Resource Evaluation of Marginal Lands in Dry Areas

1. Geomorphological Analysis

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Abstract

Meso-landforms of Mt Abdal Aziz region in northeastern Syria, were classified into five units consisting of alluvial plains, fans, steep hillslopes, medium-relief hillslopes and rolling uplands, based on field surveys and aerial photograph interpretation. Each landform unit was analyzed in relation to the topography, lithology, soil properties, vegetation, land use, degradation and surface/ground water status. The strict alignment of the northern fans with landslide scars within the anticline and the presence of shallow valleys on the plain suggest the discharge of infiltrated water into the fan deposits. While in the south, the active deepening and downward water erosion of the fans forming incised valleys suggest an older formation of these fans. The structural similarities between the Mt Abdal Aziz region and Mt Sinjar region in northwestern Iraq suggest a close origin of these large landforms. The significant landscape differences between these two regions reflect the land use level on the vegetation by the local grazing and cropping practices which started in the last fifty years.

Additional key words : geomorphological analysis, landform classification, marginal lands, land use

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Introduction

Within the dry areas, the agriculturally marginal regions which receive an annual rainfall between 200-300mm are highly susceptible to land degradation due to human activities, since both cropping and local grazing are practiced in the same areas using the fragile natural resources.

In such marginal lands of West Asia and North Africa, overgrazing, wood harvesting and inappropriate cultivation practices are commonly threatening soil and vegetational resources with degradation. Therefore, for dry land resource management, it is important to carry out a series of natural/human resource inventories, mapping and further analyses, to develop sustainable agriculture/land use systems within the arid ecosystems while avoiding the degradation problems simultaneously (Fujita, 1993[1]).

Geomorphological analysis enables to elaborate structure, processes and time of the earth surface in a target area. A geomorphological map illustrates landforms in a graphic representation and depicts a wide range of influences of natural processes in the area (St-Onge, 1968[2]).

A comprehensive geomorphological and climatological study of the dry central-southern region of Syria was reported by Abdal-Salam (1966)[3] based on a geological map, a geomorphological map, a large number of morphological diagrams and photographs. However, further analysis incorporating topography, lithology, soil properties, vegetation, hydrology into landforms is necessary to link the above land chracteristics with land use and degradation per landform unit.

The Abdal Aziz Mountain region (hereafter referred as Mt Abdal Aziz rigion) in northeastern Syria is a typical marginal land used for small ruminant production systems by combining barley cropping/rangeland grazing which are widely implemented in West Asia and North Africa.

A series of resource studies was conducted in a selected test zone in the region (40°07'30"-30'00"E, 36° 15'00"-30'00"N) during the period of 1992-1995 to analyze the vegetation, geomorphology, soil, properties, degradation processes and feed resources for animals in such a typical arid marginal region (Fujita, 1996[4]).

Within this series of studies, a geomorphological analysis of the region is described.

The Study Area

Climate

The climate of the test zone belongs to the Mediterranean group characterized by dry summer with high temperature and rainy winter with low temperature, with average maximum and minimum monthly temperatures of 29°C and 5°C in July and January, respectively. The annual precipitation varies considerably year by year within a range of 250-340mm.

Land use

Rainfed agriculture, mainly barley cropping on the plains in the north and south, and on the central uplands is a common form of land use in flat arable lands (Plate 1). Reforestation of degraded rangelands by planting *Pinus spp*, *Pistacia spp*, and *Prunus amygdalus* is being conducted widely on the moderate slopes of the

Plate 1. Barley field on plain (north) and stubble grazing after harvest in May 1994. Stubble grazing based on communal land use continues until early autumn.

anticline in the Mt Abdal Aziz region (Plates 2 and 3). Local grazing on natural rangelands is the sole land use of non-arable lands in the whole region. Mining activities for construction materials can be observed at several sites on the northern slopes of the mountain (Plate 4).

Geology (after Ponomarev *et al.*[5] and local observations)

Most parts of the northern to northeastern plain, the southeastern fans and plain in the test zone are covered by loose Quaternary sediments. These sediments are mainly alluvial deposits composed of carbonatite, clay, gypsum, loam and silt.

The Carboniferous systems are exposed in the river bed of a deeply incised valley, between two footslopes, 701.0m and 693.0m a.s.l., approximately 2km northeast of the highest elevation point (928.51m a.s.l.). These rocks consist of bedded grey shale, brownish fine crystallized limestone and fine grey sandstone.

The Cretaceous systems are widely exposed in the northern depression (north of the highest point) and they consist of mainly compact brown or grey dolomitic limestone, clay and white marl, as shown in Plate 5.

The Paleogene deposits are also developed in the adjacent parts of the Cretaceous systems. They are composed of organic compact limestones distributed widely on the northern slopes, approximately 500m northeast of the 693.0m elevation point, 1km southwest of Al Khazne village. These deposits form a high ridge made of massive reef limestone containing flint nodules and silicified organic remains. The Paleogene deposits are also exposed on the southern slopes of the anticline, as white nummulitic limestone and marly limestone.

The Neogene deposits form outcrops in the eastern, southern and southwestern parts of the test zone, as well as in the widely extended northern landslide scars. These deposits are composed of limestone and marl containing thick gypsum interbedding.

Plate 3. Nursery for trees of *Pinus spp.* and soil preparation in lines (behind)

Plate 2. Reforestation activities conducted on the northern flanks of the anticline (taken during observational flight)

Plate 4. Mining on hillslopes, northern front of anticline (taken during observational flight)

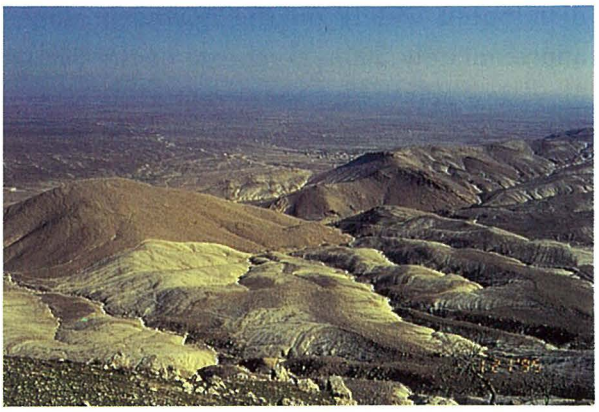


Plate 5. Footslopes and heavily dissected hillslopes in the north by deep narrow valleys. Distinct boundary of two Cretaceous systems; whitish limestone/marl and brownish dolomitic marl/sandstone divided by a fault. Photo taken from the highest elevation point of 928m a.s.l.

Methods

Reconnaissance surveys

Repeated reconnaissance surveys were conducted to obtain general bio-physical information of the test zone in November and December 1992. A geomorphological survey was conducted in January 1993 crossing the test zone in three transects using topographic maps at a scale of 1:25,000, aerial photographs and GPS (Global Positioning System). Two transects were cross-surveyed at 40°08'30" (line E-F in Fig. 1) and 40°18'00" (line C-D) meridians respectively. The third transect was surveyed from 40°30'00"E, 36°27'20"N to 40°24'40"E, 36°20'45"N in a 216 degree direction (line A-B). Significant remarks in topography, lithology, hydrology, soil properties vegetation, land use, degradation and hydrological status were recorded.

Preparatory works

Cross-section and cross-table of the above remarks of the C-D transect were constructed. Subsequent geomorphological analysis of the test zone was conducted using this cross section/table and a series of panchromatic aerial photographs (a scale of 1:45,000) taken in 1972, by applying the stereo-scopic visual interpretation method.

The test zone was classified into meso-landform units consisting of alluvial plains, alluvial fans, steep hillslopes and foot hillslopes, medium-relief hillslopes, rolling uplands, and these landform units were represented in a geomorphological map (a scale of 1:50,000). Micro-landform units of landslide scars, steep slopes, incised valleys, break of slopes, sink holes, small man-made mounds, quarries and fans were also included in the map.

An observational helicopter flight using a conventional 35mm camera and a video camera, a ground truth survey using the aerial photographs and GPS were conducted in June and July 1993, respectively to complete the field analysis, and necessary correction in the mapping was made. With the above local observation, the map and the cross-section/tables were used for the geomorphological analysis.

Results

Physiographic description

The relief of the whole test zone (Fig. 1) and the cross-section/table of the C-D line (Fig. 2) show the meso-landform units of the test zone. The anticline occupies the major part of the test zone and it rises as a range of hills up to approximately 500m above the surrounding plains, which are slightly undulating and interrupted by low (5-8m) small man-made mounds and incised valleys (see Fig. 3).

The incised valleys have gently sloping banks with a maximum depth of 10m and a maximum length of 15km in the test zone. The steep northern hillslopes and comparatively moderate southern hillslopes of the anticline are common in the whole test zone, forming alluvial fans onto northern and southern plains. The former is often bounded by landslide scars with heights of 40 to 50m, cut by deep ravines. The inclination of the southern slopes hardly exceeds 50 degrees and the relief is less rugged compared with the northern slopes.

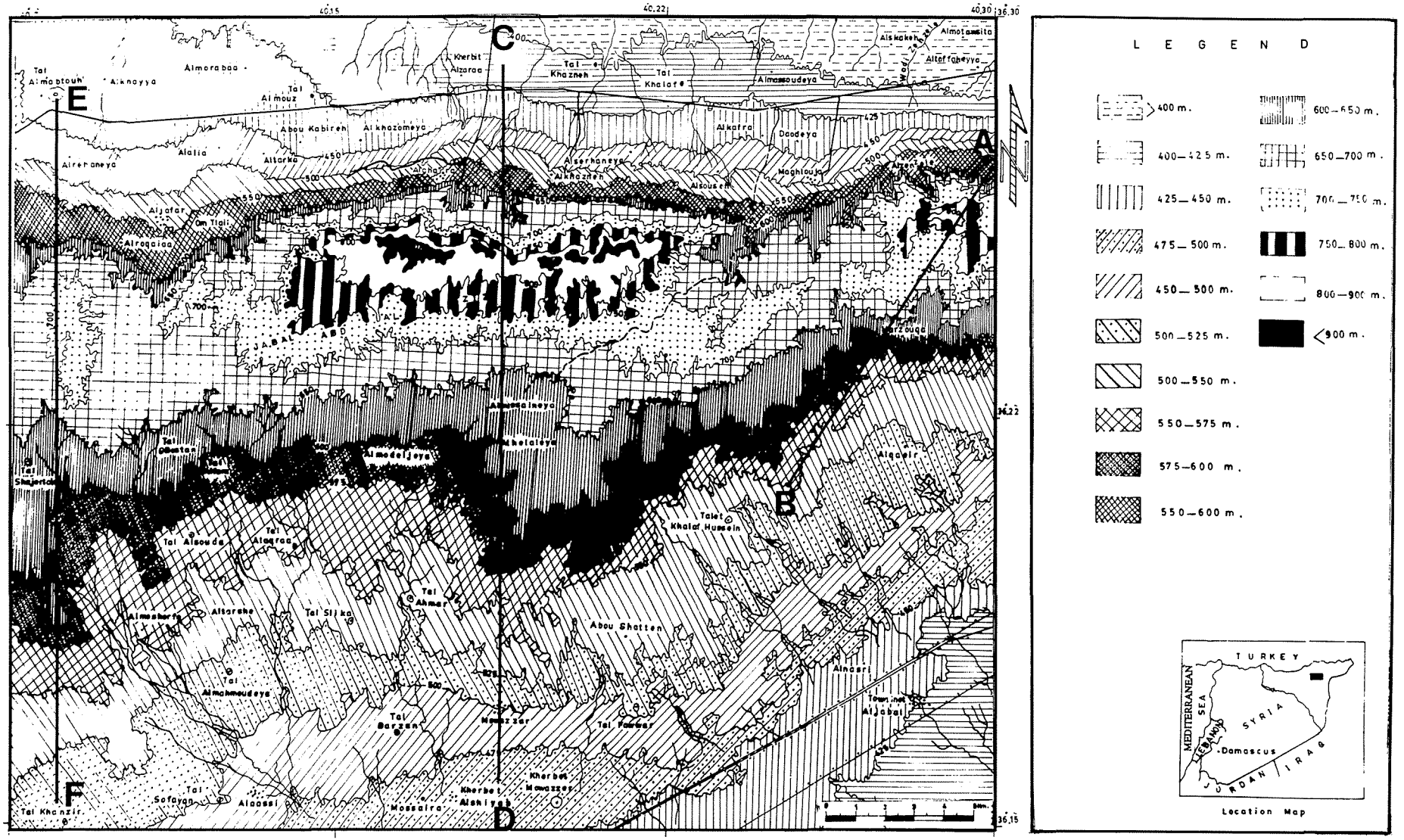
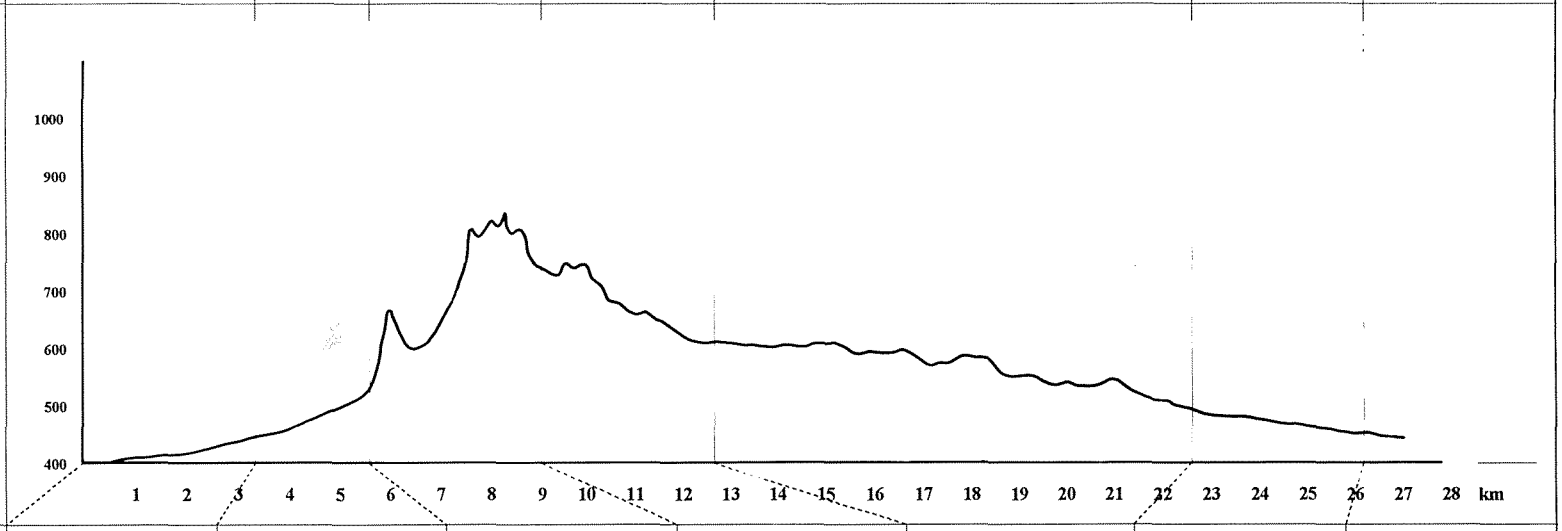


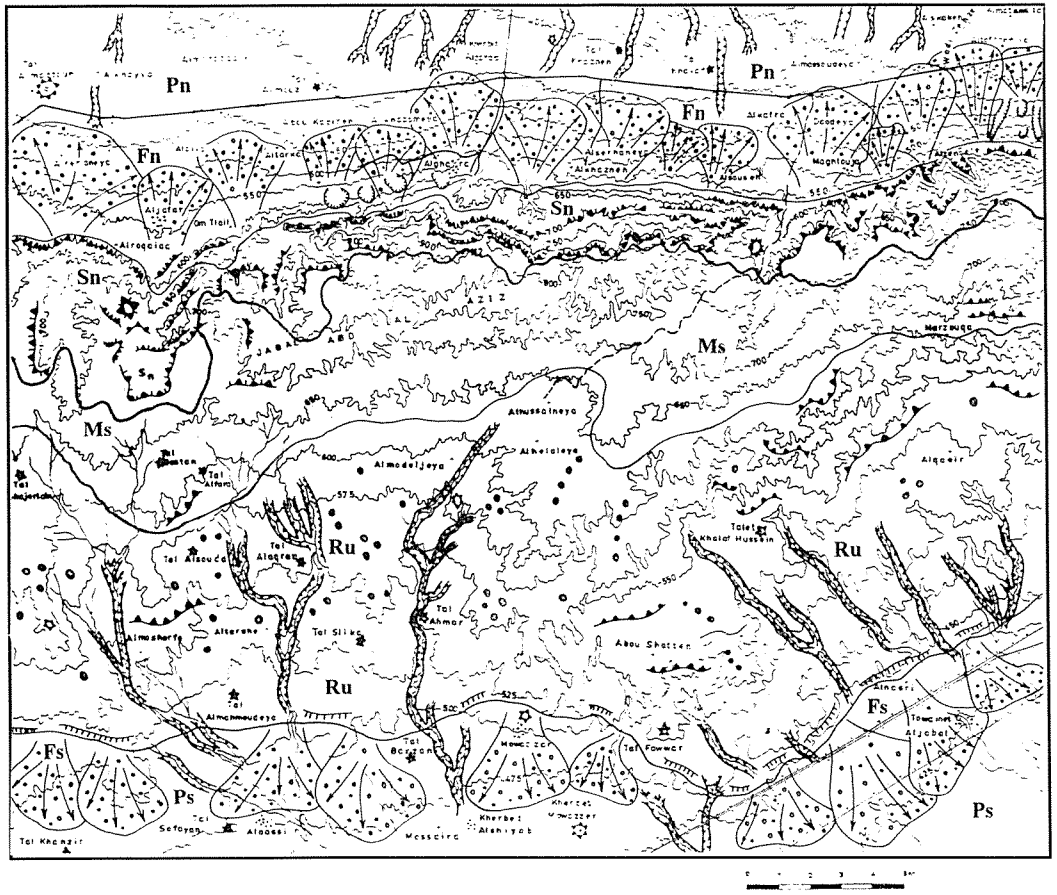
Fig. 1. Relief map of Mt Abdal Aziz test zone, northeastern Syria

Major landforms	Jajireh plain	Abdal Aziz mountain					Jajireh plain
Meso-landform units	Alluvial plain (north)	Alluvial fan (north)	Steep hillslopes	Medium-relief hillslopes	Rolling uplands	Alluvial fans (south)	Alluvial plain (south)
Map symbols	Pn	Fn	Sn	Ms	Ru	Fs	Ps



Topography	Flat plain dissected by valley	Undulating and rolling terrain	Landslide scars cut by ravines	Folded hillslopes, rock exposure	Rolling, active cut&fill by valley	Undulating and rolling terrain	Flat, dissected by deep valley
Lithology	Loose Quaternary sediments	Alluvial deposits of carbonate rock	Crystallized limestone sandstone	Paleogene chalky limestone	Gypsum, marl, clayey limestone	Marly limestone, gypsum	Debris, alluvial loam, silt
Soil	Calcixerolic xerochrepts,deep	Calcixerolic xerochrepts, stoney	Lithic xerothents, rock outcrops	Lithic xerothents, rock outcrops	Calcixerolic xerochrepts, deep	Calcixerolic xerochrepts, stoney	Calcixerolic xerochrepts deep
Vegetation	Barley fields	Shrubs, medium density	*Pistacia khinjuk*, sparse shrubs	Sparse shrubs, herbaceous spp.	Barley, medium-sparse shrubs	Barley fields	Barley and fallow fields
Land use	Rainfed agriculture/cropping	Rangeland, controlled grazing	Rangeland,uncontrolled grazing	Rangeland,uncontrolled grazing	Cropping, controlled grazing	Rainfed agriculture, cropping	Rainfed/irrigated agriculture
Degradation	Slight water erosion	Slight-moderate water erosion	Severe water erosion, landslides	Slight-moderate water erosion	Moderate water erosion	Slight water erosion	Slight water & eolian erosion
Surface/ground water	Near surface water (15-20m)	Infiltration zone, spring/streem	Ground water in joints	Ground water in joints	No surface water, +150m depth	Infiltration, no surface water	Near surface water possible

Fig. 2. Cross section of C-D transect and cross table of land characteristics for each meso-land form unit



Meso-landform units

Pn	*Alluvial plain (north),* **flat to rolling terrain, loose Quaternary sediments (loam, gravel and silt), slight water erosion, dissected by shallow valleys**
Fn	*Alluvial fans (north),* **low fans of alluvial deposits and carbonate rocks, slight to moderate water erosion, moderately dissected, aligned with landslide scars**
Sn	*Steep hillslopes,* **very steep, crystallized limestone and sandstones, severe water erosion, highly dissected by deep narrow valleys with flat river bed**
Ms	*Medium-relief hillslopes,* **folded hilly terrain, Paleogene chalky limestone, heavily dissected with deep ravines, active water erosion and valley incision**
Ru	*Rolling uplands,* **moderately to gently sloping, gypsum, marl and clayey limestone, active downward erosion and deepening by incised valleys, sinkholes and man made low hills widely present**
Fs	*Alluvial fans (south) of older age,* **being deepened by incised valleys, marly limestone and gypsum**
Ps	*Southern plain,* **nearly flat, debris, alluvial loam and silt, slightly dissected by incised valleys, slight water and eolian erosion**

Micro-landform units

Landslide scar
Steep slope
Incised valley
Break of slope
Sink hole
Man-made mound
Quarry
Alluvial fan

Fig. 3. Landform classification map of Mt Abdal Aziz test zone, northeastern Syria

Landform Classification

Geomorphological map of the Mt Abdal Aziz test zone is shown in Fig. 3.

Alluvial plains (north) (denoted as Pn):

The northern plain covers a north-border of the test zone along the northern slopes of the Abdal Aziz anticline. The plain consists of gently undulating and rolling terrain, composed of clay, silt and pebbles, and is partially dissected by shallow incised valleys (Plate 6).

Alluvial fans (north) (denoted as Fn):

Alluvial fans develop where a distinct boundary occurs between the mountainous structure and the surrounding plains. These fans vary in morphological extent, size, shape, gradient, drainage density, vegetation cover and rock types (Plate 8).

Steep hillslopes (denoted as Sn):

These slopes are characterized by very steep scarps showing sharp edges with landslides, rills and rockfalls as shown in Plate 9. These slopes occur on the northern front of the range.

The terrain is mainly composed of crystallized limestone and sandstone. The terrain is subjected to severe water erosion and is markedly dissected by deep narrow valleys of a flat river bed filled with rounded boulders and cobbles. The distinct forwarding hill structures between the hillslopes and the alluvial fans consist of foot-slopes as shown in Fig. 2 and Plate 5.

Medium-relief hillslopes (denoted as Ms):

The landform is aligned with the landslide scars in the north, and with the 600-650m isolines in the south. This region is characterized by the presence of widespread rock outcrops and sparse *Pistacia khinjuk* species as shown in Plate 10. The exposures of mother rocks with a different inclination are mainly composed of hard chalky and dolomite limestone with interbedded and

Plate 7. Rainfed barley fields on alluvial plain south of Mt Abdal Aziz. Banks of incised valleys and other non-arable lands are used as natural rangelands (taken during observational flight).

Plate 6. Landscape of villages on alluvial plain north of Mt Abdal Aziz. Reforestation site on center right (taken during observational flight).

Plate 8. Landscape of steep hillslopes and alluvial fan developed in the center. Small mounds front developed by mining.

highly weathered marl.

Rolling uplands (denoted as Ru):

The southern border is aligned with the break of slopes. These landforms are gently sloping from the hilly and undulating medium-relief hillslopes. These moderately dissected terrains are characterized by the presence of widespread sinkholes (Plate 11), karsts, sheet and gully erosion. The main rocks consist of gypsum, marl and clayey limestone. Active deepening/ downward erosion by incised valleys is common in this landform (Plate 12).

Alluvial fans (south) (denoted as Fs):

Active deepening by incised valleys develops on alluvial fans formed in older ages. Undulating and rolling terrain is composed of marly limestone and gypsum. There is no distinct footslope formation in the region.

Alluvial plain (south) (denoted as Ps):

The plain is nearly level and composed of Quaternary sediments consisting of loam, silt and debris. It is slightly dissected by incised valleys which extend over larger distances compared with those in the northern alluvial plain (Plate 7). Slight water and eolian erosion are observed.

Plate 9. Landscape of landslide escarpments and steep hillslopes with dense cover of *Pistacia khinjuk*

Plate 11. One of the sinkholes widely present in rolling uplands

Plate 10. Medium-relief hillslopes with sparse vegetation cover of herbaceous species and scattered Pistacia khinjuk

Plate 12. Active deepening by an incised valley. Upper part represents medium-relief hillslopes with sparse *Pistacia khinjuk* cover. Lower part represents rolling uplands with sparse vegetation cover

Discussion

Landform development

The landform classification and mapping revealed the structural differences in landform development and the processes of alluvial fans and incised valleys in the north and south of the test zone. Since the alluvial fans in the north developed in boundaries where distinct structural changes occurred, the formation is strictly aligned with the landslide scars and the steep slopes in the north. This fact indicates the young stage of the theoretical cycle of arid geomorphology mainly due to pediplanation (Davis, 1905[6]). The location of the shallow incised valleys, north of the alluvial fans, indicates the discharge of infiltrated water through the fans while the geomorphological alignment of these meso-landforms in the mountain front suggests the contemporary origin of the landform units.

In contrast the active downward erosion/deepening by incised valleys in the south particularity in the rolling uplands, larger in size and extent than those in the north, and the active dissection of alluvial fans, suggest the recent formation of these valleys into older structures. The complex landform in the south supports the presence of the composite cut-and-fill surfaces of low relief in dry areas (Maxson, 1968[7]).

Structural similarities between Mt Abdal Aziz and Mt Sinjar regions

The geomorphological characteristics of the Mt Abdal Aziz region described above show significant similarities to those of Mt Sinjar anticline and surroundings located in the western border of Iraq, approximately 80km east (the nearest distance) of the Abdal Aziz anticline.

The Abdal Aziz mountain shows a latitudinal trend of its stretch for approximately 85km west to east, and extends over 15km north to south, with an asymmetrical pattern in east-west oriented folds. A similar structure is observed in the latitudinally asymmetric fold approximately 75km and extending over a 12km width for the Sinjar anticline (Al-Daghastani, 1989[8]).

The common geomorphological characteristics of both anticlines are as follows;

1. deep edges of the landslide scars in the northern flank combined with steep slopes,
2. relatively gentle southern slopes with active gully erosion and hogback-like exposures,
3. active downward erosion by recently developed incised valleys onto alluvial fans and surrounding Quaternary plains.

The exposure of the oldest rocks of the Late Cretaceous age and the other stratigraphic similarities indicate the close origin of the two anticlines, which is supported by the geographical vicinity and by the distinct east-west oriented folds of the Taurus trend of the Alpine Orogeny (Dunnington, 1958[9]). The orientation of these two anticlines was also illustrated in a diagram of anticline map of Syria (Abdul-Salam, 1966[3]), while the anticlines in the central-southern Syria (Palmyra to Damascus) show a distinct northeast-southwest orientation along the Anti-Lebanon chain.

Landscape differences between Mt Abdal Aziz and Mt Sinjar

These structurally similar anticlines differ mainly in their landscapes, particularly in the vegetational cover which might be closely associated with the past and present land use of the regions.

The comparatively rich vegetational cover of an association of native *Pistacia khinjuk* trees and vigorous growth of *Artemisia halba-alba* on alluvial plains in the northern part of the Sinjar anticline (Gintzburger, unpublished[10]), suggested a very low level of the vegetational resources to the local grazing and possible low degree of shrub cutting for fuel, which is limited to the highest elevation areas of Mt Abdal Aziz (Batticha and Fujita, 1994[11]; Plate 9).

The poor herbaceous/shrub species cover with the lack of trees on the northern hillslopes of Mt Abdal Aziz (Plate 9) suggests a high level of land use by local grazing (Hirata and Fujita,

1994[12]), and shrub cutting. These activities presumably started less than fifty years ago when the low level use of nomadic grazing was replaced by the high level use of cropping by the contemporary settlers on the plains (Hole and Kouchoukos, 1994[13]).

The unique presence of dense *Pistacia khinjuk* stands on the steep hillslopes near the peak of Mt Abdal Aziz and the rather sparse but large coverage of the species on the medium-relief hillslopes (Plates 9 and 10) might be associated with the low accessibility for tree logging.

The moderate density of shrub species in the alluvial fans in the north under controlled grazing practiced by the local community (Fig.2) also suggests that the variation in landscape/plant cover may have been caused by the grazing intensity.

Conclusions

The geomorphological analysis enabled to classify Mt Abdal Aziz test zone into five meso-landform units, reflecting the differences in landform development and dissection processes in the region. The analysis also suggests the effect of recent land use level which is evident in the differences in landscape and vegetation cover. Further investigations on soil and land degradation processes are necessary.

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乾燥地域の農業限界地における資源評価・解析

1　地形学の解析

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摘　要

現地踏査および空中写真判読により北東シリアのアブダル・アジズ山試験地域における中地形を沖積平野，扇状地，急丘陵斜面，中起伏丘陵斜面および波状台地に分類し，地形学図を作成した。さらに，それぞれの中地形単位は起伏型，岩型，土壌型，植生，土地利用，荒廃および地表・地下水状況と関連づけて解析した。試験地域北部に見られる扇状地の列は，崩落崖北側に厳格に沿っていること，さらに扇状地の北側に広がる北部沖積平野には比較的浅い河谷が存在することにより，扇状地での地下水浸透帯と平野での浸出といった地形の現在における活発な形成が推測される。これとは対照的に南部扇状地帯の穿入谷による下刻の進行および浸食作用はこれらの扇状地が現在の河谷より早い時代に形成されたことを示す。アブダルアジズ山地地域およびイラク北西部のシンジャー山地地域の構造的な類似性から両山地形成に緊密な関連があると推測された。両地域の北側平野地帯における景観の相違は土地利用の程度，すなわち過去50年の間に始まったとみられる耕作および放牧による土地利用の程度の差が両山地の植生に顕著な相違をおよぼしたものと推測された。

キーワード：地形学の解析，地形型の分類，農業限界地，土地利用

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