Geoheritage (2020) 12: 78
https://doi.org/10.1007/s12371-020-00505-z

ORIGINAL ARTICLE

Geomorphological Heritage Attractions Proposed for Geotourism in Asir Mountains, Saudi Arabia

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Received: 25 May 2020 / Accepted: 20 August 2020 / Published online: 7 September 2020

Abstract

This study is going to deal with attractions proposed by the geomorphological heritage in Asir Mountains. The reason behind conducting this study is for presenting the abilities of geo-tourism development in Asir Mountains. The geomorphological heritage embraces landforms and processes playing a key role in the understanding the history of earth and having a strict relationship with both the geomorphological and cultural heritage. The geomorphological heritage is unique and distinctive within the geo-heritage and has promoted great interest over time from a touristic viewpoint. Geomorphological heritage is more than ever in a position to become a significant sustainable territorial resource, enhanced through geo-tourism. A heritage geomorphology emerges, which are not only the characterization of the geomorphological heritage, but also methods of protection and management. In order to analyze geomorphological features of this area and to achieve a digital map, a GIS database created by using both of topographic and lithological maps and satellite images. Using these datasets, the main geomorphologic features extracted and realized based on two stages. First stage is consisted of field campaigns to collect morphological information, and selection of significant geomorphologic sites was based on field survey and study of relevant literature, which chose ten geomorphologic sites. The second one achieved the map of landforms that have geo-touristic potentials in the study area. As a result of this study, the main geomorphological heritage sites were extracted; these geosites can help to interest of the geotourism attractions in Asir Mountains. All these geosites should be conserved and developed to maintain and protect natural and geological attractions while supporting the geotourism for the use of scientists and students and tourists and other casual recreationalists in Asir Mountains.

Keywords Geomorphological heritage · GIS & RS analysis · Geotourism · Asir Mountains

Introduction

The concepts of geodiversity, geoheritage, geosites, geoconservation, geotourism, and geoparks are found closely related and have significantly evolved in the last decade with the understanding that if the geoheritage sites are preserved, the geodiversity will be sustained (Wang et al. 2015). For conserving geoheritages, geotourism has been evolved as a policy instrument worldwide. Sectoral linkage is vital in this context in order to achieve inclusive development in the newly emerging tourism sub-field named geotourism.

Geotourism plays a key role both in environment and human activities. The complex relationships between geology, natural processes, landforms, landscape, soils, and climate are fundamental to the distribution of habitats and species. It also provides many essential natural resources that society and economic growth depend on, including the soils, aggregates, metals, and fuel (Gray 2004). The cultural and economic influence of geodiversity on people is also extremely strong; the location of many cities was influenced by the distribution of mineral or soil resources; the location of important fortification systems was also affected by the presence of appropriate landforms. The geologic, geomorphologic, and other abiotic features can be also seen as a resource for tourism, respectively, geotourism activities which may affect local development (Panizza 1996; Panizza and Piacente 2008). Some sites of geomorphological heritage are located within areas of

I have prepared manuscript which deals with Geomorphological Heritage Attractions Proposed for Geotourism in Asir mountains, Saudi Arabia.

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concentrated tourist traffic, while the remaining sites can be found in areas characterized by poor tourist infrastructure and low traffic.

The different definitions of geomorphological heritage reflect distinct valuation criteria (Reynard and Panizza 2005), which stem from the theoretical and methodological framework of each scientific domain and the specific objectives of each research study (Brilha 2016). The narrower or wider meanings of the geomorphological heritage prove to be equally useful and necessary by serving different application purposes (Bollati et al. 2015). Besides the geographical characteristics, the value of a geomorphosite also depends on its role in supporting a given ecosystem as well as its interrelation with other heritage typologies and its potential for research or education (Justice 2018). Inventory and evaluation processes of geomorphosites' value should not focus only on landforms' intrinsic properties.

According to Dowling (2011), the geotourism is defined as a form of nature tourism that specifically focuses on landscape and geology—these components are an important part of geodiversity (Gray 2004). The geotourism promotes tourism to geosites and the conservation of geodiversity and an understanding of Earth sciences through appreciation and learning (Newsome and Dowling 2010). It is obvious that not only geological but also geomorphological features and processes are considered as a resource for geotourism. A better understanding of the earth with reference to its geological attraction is the goal of geotourism which arises from the motivation of enjoying unique features amidst of landscape (Adriansyah et al. 2015).

Reynard et al. (2003) analyzed the relationship between geomorphology and tourism: geomorphology may be a tourist resource as part of the primary or original offer (geomorphological site as an attraction or geomorphological site as a support for tourist activity, e.g., climbing) and secondary or derived offer, when tourist infrastructures (e.g., didactic trails), instruments (e.g., educational booklets), or services (e.g., guided tours) are proposed for effective use of the original offer. Gray (2004) also stated that geodiversity, respectively, geoheritage, was of great value for geotouristic and geoeducational activities—it is one of the functions of geodiversity.

It is evident that geodiversity as a whole cannot be used for geotourism purposes; tourist use of geodiversity is generally made through the exploitation of geosites and geomorphosites (Pralong and Reynard 2005). This is a quite general statement and it does not respond to the question "which sites exactly are suitable for such exploitation?" For the detection of such sites, it is necessary to do the inventory and evaluation of potential sites. The concept of geosites and geomorphosites seems to be suitable for this purpose because it includes plenty of assessment methods for evaluation of geosites and geomorphosites from different points of view.

In 1992, UNESCO—United Nations Educational, Scientific and Cultural Organization—defines the operational principles for the inclusion of Cultural Landscapes on the World Heritage List. This recognition of the heritage value of cultural landscapes stimulated the interest in understanding their shaping and evolution processes, with an increased focus on combined reading of the environmental and anthropogenic dynamics.

The main objective of the present paper is the introduction of geo-heritage-specific visibility as one of the key parameters in geo-tourism resource, an effort has been made to select geomorphosites and for specific types of geomorphological landscape. Data concerning the familiarity of tourists for Asir region geomorphological heritage are very limited. The most interesting sites, from both scientific and touristic points of view, were chosen for the study. The study focused on the ten sites proposed through field study. The exploitation of the geo-heritage resource deepens people's understanding of the natural environment's complexity and fragility and, thus, contributes to the development of ecologically responsible behavior. The creation of geo-parks diversifies leisure possibilities and offers new jobs.

Study Area

'Asir' or 'Aseer' is a province of Saudi Arabia located in the southwest of the country, named after the confederation of clans of the same name (Fig. 1). It has an area of 81,000 km^2 and an estimated population of 1,563,000 (Som and Al-Kassem 2013). It shares a short border with Yemen. Its capital is Abha, and other towns include Khamis Mushayt, Qal'at Bishah, and Bareg. Geographically, the Asir region is situated on a high plateau that receives more rainfall than the rest of the country and contains the country's highest peaks, which rise to almost 3000 m at Mount Sawdah near Abha. Though data is exceedingly sparse and unreliable, the average annual rainfall in the highlands probably ranges from 300 to 500 mm (12 to 20 in.) falling in two rainy seasons, the chief one being in March and April with some rain in the summer. Temperatures are very extreme, with diurnal temperature ranges in the highlands, the greatest in the world. It is common that afternoon temperatures are over 30 °C (85 °F) (Fig. 1) location of study area, while mornings can be extremely frosty, and fog can cut visibility to near 0% (Som and Al-Kassem 2013). As a result, there is much more natural vegetation in Asir than in any other part of Saudi Arabia, with sheltered areas even containing areas of dense coniferous forests, though more exposed ridges still are very dry.

Asir region is a unique tourist destination and has considerable unrealized potential. Government policy with regards to domestic tourism should be reviewed, and tourism diversification in this region can be undertaken in terms of product,

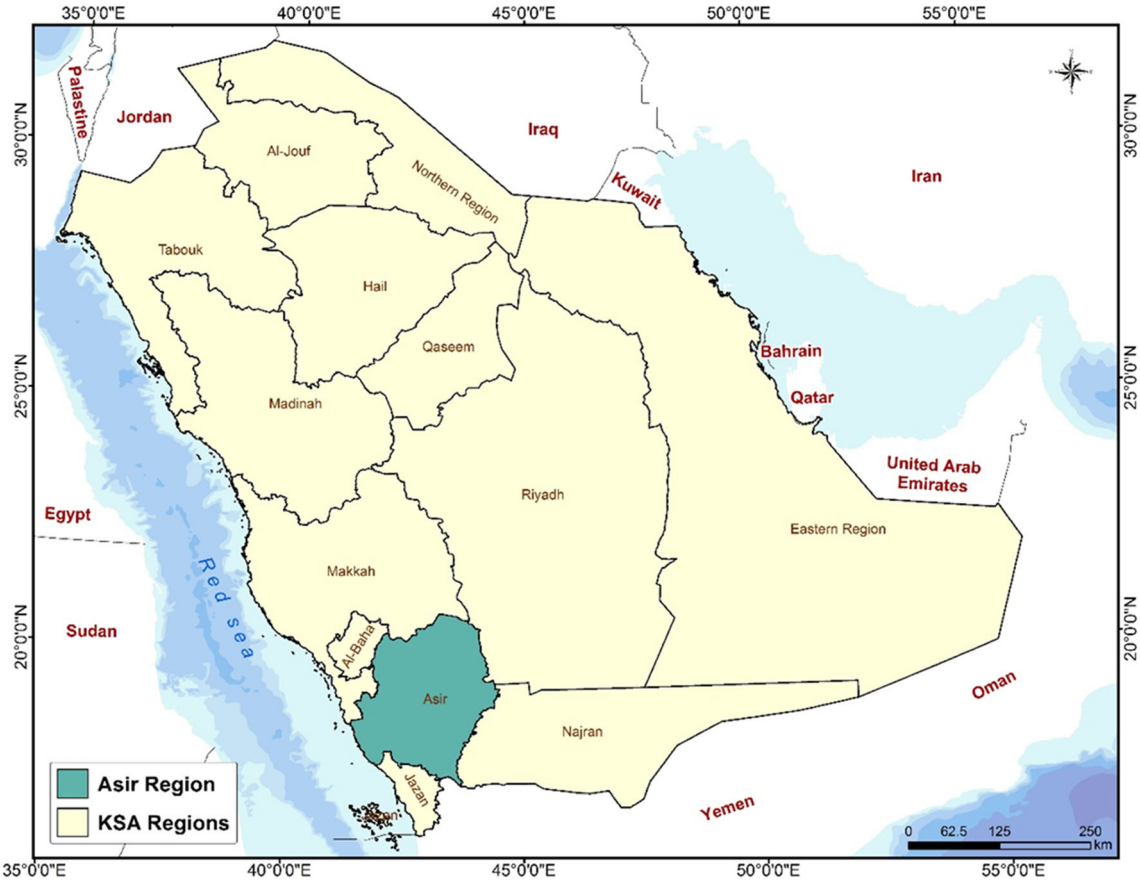

Fig. 1 Location map of the study area. Source: KSA Administrative Data, Updated Guidebook of the population names manual in the preparatory stages for the agricultural census 1436 AH

market, and geographical areas. As tourism development is a comprehensive undertaking involving many sectors and stakeholders, it is crucial for the government to come up with multi-hierarchical, all-inclusive, and coordinated development strategy, and these are the challenges to which the country's tourism industry should respond to promote domestic tourism (Jaber 2018). However, this region has great potential for tourism promotion because it consists of many hills, streams of wadis, caves, peaks, and geosites etc. which are yet to be promoted for geotourism.

Materials and Methods

The analysis of geomorphological heritage for geotourism in Asir Mountains was realized in two stages: the first stage consisted of field campaigns in which morphological information were accumulated and the second stage consisted in achieving the map of landforms with geotouristic potential from our study area.

In the following stage (laboratory stage), by GIS analysis, we realized the digital elevation model of the Asir mountains using contour lines of topographical map sheets (at a scale of 1:50,000). On digital elevation model, the morphological information obtained during the field campaigns like ridges, peaks, steep slopes, gorges, and quarries was added. Thus, by layers, overlapping resulted in a map that contains both the topography and morphology of Asir Mountains. The resulted map of our study area represented only those landforms that can be easily identified in the field and which can be valorized from the scientific, educational, and touristic viewpoint, which will be first step in achieving the geotouristic map of the Asir Mountains.

Geological Features

The geological structure of the Asir Mountains is characterized by great diversity (both in terms of age and genesis). The Arabian Shield represents the geological basis of the Asir Mountains, which consists of a series of ancient volcanic rocks, dating back to 800–1000 million years, which are composed of the sedimentary, volcanic, and metamorphic rocks formed during the protozoic periods. These rocks have been exposed since their formation and their origin to the movement of many distortion and transformation, which caused the

disappearance of most of their original properties and cut with many massive to layered plutons, sills, dikes, and irregular bodies and different directions and shapes. It is an ancient land mass formed from rocks igneous and metamorphic, which dates back pre-Cambrian era. It is spread by basalt, which dates to the Triennial and Quadratic periods, and is covered by sedimentary rocks of Paleozoic periods, in addition to the sediments of the valleys where the study area passed on a very a complex geological history of severe folding and cracking (Alwelaie 1997, p.30). The area has several mountainous volcanic peaks, which consist mainly of granite rocks and are covered by basalt blocks (Abu al-Ela 1975, p. 19) (Fig. 2).

Geomorphological

The study area was divided into three major morphological ranges, and in each range, it has property characteristic geomorphology; they are the mountain, the plateau, and the coastal plain ranges. In addition to morpho-structural forms such as faults, dikes, and rocky barriers (main—secondary), Fig. 3 shows the most important main phenomena in the study area:

Mountain Range

This range is formed in the form of mountain ranges not connected; it is about a group of mountain blocks, extended straight nearly, separates this mountain mass from each other valleys accidental and longitudinal, cracks played a major role in its extension and direction. This range includes the following geomorphological phenomena: Faults scarp, Hogbacks-Razorback scarps, Potholes, and Gorges.

The mountain range extends from north to south, adjacent to the Red Sea, known as the Asir Mountains. The mountains descend rapidly and suddenly towards the west to Red Sea coast and descend gradually towards the east. The mountains range a height of from 1500 m to more than 3000 m. This elevation exceeds some of the high mountain peaks, such as

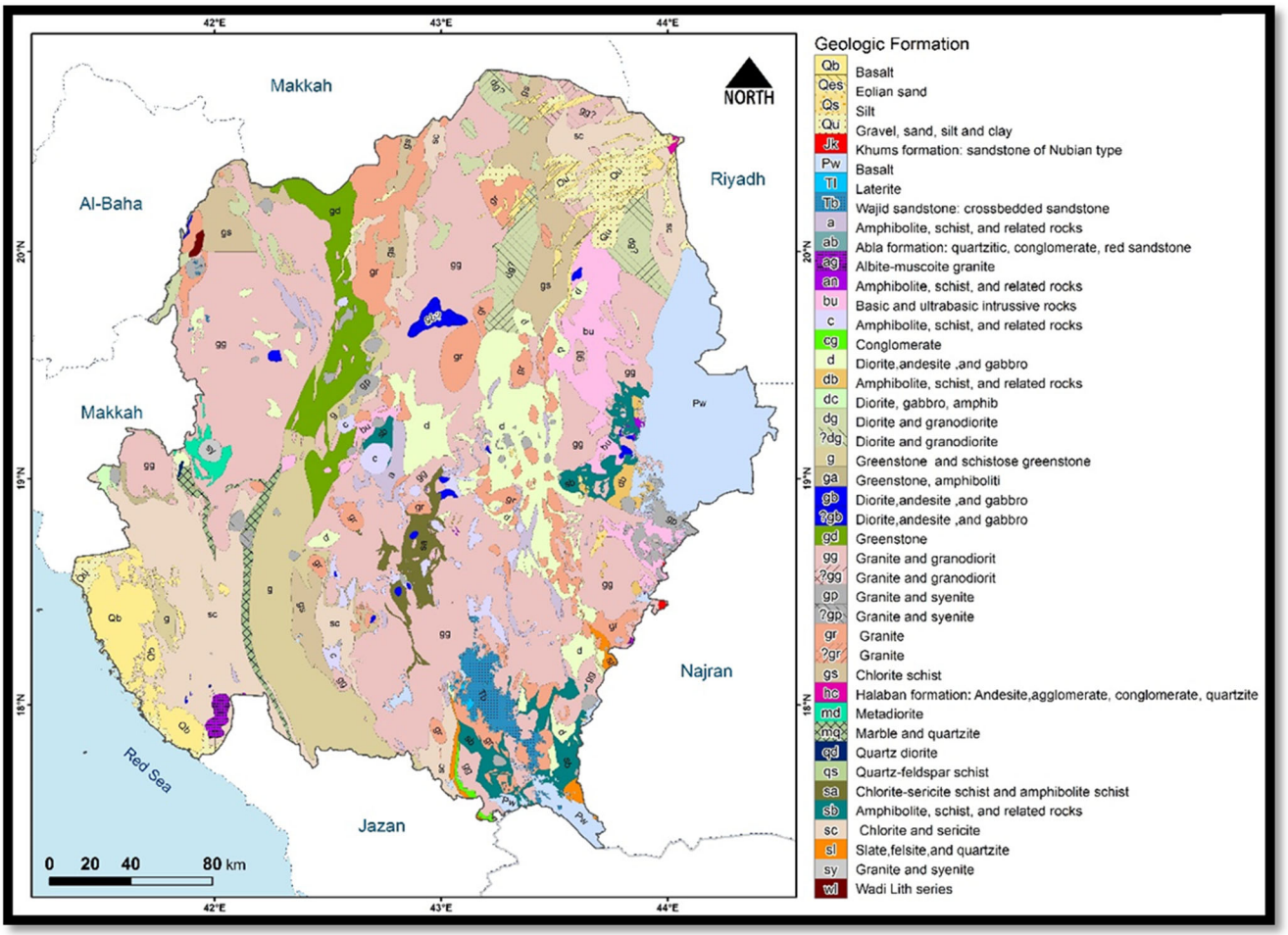

Fig. 2 Geological features of the study area. Source: Ministry of Petroleum and Mineral Resources-General Directorate of Mineral Resources (Asir JM 217) (Najd Southern JM 2011; Southern Hijaz JM 210; Tihama Sham JM 216), 500,000 scale

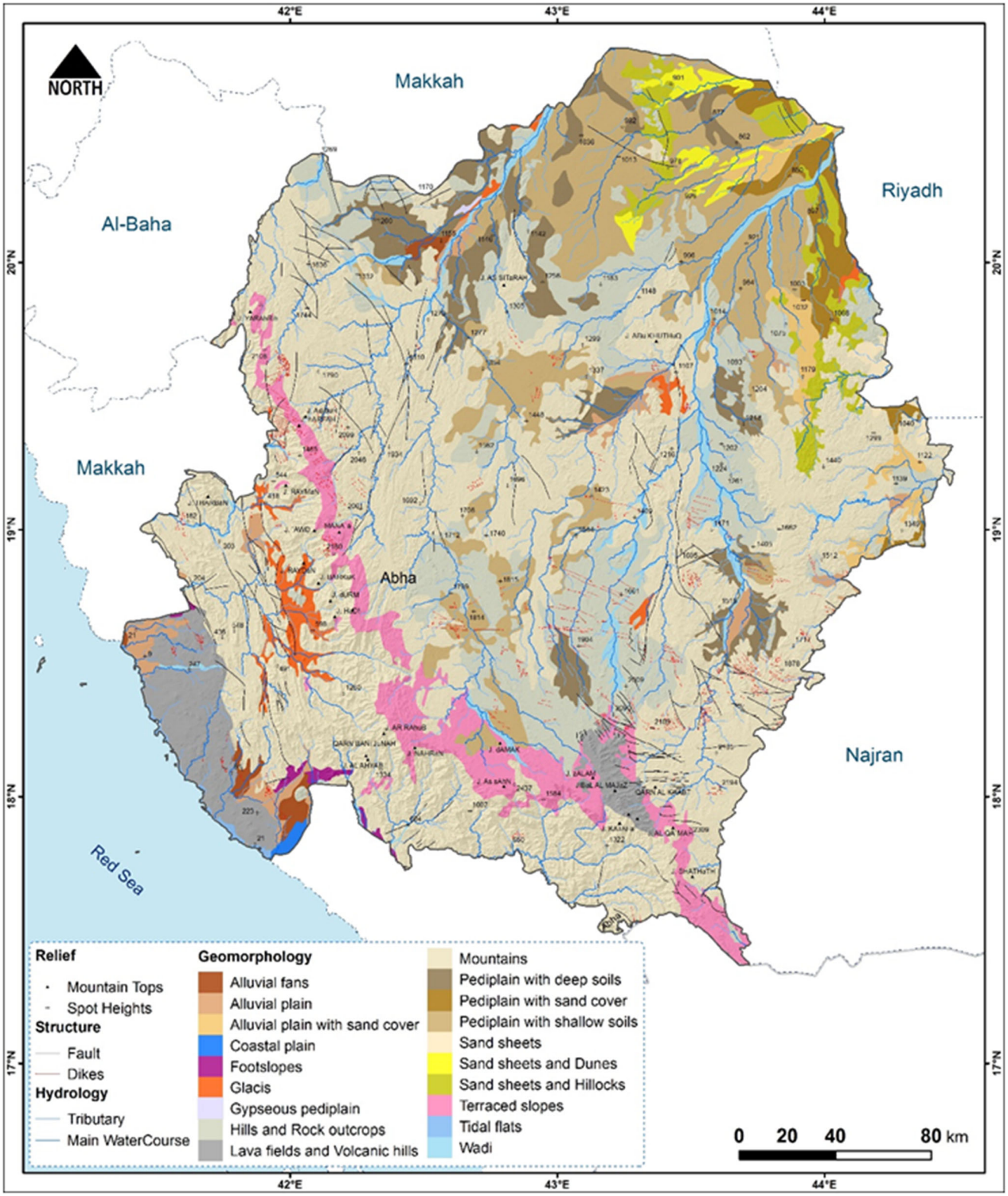

Fig. 3 The digital map of landforms with geotouristic potential of the study area. Source: Field Study, Geologic Map 500k, Topographic Maps 250k, SRTM Runoff Characteristics, Land resources Map (Land Resources Atlas, MEWA, 250k, 2011G)

the " Al Soudah" Mountain, 3015 m above sea level. The highlands of the mountain range are water-dividing areas for valleys draining into direction east and west (Al-haideb 1992, pp. 10–11).

Plateau Range

This range is the northern and eastern parts of the study area. This range represents the transition zone between the mountain range, known as the Piedmont range or the range of the mountain feet. This range is the sedimentation surface of the valleys and the spherical fans consisting of gravel, glamide, rock masses, and sand. The surface of the scale is characterized by the relative flat and gradient of the gradient from west to east. It is characterized by a strong separation due to tectonic movements. Floodplains, alluvial fans, rocky hills, rock outcrops, volcanic cones, sediment valleys, cuesta, sand dunes, and isenberg.

Coastal Plain Range

It is known as a Tihama Asir, narrow coastal plain. It is a specific geomorphological unit which consists some of the basaltic flows and cones of volcanic ash materials and the tongues of the aharat (Habib 1995, p.9). On the Tihama Plain, spans range of Parallel valleys, which descend from the mountains of Sarwat Such as the valleys of Bish, Jizan, and Sabia and other short and fast-flowing valleys. It contains dry and wet sabkha, some of the high hills, sand dunes, coastal sandy plain, sharms, platform reef, mangrove, coastal lakes, and deposits of lime and salt (Al-Sharif 1984, p.41).

Asir Mountains is distinguished by its rich and diverse geomorphological heritage as part of the overall geo- and natural heritage. The reason for this is the dramatic geotectonic activity and dynamics in this part of the Saudi Arabia. Additionally, significant climate change during the Quaternary has had an impact on that diversity. In terms of geodiversity, the 38 mountains and mountain ranges which cover two thirds of the total country area are very unique. The rest are plains in the valley bottoms, large valleys, and the hilly landscape in some depressions. Given the differences in geospatial position, geotectonic structure, and dominant geomorphological processes, the mountains are the "basis" of geodiversity in Asir region. Also, in general, each mountain has its own geomorphological values and distinctiveness. In some mountains, on some remarkable wadis-denudation landscape, there are also those that have combination of more geovalues.

Distinct Geomorphological Units for Geotourism

Asir Mountains, 3000 m above the sea level, is distinguished with their moderate weather in summer and beautiful scenery. Asir region is distinct not only for its natural scenery, forests, and wild trees which cover most of the area, but also is well known for its heritage attraction and beaches at the foot of the mountain. The strategic location of Asir gives the region a high level of tourist diversity. Therefore, Asir can be distinct geomorphological units being divided into five main areas as follows; Fig. 4 shows distinct geo-tourism in the study area:

Coastal Plain It stretches from the western slopes of the Sarat Mountain range; the distance does not exceed 150 km. As well as where there is the coastal plain, which is a narrow coastal bar, its width ranges between 10 and 30 km, the coastal plain rises about sea level at a rate ranging from 100 to 150 m, it is punctuated by a number of canyons and valleys that carry rainfall water, on Sarat Mountain range and pour in the direction of the Red Sea.

Tihama Asir Tihama Asir is located in the west of the study area, the area between the Sarat Mountains and the Red Sea coast; it extends from the western slopes of the Sarawat Mountain range at a distance of 150–170 km approximately.

The Escarpments Escarpment is located NW of Abha region. This escarpment represents a major corridor in the area which connects different cities and touristic resorts with each other. It is descended from Al Soudah at about 2700 m asl towards Tihama Asir at about 1500 m asl. The escarpments also pass through different geological and structural elements. According to different environmental factors (e.g., intensive rainy summer), there are different geological and structural elements (weak rocks, shear zones, and faults), road characteristics (different horizontal/vertical curvatures and narrow road section), and human activities in the area (touristic area).

Escarpment has been left exposed to susceptible to frequent slope failures (rockfalls, rock sliding, and raveling) from time to time. Many rockfall and or sliding events have been documented along this escarpment road, particularly during and following rainstorms. The climate of the area is characterized by cold winter (average temperature) and hot in summer (average temperature) with an average precipitation reaches about 200 mm/year which generally happens during the summer (General Presidency of Meteorology and Environment Protection 2019). The area is commonly prone to landslide activities (rock falls, sliding, and 25 debris flows) and erosion due to running water through different gullies. There are numbers of active landslides which are badly affecting the highway and bridges and are the potential sites to cause disaster in the event of a major rainfall or earthquake (Youssef et al. 2015).

Sarat Mountain Region These mountains are high and extending to Yemen southward, steeply stoop towards Tihama, and be more like a wall. While in the slopes gradually towards Rub Al khali, the heads of valleys that descend towards Tihama are called "obstacles" from there, the population of Asir climb up

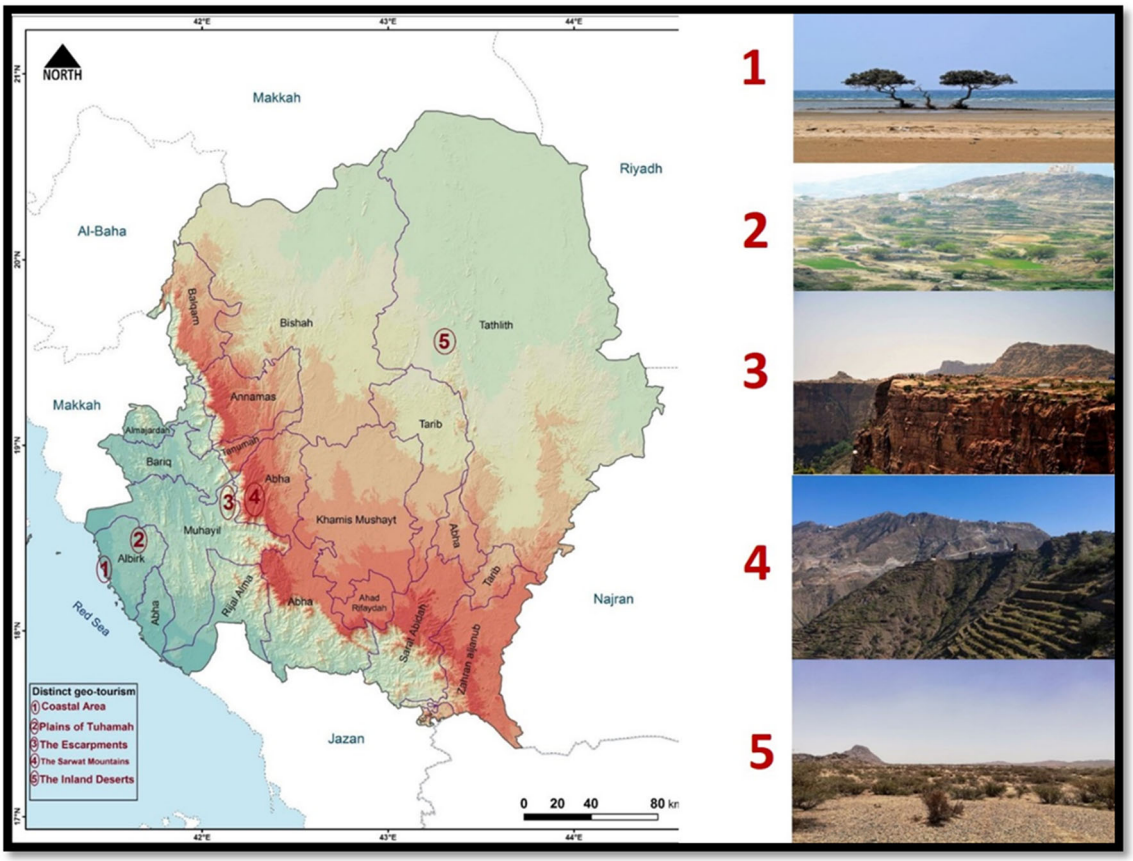

Fig. 4 Distinct geo-tourism of the study area. Source: detailed land use plan, Asir Municipality, 2018 shuttle Radar Topography Mission (SRTM) 3 Arc-Second Global, U.S. Geological Survey (2011)

and down to the Tihama. There is also in Asir Al Soudah Mountain, which is 3015 m above sea level; it is one of the highest mountain peaks in Saudi Arabia. It is characterized by the mountainous highlands by severe degradation to the west, where abound rocky cliffs, as for east, they descend steeper gradually to be the plateau and mountain slopes cut by the valleys.

Eastern Plateau It extends to the east and north of the Asir Mountain range, it is a flat plain between 600 and 1000 m, its surface penetrates through inert volcanic peaks and rocky prophecies and consists of crumbed rocks eroded from the mountains. The plateau extends from Alnoasf and Bakom north to the plateau of Najran and Sarwat Mountains in the south, from the Najd plateau in the east to the west Sarwat Mountains, and it is generally sloping towards the north and east, the height ranges between 600 and 1200 m above sea level.

Results and Discussions

The result of our research consists in achieving the digital map of landforms with geotouristic potential of Asir Mountains using GIS analysis. On the map, we have represented only spectacular landforms, respectively, those areas where geomorphological heritage can be a resource for practicing geotourism. To get information, altitudes and accessibility to the interest points were represented on the resulted map, the land elevation by using color tints. On the digital map, landforms with geotouristic potential of the Asir mountains were represented by the following elements with geotouristic potential: ridges, steep slopes, peaks, gorges, fossiliferous points, and quarries. Depending on the landforms identified as being part of geomorphologic heritage, in the following, we will present each morphological element identified and represented on the map and its geotouristic importance.

Ridges are one of those landforms that are part of geological and geomorhopological heritage. One of the most representative ridges with geotouristic potential from our study area is due to granitic lithology, alpine morphology, and due to the resulting forms generated by weathering processes. Thus, geotouristic interest is due to their morphology characterized by pyramidal peaks (Al Soudah, Al Far'aa, Musharaf, Tahau, Riman, Munea, Athrib, Al-Sayyrah, and Qarn Mijal peaks) and steep slopes that strongly contrast with the lower limitrophe units. The geomorphological landscape is completed by unique ruiniform landforms represented by spherical blocks, towers,

columns, etc. Ruiniform relief is distinguished by size, by its chaotically distribution, and also by its occurrence frequency. Remarkable are spherical blocks that occur both isolated and associated increasing the spectacularity of the landscape.

The main ridge of the Asir Mountains represents another morphological element with geotouristic interest; Fig. 5 shows main geosites in the study area. From landscape point of view, the main ridge of Asir mountains is distinguished within territory by massiveness, amplitude differences imposed by the rock hardness level, etc. Thus, almost horizontal surfaces alternate with steep slopes, structural sharps, and peaks. The occurrence frequency of morphology generated by weathering processes is lower than that of ridge, escarpments, and plateau, but the spectacularity of forms is similar. We have also noticed that the landscapes of these ridges present real opportunities for practicing geotourism.

Likewise, representative for the development of geotourism in the Asir Mountains is the pyramidal and rocky peaks that offer the possibility of observing the types of rocks that form the structure of the studied area: Al Soudah, Al

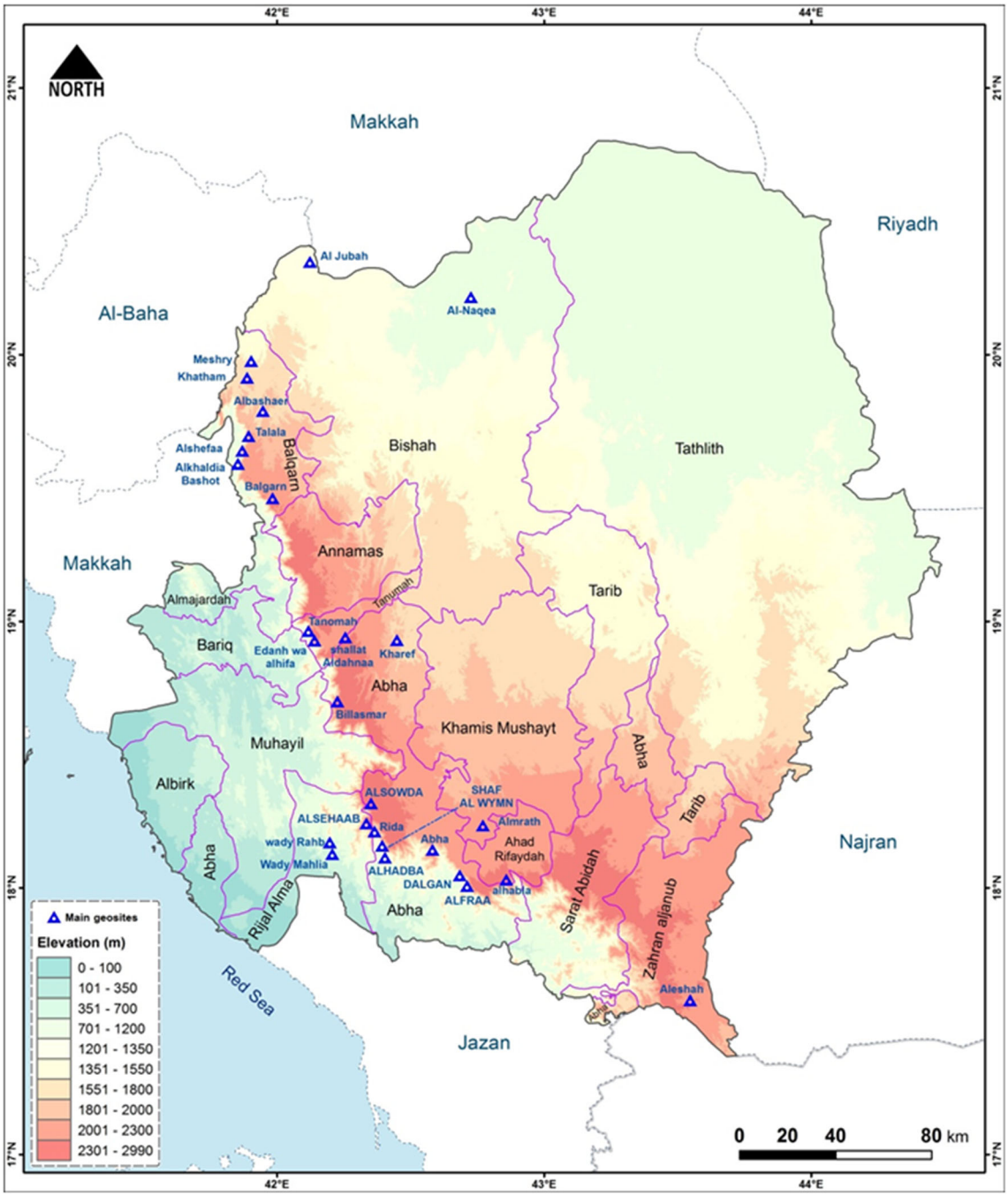

Fig. 5 Main geosites of the study area

Far'aa, Musharaf, Tahau, Riman, Munea, Athrib, Al-Sayyrah, and Qarn Mijal peaks etc. (Fig. 1). From the 28 mountains and mountain massifs in the country, 19 are higher than 2500 m, with 10 even higher than 1000 m: Alsuwda (3015 m), Al Far'aa (3004 m), Ntfa (2965 m), Alsuqaa (2863 m), Munea or Mnaa (2782 m), and Musahar (2600 m). About 2000 m, the high-mountain areas are characterized by well-preserved landscape, and to some extent on the mountains of Athrab (1800 m), Tahau (1600 m), and Riman (1600 m). The (fossil) is represented by cirques, troughs, sharp cliffs, and peaks; geological peculiarity of this geosite lies in its rich geodiversity which is represented by rhyolite, andesite, basalt, tuff, granite, pegmatite, gneiss, and magmatite formations. Excellent display of geo and biodiversity is presented in Table 1 and Fig. 6.

Al Soudah Mountain

Jabal Al Soudah has the highest peak in the Kingdom, with 3015 m above sea level height. It is situated some 20 km away from Abha, one of the cities located on Asir Mountain range. It is covered with a number of Juniper trees, forming the green mountain forests of Asir's mountain range where different kinds of flora and fauna exist. Al Soudah is one of the most important summer resorts in Saudi Arabia, with cold and rainy weather in the summer, as the clouds are gathered on top of these heights, to record the highest raining percentages than other places.

Al Soudah residents hope that the cold weather would encourage more investments in Saudi Arabia's highest mountain peak, the coldest and the rainiest weather in the summer. According to Al Soudah annual records, the indicators show an increase in the number of visitors from all over Saudi Arabia and some GCC countries who like the cold weather and the mountains nature Plate 1. It also includes a number of short- and medium-length waterways, and that descends in great degrees and contributes to danger resulting from the flood waves and heavy rain; the area is also characterized by the presence of waterfalls, whose waters pour in most of the year, as is the case with the waterfall in the area known locally as Al-Mahtaba (Plate 2).

Al Far'aa Mountain

Mount Al Far'aa, in al-Harjjh governorate in the western part of Asir region, is 3004 m above sea level. The third-place peak is mount Al-Majaz, which comes after Al Soudah and Al Far'aa peaks; it is 2902 m above sea level. It is a popular destination for tourists, especially mountaineering enthusiasts (Plate 3).

Musharaf Mountain

Musharaf Mountain, from the Sarawat Mountains, one of the highest mountains in Saudi Arabia, is located in Wadi Awad in the Al-Harja Center in the Asir region. And its height is

Table 1 The list of peaks and geomorphological sites of studied

N	No. geosite name and label	High	Coordinates	Description
1	Al Soudah	3015 m (9892) f	18° 15′ 58″ N, 42° 22′ 05″ E	Part of the heterogeneous volcanic rock formation composed of various types of basalt, andesite and tuff. Highest peak in the Kingdom.
2	Al Far'aa	3004 m (9.856) f	18° 3′ 10.8″ N, 42° 42′ 11.45″ E	Composed volcano appears, spatter scattered on the slope, land adjacent and, tafoni gap installed in granite rocks
3	Musharaf	2859 m (9380) f	17° 54′ 40″ N, 43° 18′ 20″ E	The Basalt columns of variety of volcanic landforms: basalt dikes and extrusions, and the basalt columnar jointing.
4	Tahau	1600 m (5249) f	19° 6′ 42.45″ N, 41° 59′ 4.69″ E	The Basalt rocks, mountain terraces, smooth black rocks, and mountain lake.
5	Riman	1600 m (5249) f	19°9′51.72″N, 41° 58′ 28.42″ E	Looks like a volcanic cone, smooth black rocks, tafoni gaps, and heritage houses of local basalt rocks on the terraces.
6	Munea	2782 m (9127) f	18° 58′ 38″ N, 42° 11′ 15″ E	Looks like a composed volcano, a window rock by weathering and erosion, tafoni gaps, and Smooth black rocks by waterfalls and gully abrupt.
7	Al-Ḥabalah	(2418) m (7931) f	18° 1′ 56.27″ N, 42° 51′ 8.85″ E	Represents outstanding geological site that is very suitable for educational purposes. The site is composed of variety of igneous and metamorphic rocks. Also, there are a number of volcanic sills and dikes which penetrates the older crystalline complex.
8	Athrib	(1800) m (5906) f	18° 58′ 37.85″ N, 42° 0′ 16.67″ E	Looks like a composed volcano, waterfalls, mountain terraces were exploited in agriculture, and the smooth black rocks.
9	Al-Saarh	(1364) m (4476) f	19° 55′ 50.36″ N, 42° 41′ 20.42″ E	Described by the iceberg, consists of quartz sandstones.
10	Qarn Mijal	(2170) m (7122) f	18° 23′ 55.14″ N, 42° 54′ 18.86″ E	Looks like a volcanic cone, basalt columns, dikes and jointing.

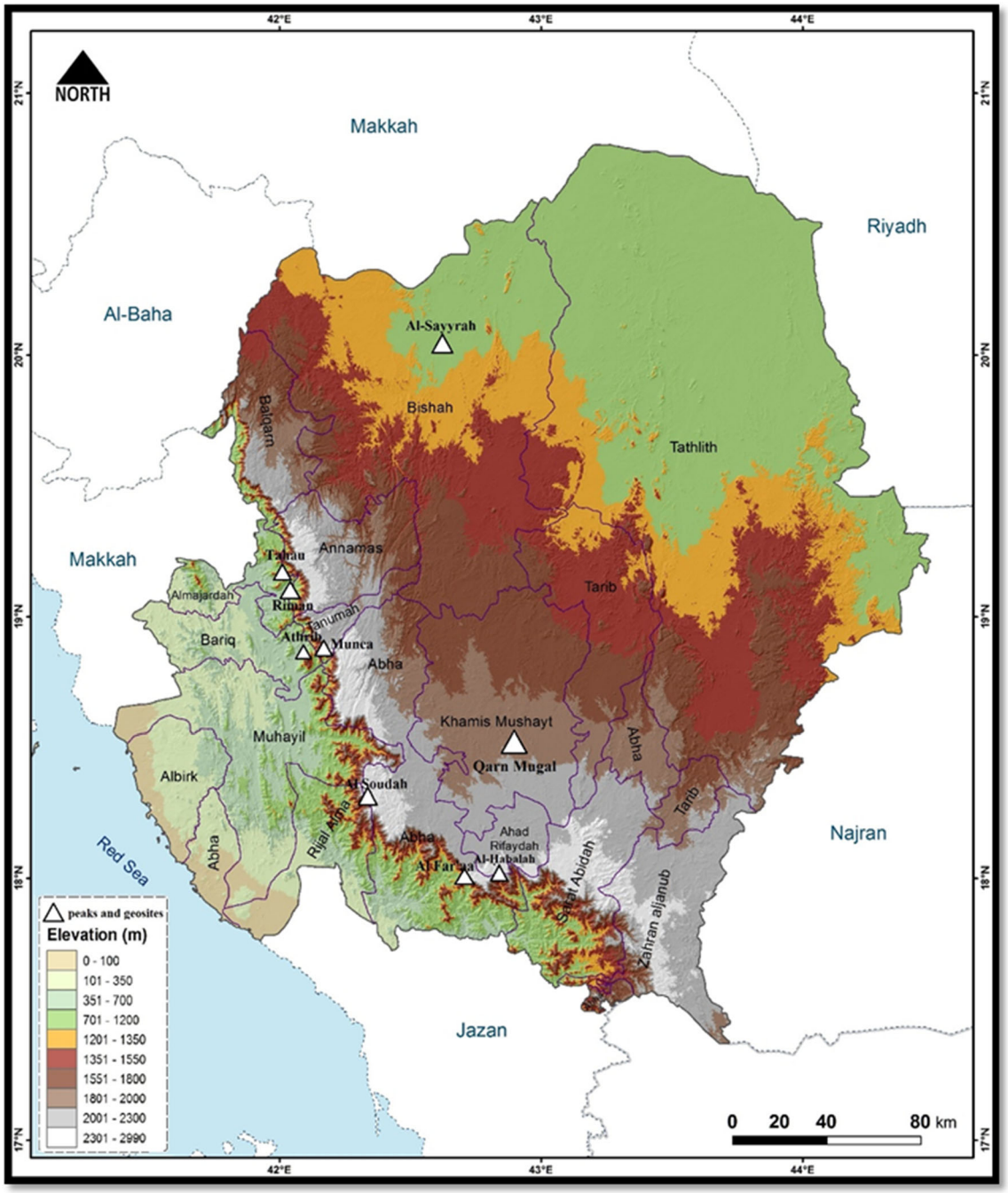

Fig. 6 Location of the studied geomorphosites in the study area

2859 m above sea level. A structure that forms in rocks (most commonly in basalt) consists of columns (most commonly hexagonal in shape) that are separated by joints or fractures in the rock that formed when the rock contracted, most often during cooling. The formation of columns is particularly enhanced by water. Where water cooling has played a significant role, often when lava flows are 'ponded' in river valleys and are cooled by river water flowing over them, a predominantly two-tiered set of columns can develop, known as entablature and colonnade. The colonnade columns rise straight up from the basal cooling, whereas the ingress of water in the upper parts of the flow sets up a variety of different angles of cooling fronts. This leads to an irregular and sometimes hackly jointing called entablature in the upper parts of the flow (Bosshard et al. 2012). The diameter of the basalt columns in it ranges from approximately 40 to 50 cm, which shows the beauty of the geology of the place and its amazing charm, pointing out its importance in the areas to be a tourist attraction in the future (Plate 4).

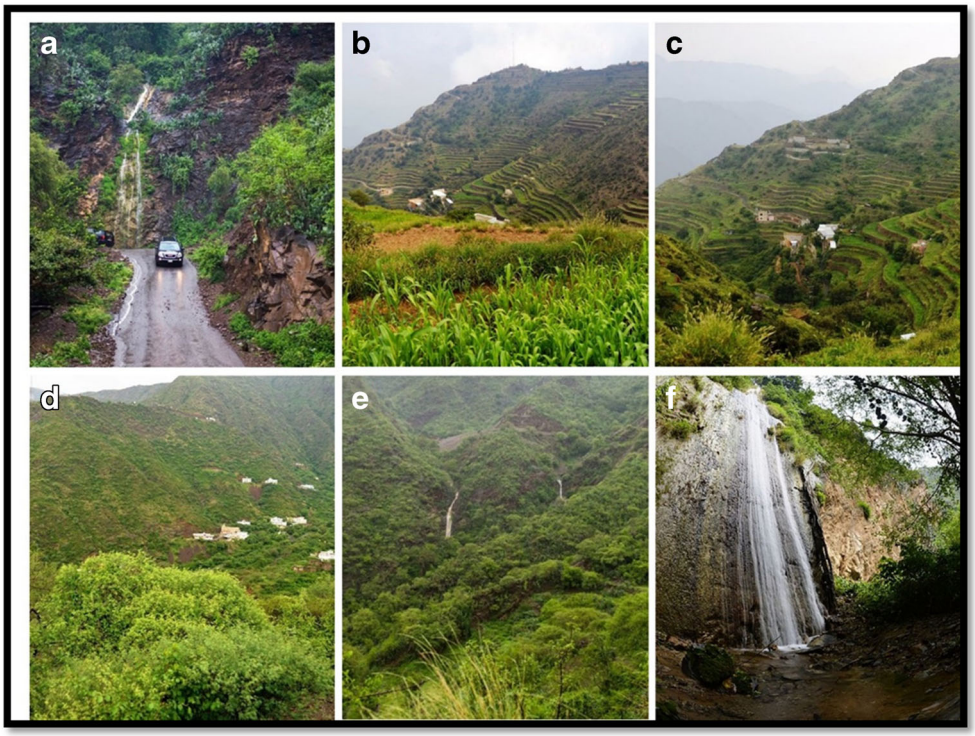

Plate 1 Al Soudah Mountain in the study area (**a**, **d**, and **e** gully abrupt; **b** and **c** agricultural terraces; and **f** waterfall)

Tahau Mountain

Tahau Mountain is located in the southeast of Al-Majardah Governorate, in the Asir region of Saudi Arabia. It is about 1600 m (5249 ft) above sea level. Constituting a watershed that descends from the highest mountain top, waterfalls were drawn on its surface and the curves of its smooth black rocks are decades of magnificent geometric shapes (Plate 5).

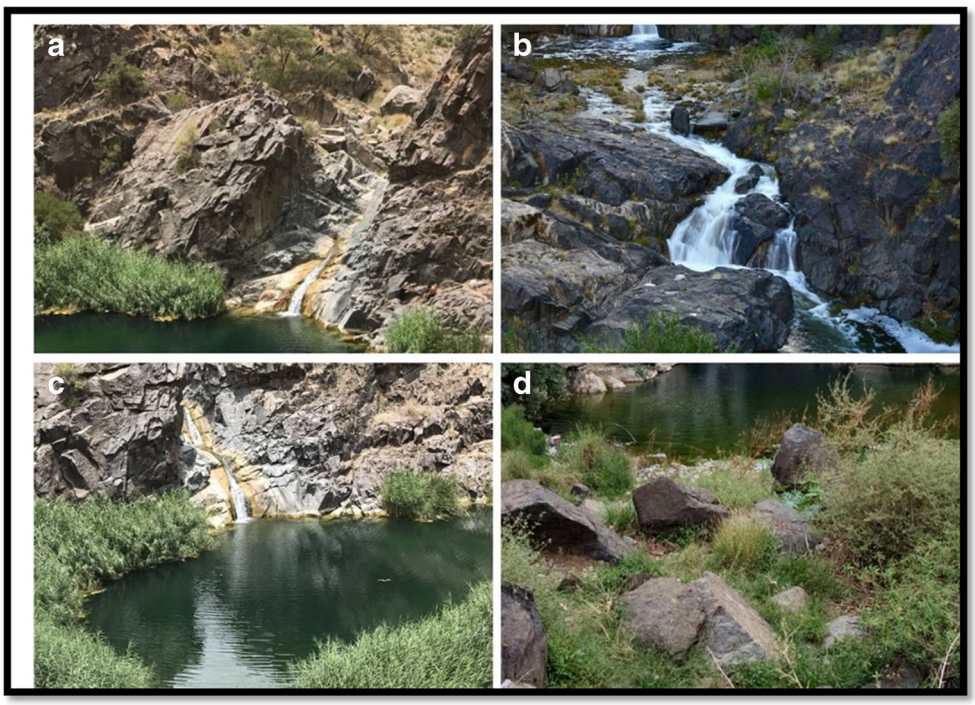

Plate 2 **a**–**b**–**c** and **d** Al-Mahtaba waterfall and lake in the study area

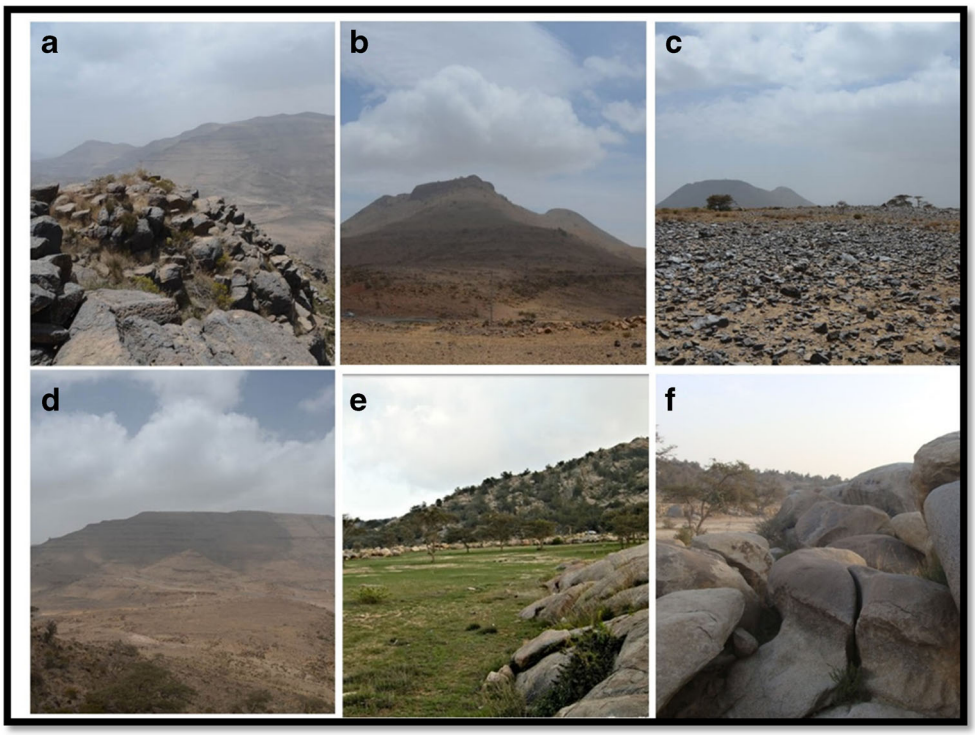

Plate 3 Al Far'aa mountain in the study area (**a**, **b**, and **d** composed of volcano that appears; **c** spatter scattered on the slope and land adjacent to the Al Far'aa mountain; and **e** and **f** tafoni gap installed in granite rocks)

Riman Mountain

Mount Riman is a mountain of high altitude located to the west of the city of Al Namas, and it is administratively attached to the Khataba Center of the Majardah Governorate in the Asir region. This mountain is inhabited by a famous tribe called the "Bani Hussein" tribe. There is the village of Al Hilal, and they are all from Bani Shahr. As for the villages that are located at Mount Rayman, they are as follows: first, the villages of Al Melih where Bani Hussein lives, as they form

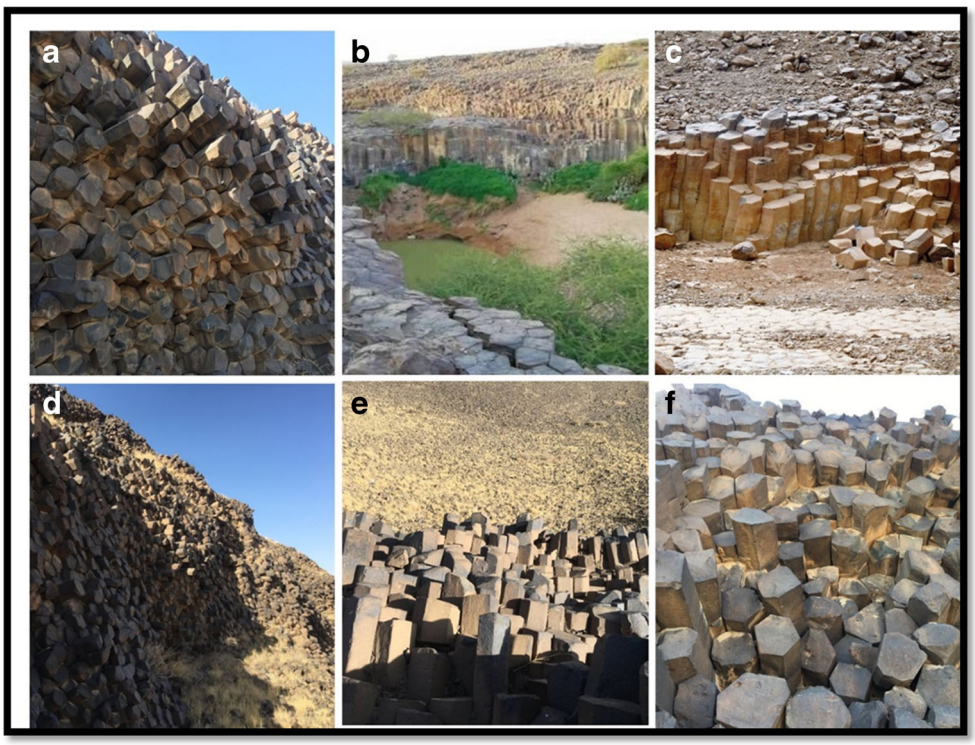

Plate 4 The basalt columns of the Musharaf Mountain. **a**–**b**–**c**–**d**–**e** and **f** Variety of volcanic landforms: basalt dikes and extrusions and the basalt columnar jointing

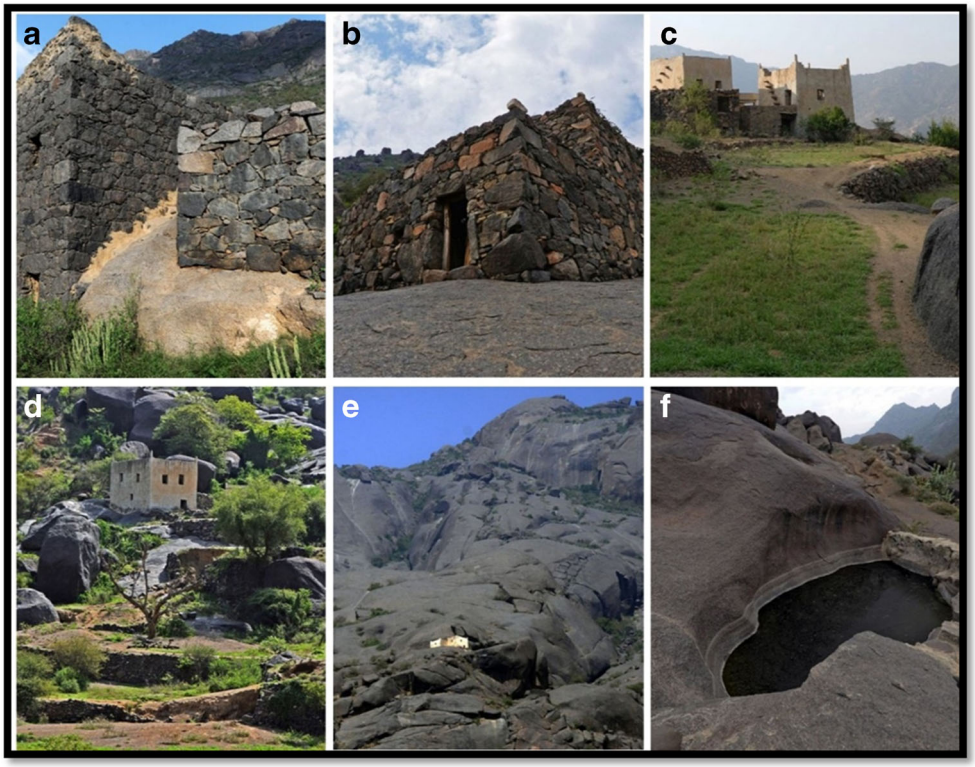

Plate 5 Tahau Mountain (**a**–**c** heritage houses of local basalt rocks on the terraces; **d** mountain terraces; **e** smooth black rocks; and **f** smooth black rocks and mountain lake

the majority in it, and the number of these villages is five: the village of Al Qalil, the village of Al Faraa, The village of Al-Mawkada, the village of Al-Hadn, the village of Al-Jarud; second, the village of Ataq, which is the village inhabited by the family of Bani Zuhair (Plate 6).

Munea Mountain

Mount Mnaa or Munea is located in the district of Tanum Bani Shahr. And there are archeological inscriptions that have not been explained yet, and there is an inscription on his upper chest that depicts giant snakes and serpents of people. In the rocky section and the mole and at the top, there is a large cave with inscriptions on the roof, as well as a laurel on top of a mosque, which is one of the greatest mountains in the Kingdom, and waterfalls flow from it when it rains (Plate 7).

Athrib Mountain

Mount Athrib is one of the most important features of the Bariq governorate of the Asir region. The mountain height is 1.800 m above sea level. The Athrib mountain extends between the Baqara Valley from the south to Wadi Khatt from the north, and in its width are many farms, fields, and villages, especially at the region The eastern and eastern parts of Barq and these farms produce various types of crops such as honey, coffee, wind, corn, and millet, and its population is 2000 people, where the mount Athrib region is distinguished by being a first-class agricultural area that the orchards extend along its sides, and intentionally affected rain water and well water in agriculture, the area is most famous for honey (Plate 8).

Al-□abalah

Al-Ḥabalah is a small mountain village in Asir region of Saudi Arabia. It is located in a valley 300 yards below the peak of the front mountain. It was originally inhabited by a tribal community known as the "flower men", because of their custom of wearing garlands of dried herbs and flowers in their hair. In the past, the village was only accessible by rope ladder, and in fact, the name Al-Ḥabalah comes from the Arabic word for rope. They were supposedly fleeing the Turks at the time of the Ottoman Empire (Plate 9).

Al-Saarh Mountain

It overlooks the "mount white Al-Saarh", or as it is described by the iceberg, distinguished by its height and the nature of its components, which differ from all the surrounding mountains, covered in white embroidered with some colored stones, a block of ice white glossy, and is rare in its shape and image, white Al-Saarh Mountain consists of (quartz) stones that contain the mineral (quartz) used in the manufacture of glass. The Mountain can be exploited as a tourist destination by providing the site with all the necessary elements of tourism (Plate 10).

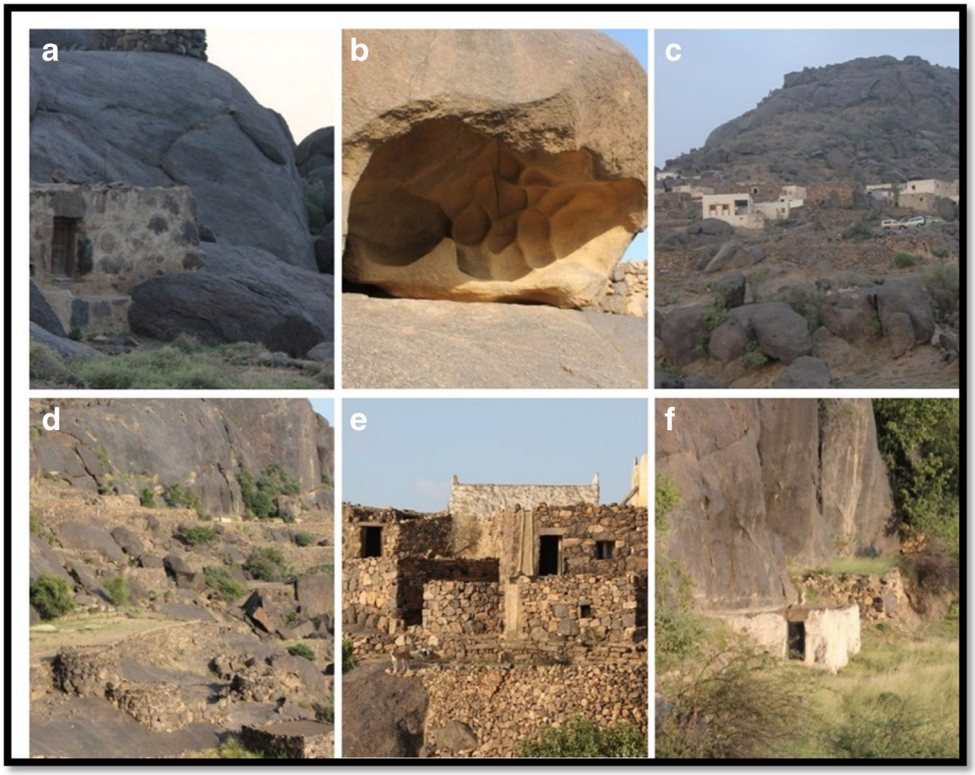

Plate 6 Riman Mountain (**a** and **f** smooth black rocks; **b** tafoni gaps; **c** Riman mountain looks like a volcanic cone; **d** mountain terraces; and **e** heritage houses of local basalt rocks on the terraces)

Qarn Mijal Mountain

A single conical volcanic mountain of granite rocks covers the floor of the mountain granite boulders; it has many distinct forms of granite rocks, such as cobra and mushrooms, caused by weathering and erosion and desquamation of granite; at the top of the mountain, there are basalt columns (Laboun 2019, p. 174–180) (Plate 11).

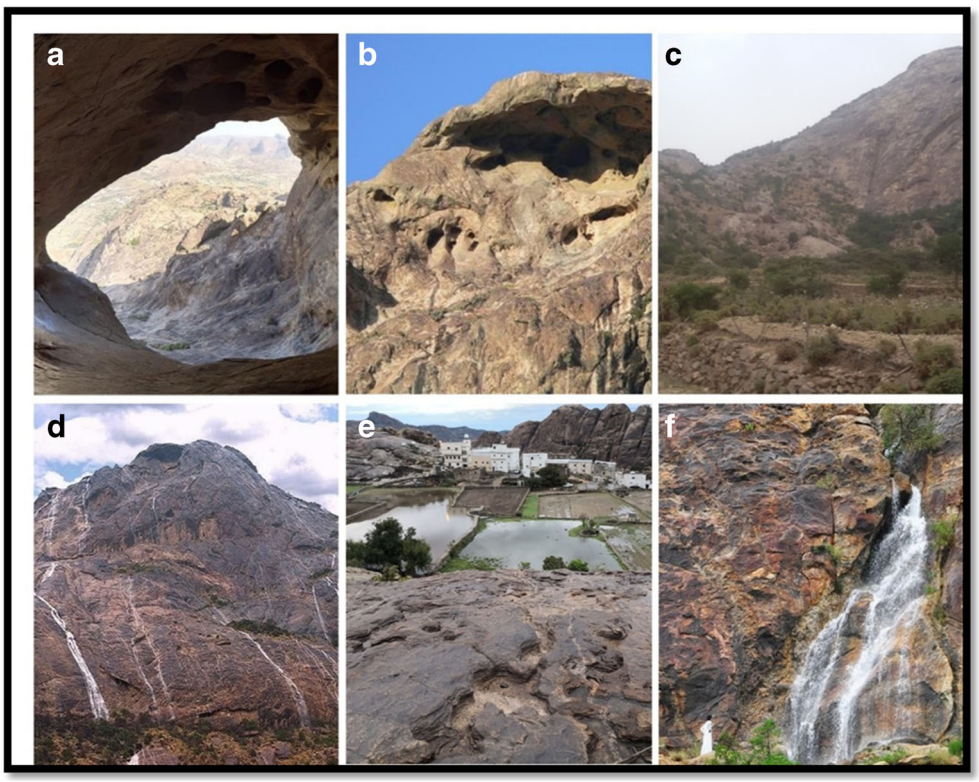

Plate 7 **a** Window rock by weathering and erosion; **b** Tafoni n gaps; **d** and **f** smooth black rocks by waterfalls and gully abrupt; **c** Munea Mountain looks like a composed volcano; and **e** smooth black rocks

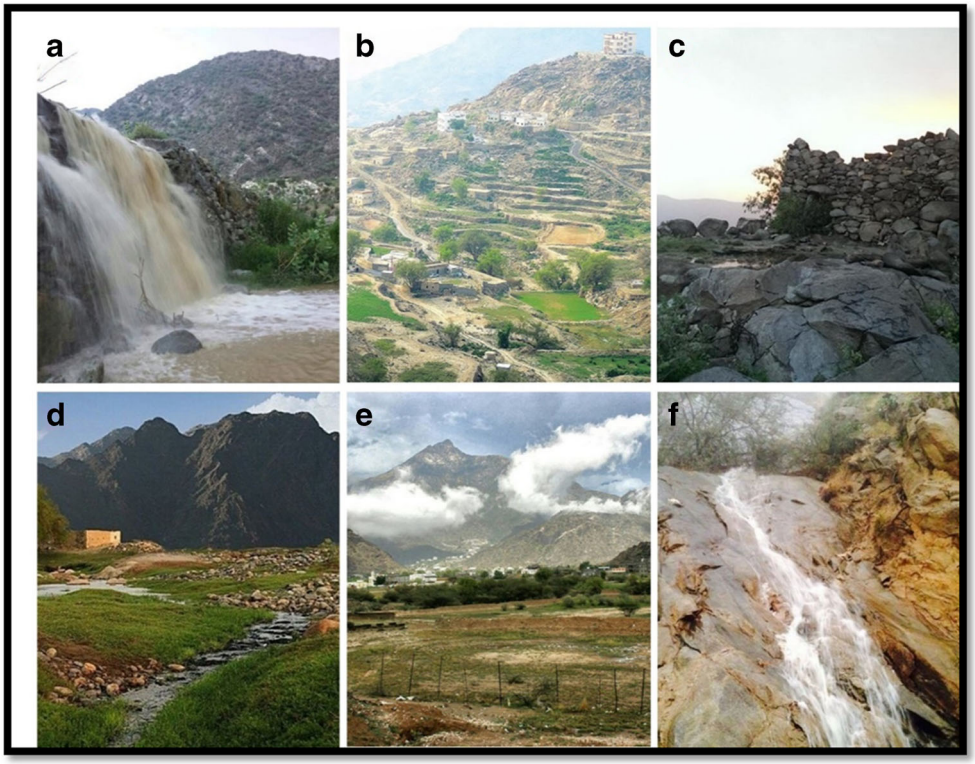

Plate 8 **a**, **f** Waterfalls formed a mountain lake; **b** mountain terraces were exploited in agriculture; **c** the smooth black rocks; **d** and **e** Athrib Mountain looks like a composed volcano

In general, from a scientific perspective, the sites have been appreciated for their biotic component, while abiotic elements of nature in the context of conservation have not had such attention, there are no care plans for the geological and geomorphological sites; these sites' suggestion will be made included in the management and care plan such as natural reserves. The above-mentioned facts propose the question whether the wider attention should be offered to the

Plate 9 Al-Ḥabalah. **a**–**c** Waterfalls formed a mountain lake; **d** mountain terraces were exploited in agriculture; and **e** and **f** escarpment abrupt

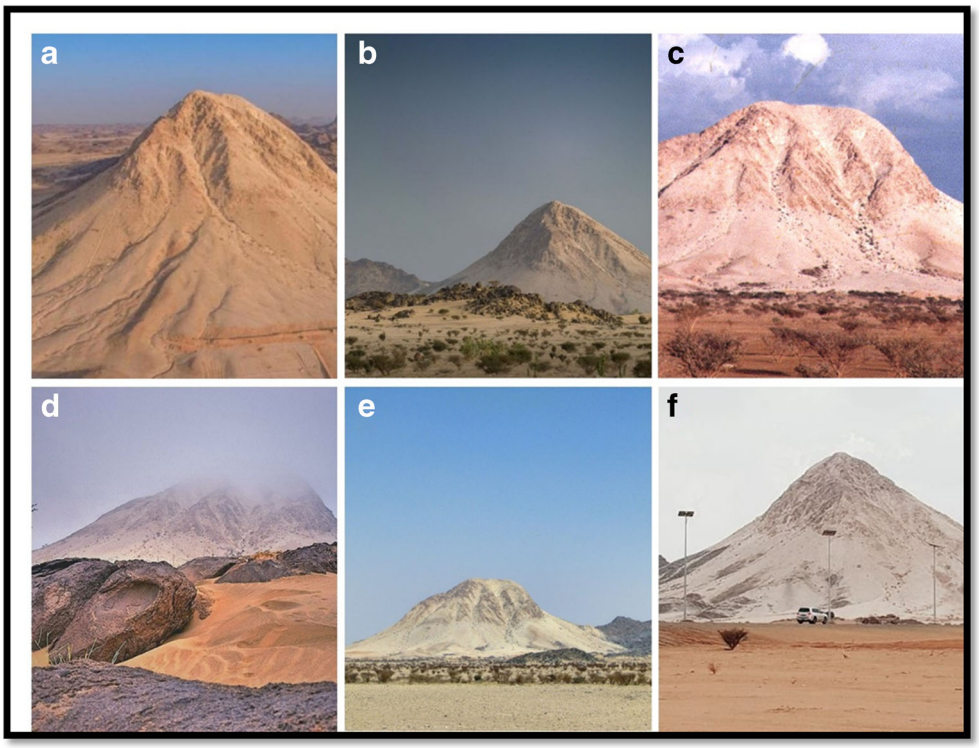

Plate 10 **a**–**b**–**c**–**d**–**e** and **f** White Al-Saarh Mountain consists of quartz stones

geo(morpho) logical components of the sites of interest. Indeed, this is the geomorphological and geological component of the landscape that usually determines all the other components of the landscape and may thus significantly contribute to the understanding of the need to protect geoheritage.

Another element of scientific interest represented on the digital map consists of paleontological protected area, where traces of fauna were discovered which testify the lithological deposits. Likewise, the areas where the artificial oppenings occurred like quarries were represented. The abandoned mining and Al Soudah, Al Far'aa, Musharaf, Tahau, Riman, Munea, Athrib, Al-Ḥabalah, Al-Saarh, and Qarn Mijal present a particular importance for comprehension of Asir Mountains evolution. The resulted map also represented the main hydrographic elements and limitrophe morphological units. Apart from intrinsic values, geomorphosites possess economic,

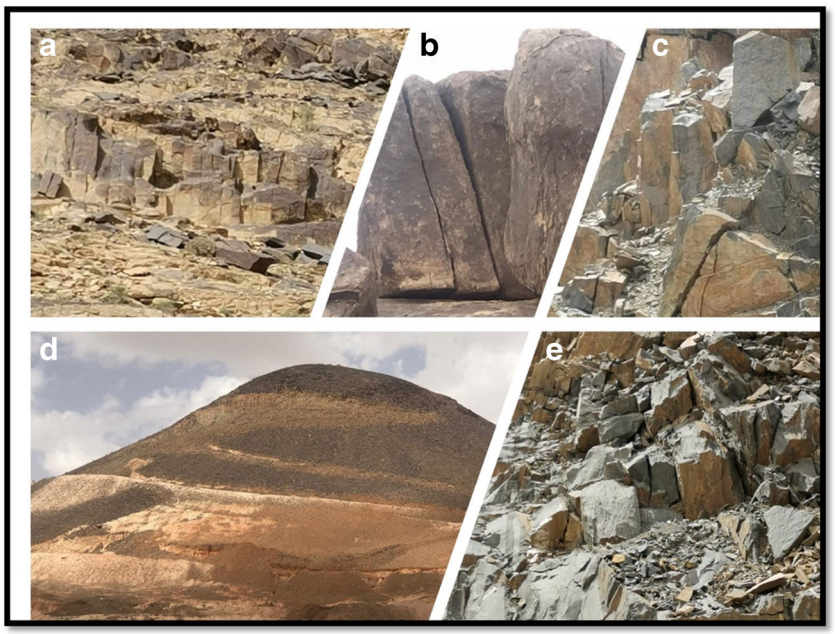

Plate 11 **d** Qarn Mijal Mountain looks like a volcanic cone. **a**, **b**, **c** **e** Basalt columns, dikes, and jointing

cultural, scientific, and esthetic values attracting visitors (Gray 2004).

Instead of specific geomorphological heritage, categories such circuits possess representative of various categories together in its fold to serve the educative purposes of geotourism. Such ventures involve both host and guest, who may not have enough technical background to discriminate between the geomorphological heritage category sites but have interest in geomorphological heritage while traveling as geotourists.

In the study area, geomorphological sites are not equipped of any viewing platforms nor on-site interpretive panels for explaining the nature of geology. Volcanic areas with unique landscapes are available for study and observation mainly to a small circle of experts: geologists, scientists, and rare tourists. The development of geological tourism requires support.

Conclusions

The paper aimed to analyze the geomorphological heritage of Asir Mountains for geotourism development in the area. In these senses, the geological and geomorphological features of our study area were analyzed, which were identified landforms which consist in geotouristic attractions.

A spatial analysis undertaken with the application of GIS software reveals the pattern of distribution of such geomorphological heritage for planning and development of geotourism in the region. The expectation is to increase the volume of quality visitors for whom educative tourism is an essential requirement. Trained guides are required to explain the past geological environment relating with the geoarchaeological materials excavated from these sites. The audio-visual infrastructure in interpretation center of each of such sites is essential to draw the attention of geotourists, which serve the objective of blending geomorphosites with the cultural history of mankind.

The article briefly examines the relationship between geodiversity, geoheritage (represented by geosites and geomorphosites), and geotourism. It is obvious that geosites and geomorphosites represent a fundamental resource for geotourism. As geosites are defined as sites that present particular importance for the comprehension of the earth history and bear mainly scientific values, geomorphosite concept is wider and includes also added values (e.g., cultural, esthetic, and economic). Therefore, for assessing the importance of the geological and geomorphological sites for geotourism purposes, the concept of geomorphosites is more appropriate. It will promote the value and social benefits of geomorphological and geoarchaeological sites and their materials. It will recommend a conservation area of the geoarchaeological sites for the use of scientists and students and tourists and other casual recreationalists. Finally, it is important that geodiversity is employed within a multi-disciplinary framework, where the human factors (and artifacts) are given due emphasis: from archeological sites and monuments to land-use change and management.

Geotourism is a relatively new concept to be implemented, which probably has the maximum potentialities in the context due to availability of a number of geosites in different scales throughout a region like the study area concerned. Since the conservation objects are very much fragile, a high level of maintenances is required for two main reasons: (a) preservation of the value of geoheritages and (b) to cope with the threats increasing with human activities, a model approach is, however, prescribed in the transition from the geomorphosite evaluation to the geotourism interpretation to achieve sustainable development of geotourism (Neches 2013). Initially, understanding geology and geomorphology was key (Hose 2008) which has further extended to landscape interpretation approach (Newsome and Dowling 2010). Focus on community involvement (Boley et al. 2011) relates it with sustainable development contributing to the alleviation of poverty in geotourism areas (Reimold et al. 2006). The space in geotourism context sets up a working landscape, where nature and people come together for geoconservation perspective (Yolal 2012).

The previous analysis shows that the Asir Mountains has numerous, very important, and unique geomorphological sites and areas. Given the diversity in area, height, position, geotectonic structure, and dominant geomorphological processes, the mountains are the "foundation" of geoheritage in the study area and some characterized by multiple geo-values. Thus, the geological diversity along with the age of the lithologic deposits and the morphological variety individualized for Asir mountains within the territory of our country like a mountainous area with real possibilities of practicing geotourism, the parameter proposed in the present paper is treated as a tentative, qualitative manner. Broad consultations between theoreticians and practitioners in geotourism are necessary in order to strengthen the approach of its application. It will recommend a conservation area of the unique geologic, geomorphologic sites, and geoparks for the use of scientists and students and tourists and other casual recreationalists.

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