

**Investigation of Geomorphological Forms of Goyjah Bel Basin in Ahar Plain****Investigação de Formas Geomorfológicas da Bacia de Goyjah Bel na Planície Ahar Plain**

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**Abstract**

Geological and geomorphological studies as the basic studies, play a key role in watershed, soil protection and flooding management projects. Goyjah Bel basin is located ten kilometers southwest of Ahar County. The study area is a part of Aharchay River watershed, which joins Qarah Su River and then Aras River. The mentioned basin is located in the structural zones of Alborz and Central Iran and is composed of various rock-sedimentary units due to its vastness and geographical location. The morphological appearance of this basin is affected by two mentioned zones and the trend of structures in the northwest-southeast region. In the formation of these structures, factors such as the collision of Iranian and Turan plate, the performance of thrust faults and finally the performance of northwest-southeast strike-slip faults have played a role. The morphology of the basin mainly includes mountains and hills. This was a descriptive and analytical research based on field and library studies. Spatial data of this research included the satellite images, topographic maps (1:25000), aerial photographs and geological maps (1:100000) which the types, units and facies of geomorphology were determined by them. In the study area, three units, three types and seven geomorphological facies were identified. The most dominant geomorphological unit was Hill unit with an area of 3665.1 hectares, occupying 49% of the total basin. In addition to the Hill unit, the mountain unit also has a very large area, but the plain and river unit covers a small area. Various morphological forms in the study area include anticlines, synclines, alluvial cones, sedimentary dams, canals, ditches, grooves, landslides and various types of canal wall collapse movements.

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**Keywords:** Basin; Plain; Geomorphology, Facies, Ahar Plain, Hill.

### Resumo:

Os estudos geológicos e geomorfológicos, como estudos básicos, desempenham um papel fundamental em projetos de bacias hidrográficas, proteção do solo e gestão de inundações. A bacia de Goyjah Bel está localizada dez quilômetros a sudoeste do Condado de Ahar. A área de estudo faz parte da bacia hidrográfica do rio Aharchay, que se junta ao rio Qarah Su e ao rio Aras. A bacia mencionada está localizada nas zonas estruturais do Alborz e do Irã Central e é composta por várias unidades rochosas-sedimentares devido à sua vastidão e localização geográfica. O aspecto morfológico desta bacia é afetado por duas zonas mencionadas e pelo movimento de estruturas na região noroeste-sudeste. Na formação dessas estruturas, fatores como a colisão das placas Iraniana e Turan, o desempenho de falhas de empuxo e, finalmente, o desempenho de falhas de ataque-deslizamento noroeste-sudeste têm desempenhado um papel. A morfologia da bacia inclui principalmente montanhas e colinas. Trata-se de uma pesquisa descritiva e analítica baseada em estudos de campo e bibliotecários. Os dados espaciais desta pesquisa incluíram as imagens de satélite, cartas topográficas (1.25000), fotografias aéreas e cartas geológicas (1.100000) cujos tipos, unidades e fácies da geomorfologia foram por eles determinados. Na área de estudo foram identificadas três unidades, três tipos e sete fácies geomorfológicas. A unidade geomorfológica mais dominante foi a unidade Hill com área de 3665,1 hectares, ocupando 49% do total da bacia. Além da unidade de Monte, a unidade de montanha também possui uma área muito grande, mas a unidade de planície e rio cobre uma área pequena. Várias formas morfológicas na área de estudo incluem anticlinais, sinclinais, cones aluviais, barragens sedimentares, canais, valas, sulcos, deslizamentos de terra e vários tipos de movimentos de colapso da parede do canal.

**Palavras-Chave:** Bacia; Planície; Geomorfologia; Facies; Planície de Ahar; Morros.

### Introduction

The surface of earth is made up of various shapes that are constantly changing and developing. Two categories of external and internal factors play a decisive role in the evolution of these forms. Internal factors cause the formation of the primary structure and external factors cause erosion, deformation and destruction of these forms (Mousavi Harami, 2007). Climate change increases or decreases vegetation, changes the amount of runoff, sediment load of rivers, the erosion processes on the surface, and consequently changes the landform. Climatic conditions and the amount of water available have a direct effect on factors such as weathering, sediment

production and vegetation (Keller and Pinter, 1996; Harvey, 1999). Lithology and resistance of rocks to various weathering factors are directly involved in providing sediments. The role of tectonic factors and sedimentation in the formation and evolution of morphology of different regions is important (Keller and Pinter, 2002; Li, 2000; Ritter et al., 1996; Walker, 2006; Harvey et al., 1989; Goswami et al., 2004; Harvey, 2012).

The most important factors forming a basin are tectonic (morphotectonic) activities that operate on a large scale and control the process of folds. Large and small anticlines and fault and joint systems are the result of these factors' effect. Most earthquakes occur with the movement of rock masses on the fault surface. Such seismic movements in geomorphological zones cause the special conditions (repetition and sequence) to be dangerous (Shayan and Zare, 2011).

In this study, the relationships of sedimentology, geomorphology and effective processes in them as well as their morphological forms, units and facies in the Goyjah Bel area have been studied. This relationship is investigated by remote sensing studies, tectonic morphology and sedimentology that have been affected by tectonic activity and faults in the region.

#### Geographical Location and Ways to Access the Study Area

Aharchay Basin is located in the geographical coordinates of 20' 46° and 30' 47° east longitude and 20' 38° and 45' 38° north latitude from west to east. The study area is located in the southwestern part of Ahar plain and is a part of the basin of Aharchay river (Figure 1).

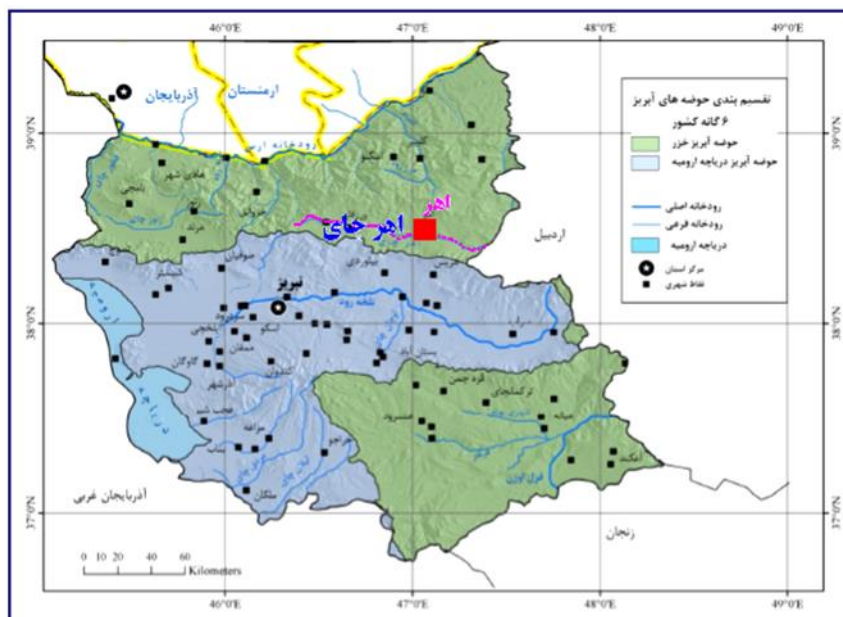


Figure 1 - The position of Aharchay basin in the division of six basins and rivers feeding them área.  
 Source: Authors (2022).

The main access road to this area is the main Tabriz-Ahar Road, which enters from the south of the basin in the area of Goyjah Bel pass in a south-north direction and exits in the northeast direction of the basin exit area of (Figure 2). The morphology of the basin mainly includes mountains and hills, and there is only the river from the geomorphology unit of the plain and river. According to Amberje method, Goyjah Bel basin has a cold semi-arid climate with an average rainfall of 342.2 mm per year.

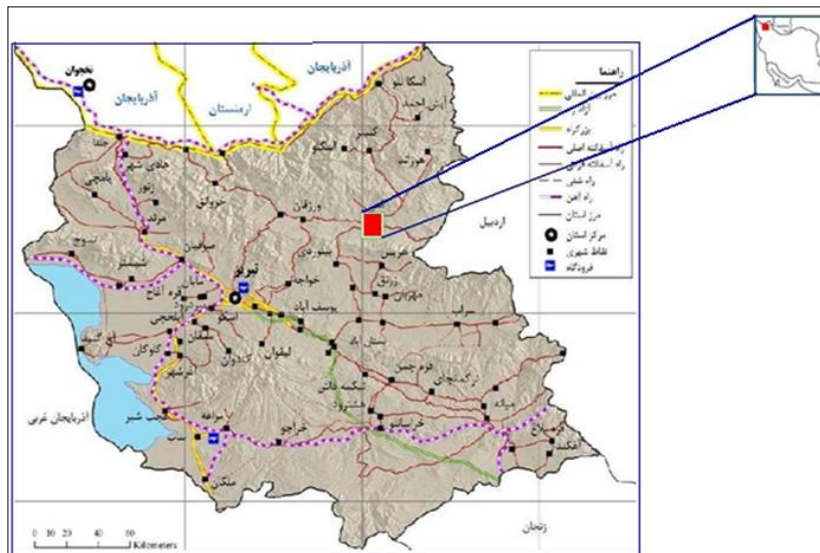


Figure 2 - Communication channels of the study área.  
 Source: Authors (2022)

### Method of Study

Information and data available to study the target area include the spatial data from satellite imagery, topographic maps (1:25000), aerial photographs (1:40000) and geological maps (1:100000), as well as library documents and resources, statistics information and data obtained from field studies. This research is generally done by analytical-descriptive method and with reference to field and library studies. Theoretical and library studies have been selected mainly to study the literature review and the research background, as well as to achieve a suitable framework for studying the subject and views related to it. Since a part of the research was to examine the current situation, then the study method of this part is a descriptive method. On the other hand, since the relationship between factors such as geomorphology and the factors affecting them has been studied, then in this section, a prospective analytical method is used. Geological maps, topographic maps, aerial photographs and satellite images of the study area were collected.

Then, the study basin was limited and specified on topographic maps, and finally, a geomorphological map of the area was prepared through the available information.

### GEOLOGICAL STUDY OF THE AREA

Ahar plain is located in the northwest of Iran and between two mountains of Qara Dagh in the north and Arasbaran in the south and its floor height varies between 800 and 1400 meters. This plain is structurally a tectonic and subsidence hole that subsides between two southern and northern faults of Ahar with different downward views and assumes the graben mode; In the geological map section of 1: 250,000 Ahar, the Ahar hole is presented as a syncline. The southern part of the plain has a relatively good smoothness and as we move northwest, the wavy hills connect the uniformity of the plain. Ahar plain is in the form of a long rectangle that has a gentle slope from northwest to southeast. Aharchay river passes through this plain while maintaining the trend of the hole and in this way, it has formed stepped surfaces on its sides. Young alluvial deposits mainly cover the bottom of this plain.

According to the division done by Nabavi (1976), Goyjah Bel basin is a part of the western Alborz zone. The study area has platform conditions in terms of tectonic events during the Paleozoic period, such as Central Iran and Alborz, and low-lying continental marine sediments have been accumulated across it. The main cause of these conditions can be imagined in the stability of Baikalin rock due to Katangai orogeny phase. Deposits in this area have continued until after the Jurassic, and only terrestrial (epirogenic) movements have caused the lack of sedimentation that have been related to the Ordovician, Silurian and Carboniferous periods. The volcanic rocks of the region, which are mostly of andesite type and different types of pyroclastic materials with Eocene, have been formed due to the pyrene orogenic phase and are probably a part of the Sahand-Bazman volcanic belt.

The diversity of rock-sedimentary units in Goyjah Bel basin is so great and a series of volcanic and sedimentary rocks along with alluvial units are located next to each other. The southwest of the basin is composed of sediment-like sediments, the southern part of which includes volcanic rocks and pyroclastic rocks, and in the north of the basin a combination of these

two units can be seen in the vicinity. The central, eastern and western parts of the basin also include the PIQC conglomerate unit and the alluvial unit for agricultural and horticultural use. Volcanic and pyroclastic units in the north of the basin, like sedimentary units, show a sequence in the order of the units' age, which are compatible with the southern units of basin. The lithological units of the study area are: K-Pef Flysch unit, Pec conglomerate unit, Pesh unit, Pe1 unit, Unseparated pyroclastic EV1 unit, volcanic unit,  $E_1^{an}$   $E_1^{da}$  volcanic unit,  $E_1^{t2}$  unit, EL1 unit,  $E_2^{an}$  unit,  $E_2^{ta}$  unit,  $E_2^{t2}$  unit, EL3 unit, Md plutonic unit, Pliocene Conglomerate Unit (PIQC), Young Alluvial Terraces (Qt3), Young Convex Alluvials (Qf), River alluvial unit (Qal)

### GEOMORPHOLOGICAL STUDY OF THE AREA

Geomorphology is the recognition of forms resulting from the influence of internal and external forces on the earth's crust, which can include the mechanisms of creation and evolution of these forms and the effect of secondary factors on them (Refahi, 2003). On the other hand, many features of the physiology of a basin are influenced by geomorphology. Therefore, issues related to geomorphology are important (Rostamizadeh, 2004). The most important factors forming a basin are tectonic (morphotectonic) activities that operate on a large scale and control the process of folds. Large and small anticlines and fault and joint systems are the result of these factors. Simultaneously with tectonic and tectonic processes, climatic processes (morphoclima) have entered into action and depending on the latitude of the region, altitude of different parts of the basin, nature and genesis of existing formations (morphogenesis) and the existence of weaknesses resulting from tectonic processes, the erosion and degradation begin at the basin level (Schumm, S.A., (1987) Lepera, E., and Sarriso-valvo, M., 2000). In this study, first the forms obtained from morphological processes in Goyjah Bel basin are investigated and finally the types, units and facies of the study area are described.

### FORMS RESULTING FROM GEOMORPHOLOGICAL PROCESSES IN THE GOYJAH BEL BASIN

#### *STRUCTURAL GEOMORPHOLOGY (FORMS RESULTING FROM TECTONIC ACTIVITY)*

According to the construction geology, there are several folds, faults and joints in the study basin (Figure 3). Very few faults are exposed in the basin due to the small size of the basin and the fact that most of it is covered by agricultural lands, and because tectonic events occur on a regional scale; Since the tectonic events occur on a regional scale, several faults adjacent to the basin have been used to detect forces entering the region. The predominant extension of the region's faults, as predicted, is northwest-southeast. Regarding the trend of the main and conjugate faults in the region, the main normal force acting on it should be along the northeast-southwest, which is due to the movement of the Arab block towards the Iranian plate. There are several faults in the vicinity of the basin, the most important of which are Tabriz and Khajeh faults, which are briefly described.

#### *TABRIZ FAULT*

Tabriz Fault is one of the linear structures of Iran that can be traced in a length of 100 km from Mishu Mountains (in the west) to Bostan Abad (in the east). Its best effect is seen in the immediate north of Tabriz; That is why it is called Tabriz fault. Its general trend is north 115 degrees east and its slope is vertical. The Tabriz fault passes through the south of the basin (outside it) with a northwest-southeast trend. Regarding the relatively short distance of this fault to Goyjah Bel basin (75 km), the seismic activity of this fault in the basin is noticeable and can have destructive effects on the structures constructed in it.





Figure 3 - Joints and gaps in andesitic lavas of unit  $E_1^{t2}$ .  
Source: Authors (2022).

### *Khwaja Fault*

It is an inverted fault, which passes from the north of Khajeh village with a northwest-southeast trend. This fault is the same with the trend of Tabriz fault and is located 50 km south of the basin. The slope of this fault is to the southwest and its mechanism is compressive and reverse. In the direction of this fault, Miocene deposits have been pushed on top of each other.

### *Erosive Geomorphology (Forms of Erosion)*

Tectonic activity leads to the initial formation of the basin. Simultaneously or continuously with them, erosion that is affected by the climate and the type of rocks, enters into action and begins to destroy the surface of the basin. Basin heights, soft formations, faults and fractures are prone to erosion. In the study of basin erosion and the resulting problems, cases such as eroded slope, problems resulting from various slip slides, width and density of waterways are considered (Figures 4 and 5).



Figure 4: Groove erosion in the aerated section of Pesh shales in the Goyjah Bel pass (west view).  
 Source: Authors (2022).

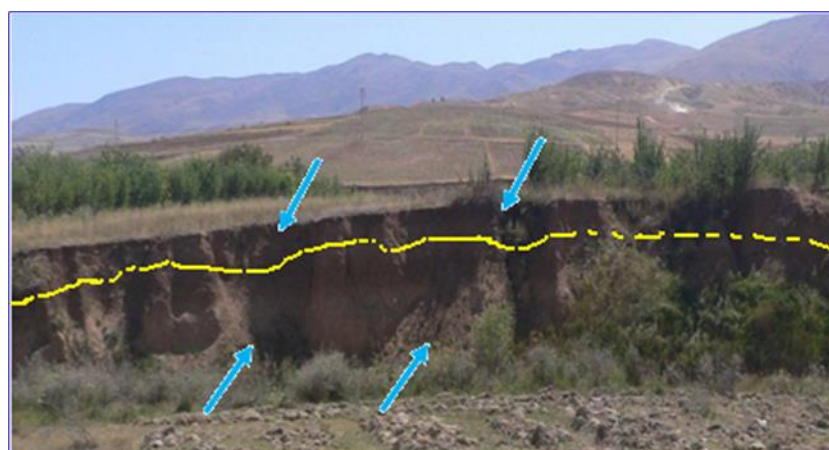


Figure 5: Erosion along the river in the alluvial terraces of Goyjah Bel River in the north of the basin.  
 Source: Authors (2022).

### *Sedimentary Geomorphology (Forms Resulting from Sedimentation)*

Sediments resulting from erosion of formations at high altitudes are transported and deposited by streams and canals to the lower energy parts of the basin. These sediments have been seen in different shapes and sizes and different mechanisms have caused their formation (Figure 6).

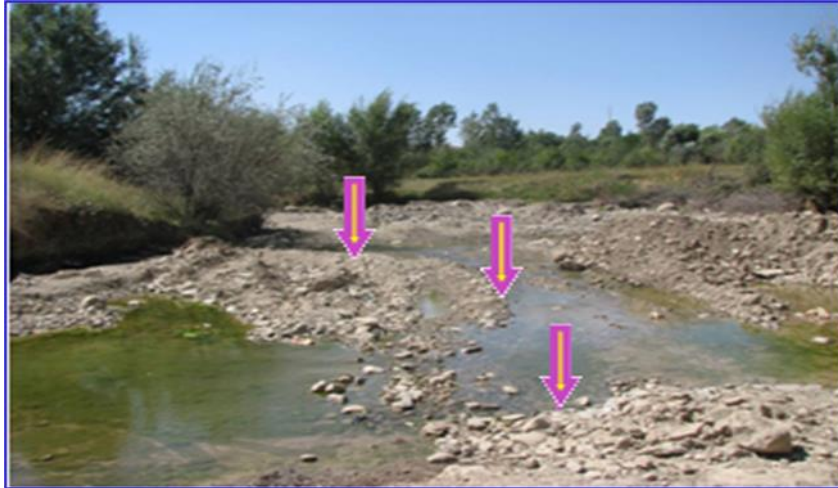


Figure 6: Alluvium of Goyjah Bel riverbed resulting from the erosion in the north of basin.  
Source: Authors (2022).

### Geomorphological Units, Types and Facies

To determine the units, types and facies of geomorphology in Goyjah Bel basin, the aerial photographs and topographic map of these units and types were initially identified through the photogeology. Then the area and type were corrected and drawn with field trip. Accordingly, three units, three types and seven facies were identified in the study basin, and the specifications of which are presented in Tables 1 and 2.

The most dominant geomorphological unit in the study area is Hill unit, which has an area of 3665.1 hectares, occupying 49% of the total basin. In addition to the Hill unit, the mountain unit also has a very large area, but the plain and river units have a small area (Figure 7). Each of the units, types and facies of the basin is described in the following section.

#### *Geomorphological Types of The Region*

##### *Regular Slope Type (R)*

In this type, the slopes have gradual or steep changes in slope. One of the reasons for the formation of this type is the compatibility of the layering surface with the ground and the compliance of the earth slope with the layering slope. Regarding the high percentage of rock outcrops of this type (25 to 75%), rock protrusion facies has been considered for it. In the facies,

the waterways are branched. This type exists in both mountain and Hill units. In some areas, due to the steep slope of slopes and weak runoff, debris from volcanic lava remains in place and has formed a regular slope type, including a part of the mountains south of the basin.

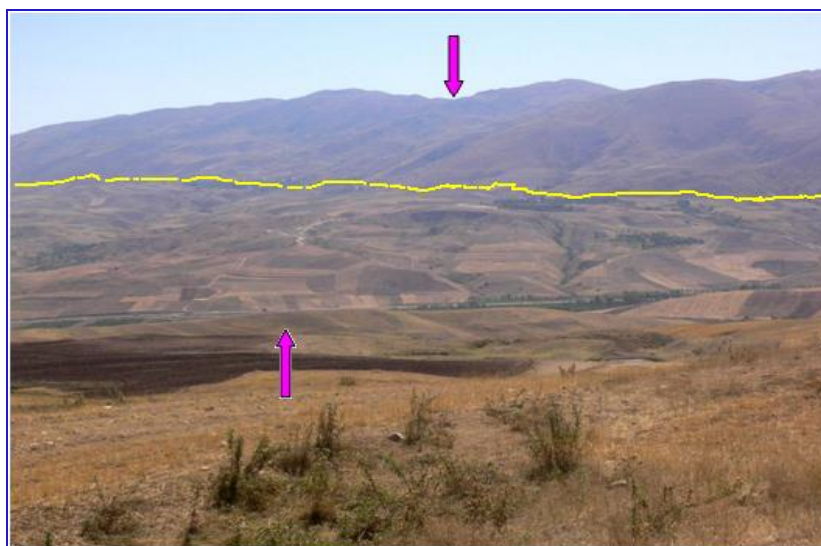


Figure 7 - General morphology of Goyjah Bel basin, which mainly includes mountain unit and Hill (view to the south).

Source: Authors (2022).

### *Irregular Slope Type (I)*

Irregular slopes in volcanic units are caused by different joints, fissures and erodibility of its minerals. Minerals such as quartz, for example, are more resistant than feldspars. This type, which is located in the south of the basin, has slopes with variable slopes that suddenly increase and decrease. The reason for the formation of this type is seams and cracks and heterogeneity of stone structures. On one hand, pyroclastic lavas or sedimentary units are composed of different lithologies, and on the other hand, in the structure of lavas, there are various minerals such as ferro magnesiennes minerals that are more sensitive to weathering and erosion. It should be noted that landslides topography, faults and tectonic activity of these irregularities have intensified these irregularities.

*Mountain Unit (m, M)*

This unit extends only in the south of the basin and its total area is 3317.6 hectares. The average slope of its slopes is 20 to 80% and its height difference from the floor of the basin main waterways is at least 200 meters. The lithology of this unit in the south of the basin includes volcanic, sandstone, shale, conglomerate and cretaceous limestone units.

In some areas of the basin where the destructive coverage of the mountain was less than 25% (rock mass), mountain unit is indicated by the sign M and if the rock outcrop of this unit was less than 75% (destructive cover more than 25%), it is indicated with the sign m. The mountain unit is divided into two types of regular slope (r) and irregular slope (i) based on its slope status (Table 1).

Table 1 - Guide for determining the unit code, type and facies of a geomorphological map.

<i>Code type</i>	<i>Exclusive code</i>	<i>Description of code</i>
<i>Geomorphological unit</i>	<i>M</i>	<i>Mountain with less than 25% destructive cover (rock mass)</i>
	<i>m</i>	<i>Mountain with rock outcrops less than 75%</i>
	<i>H</i>	<i>Hill with less than 25% destructive cover (rock mass)</i>
	<i>H</i>	<i>Hill with rock outcrops less than 75%</i>
	<i>Q</i>	<i>Plain and river</i>
<i>Geomorphological type</i>	<i>I</i>	<i>Irregular slop</i>
	<i>R</i>	<i>Regular slop</i>
<i>Geomorphology Facies</i>	<i>O</i>	<i>Rock outcrops between 25 to 75% (average 50%)</i>
	<i>C</i>	<i>Surface covered with in situ and misplaced debris cones and soil (colloquium)</i>

*Rock Outcrop Facies in Mountain Unit (mio)*

This facies also refers to a variety of rock outcrops, which on average about 50% of their surface is covered with sparse destructive deposits and debris (between 25 and 75% of colloquium cover). These areas can be understood through adapting the geomorphological map with the topography and the slope map and adapting the steep and peak areas as rock outcrops. This facies occupies 16.5% of the total area of the basin and in the south of the basin includes three separate areas in the basin heights. One of the reasons for the formation of this facies is the occurrence of landslides in the destructive cover of the basin heights (Table 2).

Table 2 - Geomorphological units, types and facies in Goyjah Bel basin.

unit	type	facies
<i>Mountain</i>	Irregular slop with sign i	mio: Irregular slopes with rocky outcrops, both parallel and branch drainage pattern forms and debris facies in colluvial areas (coverage of discrete materials between 25 and 75%)
	Regular slop with sign r	mrc: Regular slope in mountain unit with thick cover of detached materials, branch drainage pattern and plant and shrub density
		mro: Regular slope in mountain unit with high rock outcrop between 25 to 75% and branch and parallel drainage pattern
<i>Hill</i>	Regular slop with sign r	Hrc: Regular slop in Hill unit with thick cover of discrete materials and branch drainage pattern
<i>Plain and river</i>	River alluvium	Q <sup>t</sup> : Mountain foot terraces with alluvial origin and gentle slope
		Q <sup>al</sup> : Flood sediments on the riverbed
		Q <sup>f</sup> : Alluvial fan

*Regular Slope Facies with Colloquium Cover in Mountain Unit (Mrc)*

This facies covers a large area in the southwest of the study basin. The area is about 15.9% (1190.2 hectares) and is composed of lime and conglomerate. The regular slopes of this facies are

mainly formed as a result of the formation of destructive cover on the mountain unit (Figure 8). One of the prominent features of this facies is the radial waterways that flow from the top of the mountain to the slopes. In the topographic map, the isosceles lines in the circular facies are parallel (Table 2).



Figure 8 - Mountain facies with regular slope and destructive cover (mrc) in the south of the basin. Source: Authors (2022).

### *Hill Unit (H, h)*

Hill is a geomorphological phenomenon with low highlight often in clay environments. According to the contractual conditions, during the photogeological operations, the areas with the following characteristics have been selected as Hill and their extent of expansion has been differentiated from the other geomorphological units; Slopes with a gentle slope less than 25% (which in some facies can reach up to 40%) and a height difference more than 50 meters and less than 200 meters.

Hill unit, like mountain unit, is divided into two types of regular and irregular slopes based on the slope and order characteristics of the slopes. The morphological characteristics of regular

and irregular slopes are the same as the mountain unit. There is only one hrc facies in Hill unit of Goyjah Bel basin.

*Facility of Destructive Cover with Regular Slope (Hrc)*

The facies are seen as satellite Hill with regular slop and thick cover of discrete materials and drainage pattern of branches. The thickness of the destructive material in the facies is so great that it covers the mother rock in most places. The facies are seen in the center of the basin, which is composed of Pliocene conglomerate units (Figure 9).

The facies are the largest facies of Goyjah Bel basin, which alone covers 49% of the basin area. In terms of lithology, it is a thick cover of destructive materials that has covered the surface of pyroclastic units in the north of the basin and the Pliocene conglomerate. Most of the area of this facies is under rainfed cultivation.



Figure 9 - Hill facies with regular slop and destructive cover (hrc) in the center of the basin 5-2-2-3 River and Plain Unit (Q).  
Source: Authors (2022).

This unit includes the main waterways and rivers, flood plains, alluvial zones along the river, and low slopes and eroded slopes. This unit is related to the last period of geology (Quaternary) in terms of formation time and is important in terms of studying soil profiles. Since



most basin management and water resources management projects are implemented in this geomorphological unit, it is important.

In Goyjah Bel basin, this unit has a moderate area (6.6%) and is seen as three facies  $Q^{al}$ ,  $Q_t$  and  $Q^f$  (Table 2).  $Q^{al}$  facies contains flood sediments of Goyjah Bel riverbed. However, the facies are not visible for other waterways with the studied scale.

Various forms and patterns of erosion, including rainfall, surface, and furrow are active in the areas related to the plain and river unit, and waterways in these areas are without meander due to high slope. The bed of most of these waterways contains destructive and erosive parts and particles transported from the upstream areas of the basin and its wall is seen in sloping areas with fine-grained soil texture as lateral erosion.  $Q^f$  facies are alluvial fans that are partially seen in the north of the basin. The  $Q_t$  facies, which includes agricultural lands and gardens, is seen as a high plain within Gomshabad village and is of special importance in the basin due to its role in storing and transmitting surface and subsurface flows.

### Conclusion

Goyjah Bel basin is a part of the basin of Ahrachay river which joins Aras River after joining Qara Su river. The mentioned basin is located in the structural zones of Alborz and Central Iran and due to its vastness and geographical location, it is composed of various rock-sedimentary units.

The morphological appearance of this basin is affected by two zones of Alborz and Central Iran. The trend of structures the region is the northwest-southeast that factors such as the collision of Iran and Turan plate, the performance of thrust faults and finally the performance of faults along the northwest-southeast landslide have played a role in the formation of these structures.

The lithological units of the basin in the southeast and north mainly consist of volcanic lavas and pyroclast as old as Eocene. The Chilean, calcareous, sandstone and conglomerate formations related to Cretaceous and Paleocene are located in the southwest. In the center and a part of the northern basin, the Pliocene conglomerate unit (PIQC) and the young alluvial unit ( $Q_{t3}$ ) cover the above units.

The most important factors forming a basin are tectonic (morphotectonic) activities that operate on a large scale and control the process of folds. According to the above, three types of geomorphological processes are observed in the study area. 1- Structural geomorphology (forms resulting from tectonic activities), 2- Erosive geomorphology (forms resulting from erosion), 3- Sedimentary geomorphology (forms resulting from sedimentation).

According to the photogeological studies, aerial photographs, topographic maps and field trips, three units, three types and seven facies were identified in the study basin.

The most dominant geomorphological unit in the study area is Hill unit, which has an area of 3665.1 hectares, occupying 49% of the total basin. In addition to the Hill unit, the mountain unit also has a very large area, but the plain and river units have a small area.

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