shallow trough behind the shore ridge); and coastal hummocks.

By applying roughly the same landscape criteria, it is notable that changes are considerably more frequent north of Haifa Bay, where the morphological shore sections are short, than from Haifa southward, where uniformity prevails over longer distances. Windblown sand blankets the morphology progressively more toward the south. As mentioned, the impact of human activities on the landscape is strong, and at some localities dominant.

The nearshore landscape from the Carmel promontory southward may be described as a series of low kurkar ridges, the depressions between which have been largely filled by alluvium, mostly soils, which form a maritime plain. Dune sands may cover a sub-Recent (post-Roman) land surface of uncertain drainage, which south of Tel Yona becomes quite hillocky, acquiring a maritime plain character. The most westward ridge, designated as the coastal or shore ridge, may be somewhat higher than the plain behind it and thus forms a trough. Alternately, it may be so subdued as to be imperceptible, or it may be a bold landmark truncated by a bench or escarpment.

The irregular and embayed coasts occur where a partly onshore, partly offshore kurkar ridge is in advanced stages of abrasion. Baylets conform to hamra or clay lenses, projections, coastal hummocks and shoals, to resistant kurkar cores. Tectonism may have played a role in bringing these formerly inshore ridges within the reach of the highly dynamic surf zone, where sand laden surges of winter storms abrade the brittle kurkar at a fairly rapid rate.

According to the relative dominance of one or more given landscape forms, the coast has been divided into the following sections (north to south):

Carmel plain (Shiqmona to Athlith, ~15 km).
Athlith – Dor indented coast (Chateau Pellerin - north of Dor vacation center, ~11 km).
Tanninim – Caesarea plain (Dor - Hadera River outlet, ~16 km).
Giv'at Olga hills, with Alexander River gap (Hadera River - Alexander River outlet, ~7 km).
Sharon escarpment (Alexander River outlet - Tel Yona) with the Poleg and Yarqon River gaps and the Yafo bulge (~47 km; Figs. 1 to 3).
Ashdod hills, with the Soreq-Palmahim interruption and the Lakhish River gap (Tel Yona - Ashdod Yam, ~24 km).
Ashqelon hills (Ashdod Yam - Shiqma River gap ~17 km).

Stratigraphy

The preliminary work to date has in general terms confirmed the stratigraphy established by earlier workers (Issar, 1968). Outcrop stratigraphy is known mainly from the Sharon escarpment where a vertical sequence is evident, with certain limitations on the positioning of the kurkar and hamra (Bakler *et al*, 1972); from top to bottom:

Stabilized Dune: yellow to gray, merging eastward with soils or marshy clays. Artifacts and ostrich egg shells may be found.

Calcarenite: mostly algal, cross bedded, and in places with land snails; often ledge forming (the "Netanya ledge"), wedging out under the maritime plain.

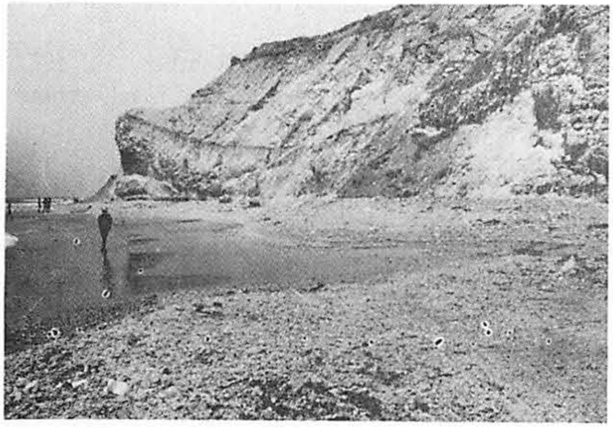

Fig. 1. Sharon escarpment north of Netanya. The Lower Kurkar forms a cliff ending with the dark line of the Lower Hamra (buried land surface). The concave slope consists of Upper Kurkar and Upper Hamra, capped by the calcarenite ledge.

Fig. 2. The Sharon escarpment at its straightest and highest, between Tel Baruch and Herzilia. Narrow belt of beach sand faced by well-developed apron of beach rock. Swash lines reach up to base of scarp. Note sand slide.

Upper Hamra: reddish sandy to clayey loam, in places with an aquatic lamination, in places with a superimposed paleosol profile (leached horizon, clay-enriched horizon, calcareous concretional horizon); contains hearth stones and Epipaleolithic artifacts at top.

Upper Kurkar: Calcite cemented quartzose sands, often eolian cross bedded ("eolianite"), in places massive; cementation loose to strong; mostly laminar in outcrop; very porous, root concretions, sedimentary structures and hamra lenses.

Lower Hamra: sandy, cafe-au-lait colored regolith on the Lower Kurkar.

Lower Kurkar: similar to Upper Kurkar.

The entire exposed series nowhere exceeds 45 m in thickness. In addition, windblown sands form a nearly continuous blanket over the swash zone, and move inland over the maritime plain and the shore hillocks in a series of dune lobes, increasing in volume from Hadera southward. Aprons of beachrock, often of lumachelle (shell-skeletal) composition, trace the waterline along considerable stretches. Collapse debris accumulates at the foot of the escarpment.

Geology

The present survey, besides providing an environmental document for land-use planning, is expected to yield in practical detail a large body of field data which have direct bearing upon geological question, some of them fairly crucial from the land-use point of view. Some of these questions, which have partly been investigated by many authors, are here briefly reviewed.

Fig. 3. Hard calcarenite ledge overlying the paleosol profile of the Upper Hamra. Layers of stabilized dune overlie the rocky ledge. Note how the rocky talus protects the Hamra cliff.

a. The alternations of hamra and kurkar indicate an interplay of environments. Much of the kurkar is clearly consolidated dune (Yaalon, 1967), but some of it is aquatic. The hamras represent both aquatic deposits and paleosols.

The top of the Lower Hamra displays an old buried land surface whose drainage is different from the present one. The burial of this surface by eolian sand (Upper Kurkar) and loams of the Upper Hamra, which contains datable artifacts, indicates a late to post-Plesitocene event of topographic impact. Geological data may supplement archeological finds in reconstructing the environments and events of this period, coinciding with paleolithic and later stages.

b. At many localities the stratigraphic units are truncated in "mid-air" at the coastline. Reconstruction of the missing sections and the establishment of possible reasons for their termination, may be aided by the three dimensional documentation envisaged.

c. The question has often been raised as to whether a tectonic line controls the position and shape of a major part of Israels coastline (Neev *et al*, 1973; Mazor, 1974; Neev, 1975; Neev *et al*, 1978). Beside the above-mentioned seaward terminations, many sedimentary units appear to be vertically displaced (e.g., the calcarenite deposit). The dating and correlation of stratigraphic units, as well as the evidence of geomorphology (fossil drainage, beach features, etc.) may help to resolve the arguments. Naturally the tectonic stability of the coast has direct bearing on land-use planning.

d. Windblown sand appears to be a very young (historical) addition to the present day landscape. Aspects of its onshore behaviour and stability may become clearer through the present study (offshore dynamics of sand movement are being studied by Nir, in preparation).

Though aiming only at documentation, the present project may add data for reconstruction of the latter-day evolution of the Israeli coastline, and provide a base for monitoring active sedimentary, erosional and man caused processes.

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ESTIMATING DISCHARGE FREQUENCY IN ARID GRAVEL STREAMS USING HYDRAULIC GEOMETRY AND GRAIN SIZE DISTRIBUTION

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The aim of this study is to calibrate a method that will permit the construction of discharge-frequency curves for ungaged streams in arid zones through the analysis of their haudraulic geometry and grain-size distribution. These two parameters are being extensively used to estimate discharge, but its frequency of occurrence – which is of prime importance for engineering design – has not hitherto been examined using this type of information. The following are preliminary results of our study, which is being carried out in some gravel - cobble ephemeral streams in the arid Negev of southern Israel.

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