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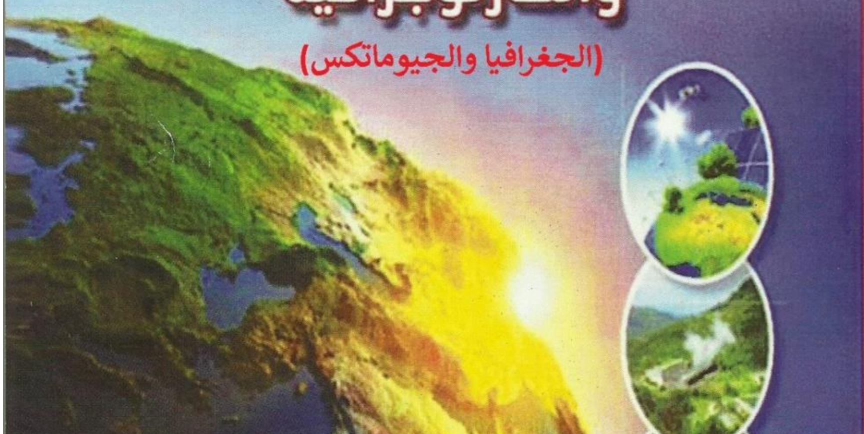

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بكلية الآداب – جامعة المنوفية

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Article:

Usage of the Geographical Information System Technique to Detect the Distribution of Limestone Sites in Wadi Nisah, Southern Riyadh, Saudi Arabia

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Abstract:

Mineral resources are important sources of income for primary producing countries. This industry is important in developing economic resources and diversifying income streams so that countries do not rely solely on petroleum as their primary source of income. As a result, the emergence of geomorphology studies, with scientific results that have economic and technical dimensions, can be relied upon when implementing development and future plans. The objective of this study concluded the economic dimensions and morphological aspects related to the location of limestone in the Wadi Nisah area, southwest of Riyadh. It is based on a range of modern scientific tools, techniques, and geographic information systems (GIS) for identifying and highlighting the presence of this rock type. The study area has been chosen his to collect spatial and geological information about the limestone in a database and locate limestone that is economically feasible using GIS and remote sensing. The researchers concluded that the Wadi Nisah area is of high economic feasibility, as it is within the Durma square and contains mineral deposits of different concentrations in the rocks. The study recommended directing the concerned authorities to the importance of establishing a cement factory in Wadi Nisah in order to supply the local and regional market with Portland cement factory in Wadi Nisah and similar products. In addition, modern geomorphological techniques are used to achieve the precision required for data on which we can depend to take the decisions and make assessments for establishing development projects to support the national economy.

Keywords: Mineral resources, Limestone, Remote sensing, GIS, Wadi Nisah, Riyadh, Saudi Arabia.

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1. Introduction

Dry valleys in the Arabian deserts, and especially in the Kingdom of Saudi Arabia, represent a geomorphologic phenomenon that still requires further studies and applied research to enable the identification of geological and structural formations in order to exploit the existing metals in the rocks. Geomorphologic studies are amongst the most important modern trends in the investigation of surface forms, as they play an important role in all studies related to natural geography. They represent important applied fields, and the feasibility of studies based on the geomorphologic data of the earth surface and the scientific results have economic and technical dimensions that can be used in development plans. Such studies also help us understand the evolution of the morphology of the rock, its structural content and economic feasibility. Therefore, we better understand each formation separately.

A mineral resource is one of the most important sources of income for primary producing countries, and Saudi Arabia covers a large area and has multiple geological environments containing different mineral ores, which allows for the development of many investment opportunities in the mining industry. The Ministry of Industry and Mineral Resources has been given responsibility for this industry in achieving the goals and strategies of development plans that stress the diversification of production and the development of all economic resources in order to diversify sources of income and reduce the reliance on the production and export of petroleum as a main source of income. The Ministry's exploration and excavation work has located many mineral ore sites that are of high economic importance, which represent an important source of income diversification (Ministry of Industry and Mineral Resources, 2016). Satellites images play a vital role in meeting the scientific needs of these studies, which require the use of modern technology to conduct the scientific research (Dawod, 2015).

The study area has been chosen to efficiently contribute to the economic dimension and geomorphologic aspect of the limestone sites in the Wadi Nisah to the southwest of Riyadh, using a range of scientific tools and techniques necessary for identifying and highlighting the location of this type of rock and its feasibility. Landsat 8 has been chosen because it has Thermal InfraRed Sensor (TIRS) sensors, and an operational land imager. The importance of limestone in its natural form includes building stone and decorations concrete casting, agricultural soil PH neutralisation and the chimney purification of sulphur, as well as its use as an absorbent for gases resulting from fuel combustion, as an abrasive substance with a low level of hardness and to control coal dust in the coal mines in order to avoid inflammation. The economic value of limestone contains calcite the greater its presence, the greater its value and number of uses (Wyszomirski and Galos, 2007). This enables the efficient application of Geographical Information Systems (GIS) technology and providing the study results to help decision-makers. This study aims to identify the best technical sites that are known to have limestone suitable for industrial uses (such as cement, rocky seashells, glass) and produce a relevant map. It tests the following hypothesis: "is it possible to detect limestone of Wadi Nisah via remote sensing and GIS?" Moreover, it estimates the economic value and benefits of Wadi Nisah. Finally, it highlights the importance of GIS in limestone detection.

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2. Study area

Wadi Nisah is located to the southwest of Riyadh between longitudes 46 22' 5.366" and 46 58 ' 31.519" E and latitudes 24 13' 40.699" and 24 12' 35.939" N. The Valley is bordered by multiple valleys and mountains, from north by the Al-Awsat and Al-Laha valleys, from south the Alia and Al-Teen valleys, and from west Tuwaiq Mountains, as shown in figure 1. The study area is located to the southeast of Riyadh on the Al-Arma plateau, near its western edge, and occupies about 40.85 km^2 in the form of a rectangle, with its longest axis extending in a northwest-southeast direction. The topography of the area is generally flat except for some low hills in the southern and northern part of the area, which extend in a northeast-southwest direction. The region slopes slightly and gradually in a northeast direction. The valley is located on the Al-Kharj formation, above which is a formation of the Tertiary period. The site contains full and sub-valleys as well as rivers, and, as examples of the many valleys in this area, we can mention the Tuwaiq' main edge valley and the Nisah valley. Wadi Nisah (Valley of Nisah) is one of the largest and most important valleys in the city of Riyadh, due to its promising subsurface water aquifer. It feeds a number of sub-valleys to the east and north (Hussein et al., 2013). Thus, Wadi Nisah is a suitable place for agricultural development due to its large capacity for rainwater recharge. However, the structure and character of the valley is not well known. The study area is located in Wadi Nisah, southwest of Riyadh. The maximum elevation of Nisah valley is 1065 m, situated in the southwest of the Tuwaiq mountains, followed by the west side with an elevation of 1011 m. The minimum elevation is 530 m in the east in the direction of the Al-Kharj governorate (Figure 2).

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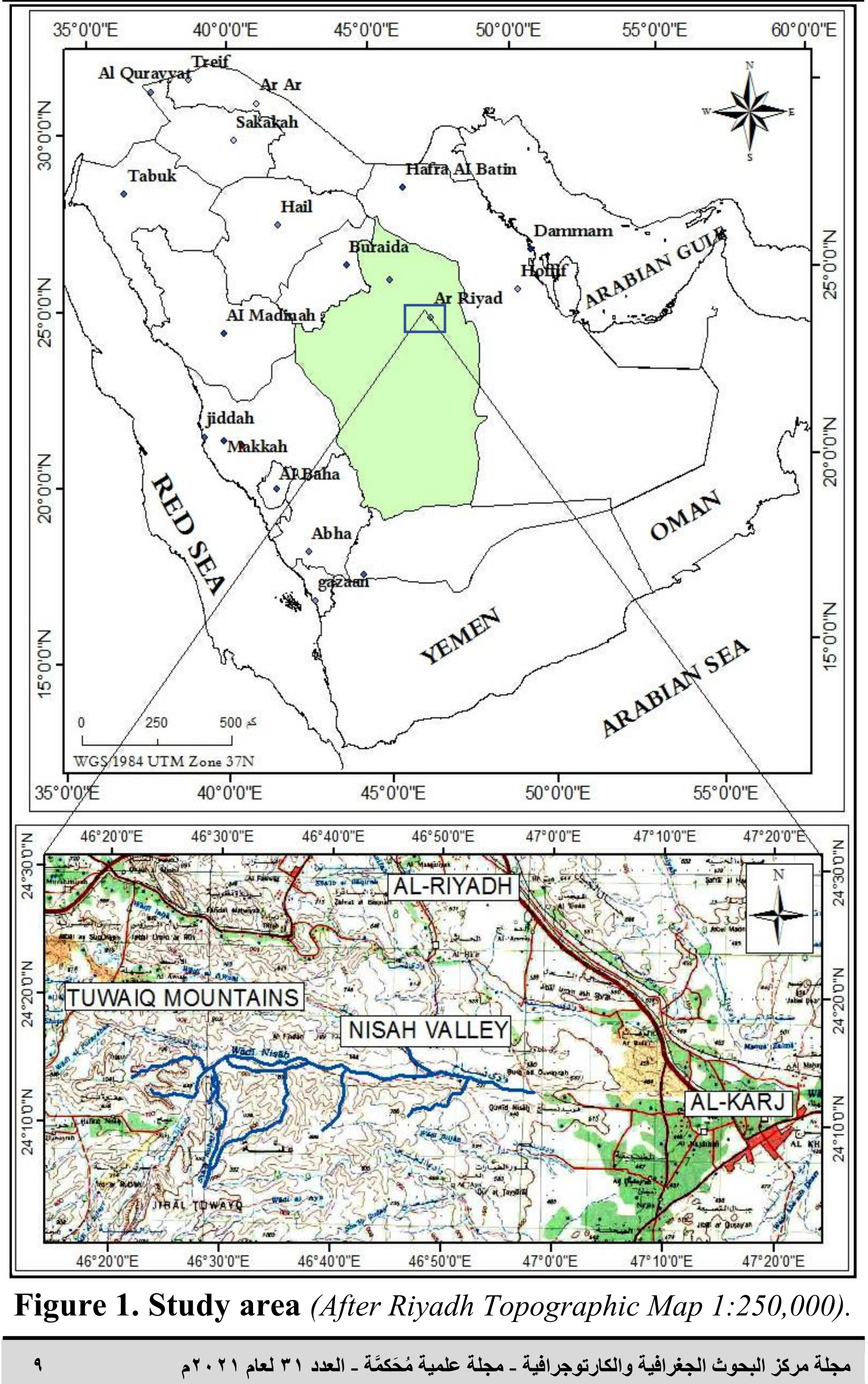

Figure 1. Study area *(After Riyadh Topographic Map 1:250,000).*

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Wadi Nisah has a number of tributaries that descend from the heights of Tuwaiq, including Shu'ayb Kahil, Shu'ayb Kahla, Shu'ayb Sadhan and Shu'ayb Al-Nuzim. According to the water resource distribution in Saudi Arabia, the water of the Wadi Nisah follows the Manjour and Dhurma rock layers (Figure 2). The study area has a continental climate system where the difference between short periods is high temperatures. The maximum temperatures for June and August are 43.7°C, but rain is rare and irregular. There may be heavy rainfall of short duration (Aboud et al., 2013).

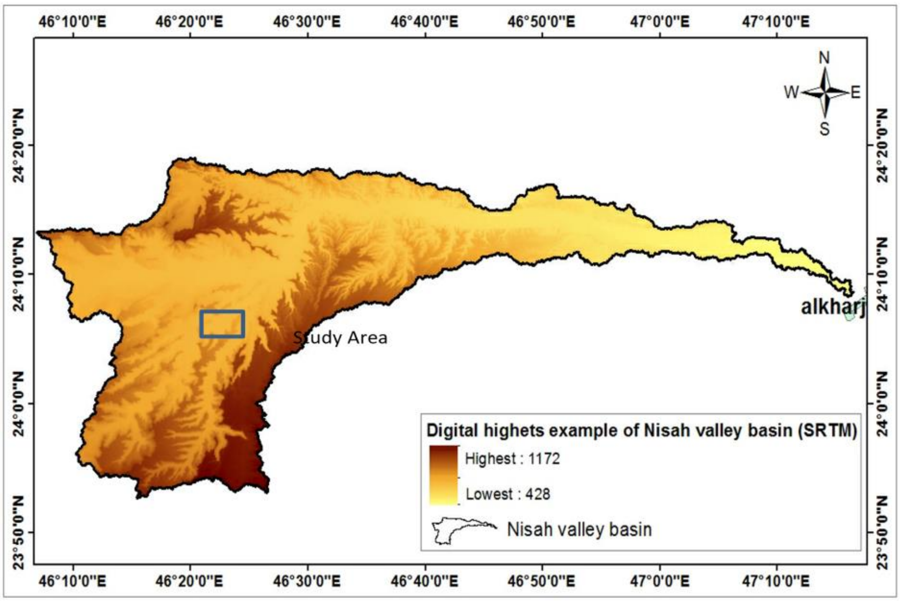

Figure 2. Digital heights example of Nisah valley basin

2.1. Geomorphology

The slope of the surface starts at a horizontal plane, and the steeper the slope, the greater the intensity of water flow and velocity. Geological and climatic processes play a vital role in the process of slope emergence and the formation of rocks. The composition of the rocks has a role in their susceptibility to erosion. The most important characteristic is the impact on hydrological processes, followed by erosion into the river and the fluvial transfer of sediment. In addition to its effect on the rivers and streams, and the density of the discharge, the slope generally lessens towards the mouth of the river. Through the SRTM model and ArcGIS software, a regression was extracted for the features of the area. Figure 3 shows the Wadi Nisah basin surface sl ope. The surface of the structure, divided into four gradient classes, represents the slopes of the Wadi Nisah basin. First class includes slopes of less than 25°, with a ratio of 70.44% of the total area of the basin. The area of this class is 1369.92 km^2 (Table 1). This class is concentrated in the valleys and nearby depressions, representing a semi-flat surface. Second class ranged from 25° to 45°, and the percentage was 20.61% of the total area of the basin with an area of 400.76 km^2. This category appeared differentiated on the sides of the water basin. Third class ranged from 45° to 65°, and the percentage was 8.30% of the total area of the basin with an area of 161.49 km^2. This class as has a medium slope. Forth class was characterized by a slope of 65° and an area of 12.72 km^2, with a ratio of 0.65%. Concentrated in the northeast highlands of the valley basin, it is an acute slope. This class represents the upstream source area (Figure 3). The acute-slope areas form a location for different erosion processes (Abul-Enein, 1995). In these areas, the water flows through a narrow gully. Some of it is full of large stones, and the coarse bed and narrow stream result in a strong withdrawal strength and movement of obstacles in all directions. However, as the river advances towards the mouth, the materials on the riverbed become smaller, and the resistance of the flow is less due to the increasing stream width. It receives a great deal of drainage, as in the mainstream of the Wadi Nisah, where deep slopes decrease the amount of material resulting from erosion and similar factors, with their flow from the highest point of the slope to the lowest.

Table 1. Wadi Nisah basin slope ratio

Slope class (%)	Area (km^2)	Percentage (%)
Less than 25	1,369.92	70.44
25–45	400.76	20.61
45–65	161.49	8.303
Over 65	12.72	0.654
Total	1,944.89	100

In brief, the slope is related to the river behaviour, where the material of crushed rocks is transferred to the plain-surface bottom slopes, which are considered as areas to gather different sediments (previous reference). From the study, it is clear that the limestone ore is concentrated in this area where it is utilised economically from the second-class slopes ranging from 25° to 45° with an area of 400.76 km^2 and representing 20% of the valley area. It has high economic value without the additional cost of extraction. These valleys cross-cut steep beds between hard and brittle Mesozoic and Cenozoic clastic, carbonate, and evaporitic rocks (Daoudi et al., 2021).

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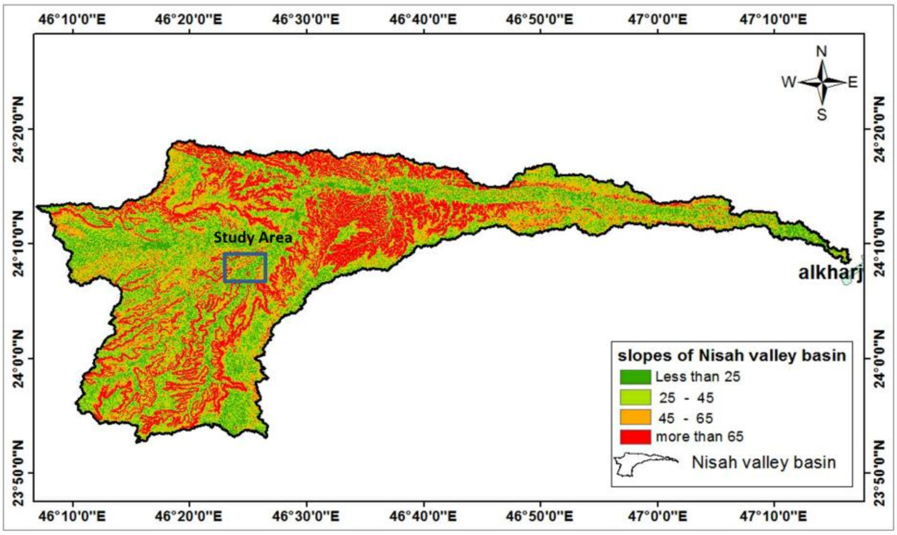

Figure 3. Nisah valley basin slope map (in degrees)

2.2. Lithology:

The properties of the rock formations and their geological construction have been affected by many natural characteristics, such as floods, porosity ratio and cohesion. This results in different concentrations and types of mineral deposit. The following is a description of the stratigraphical sequence that forms the area and influences the geological structures (Figure 4):

– A limestone with cream-coloured cavities and very fine crystalline structures, which can be classified as a type of claystone consisting of less than 10% carbonate granules and more than 90% clay (sediments of carbonate in a volume of clay) (Dunham, 1962). It forms the supporting part of the rock with a thickness of 1–5 m, and the cavities characterising this part of the rock are generally filled with carbonate deposits with calcite crystals and clay deposits with iron oxides.

– Limestone of a creamy colour is lumpy, nodal, sometimes chalky and consisting of soft organic crumbs, which can be classified (Dunham, 1962) as a granular stone, as it does not contain clay and the granules form the primary supporting factor of the rock. The thickness of this section is 5–15 mm medium-sized crystalline dolomite limestone, classified by Dunham (1962) as a crystalline limestone since its structure is supported by crystals without granules or clay with thickness ranges of 0.5-3 mm.

– A thin layer of calcareous clay sandstone with a pale-olive to grey colour, with thickness ranges from 0.10 to 0.30 mm has some changes in the proportions of the metal composition and the size of the granules, but it is almost continuous in most of the area and is considered as the separating surface between the Al-Arma and Al-Wase formations.

– An olive-green clay and yellow to red stone containing the remains of plant and fish fossils, and the claystone reveals soft sand at increased depth. Its thickness is from 10 to 12 m.

– A fine sandstone, calcareous white limestone and yellow coarse sandstone with low consistency and cross matching. The thickness of the sandstone at the maximum drilling depth is about 25 m.

– A set of regular and unlimited fissures dividing the study area in the northeast and the southeast. Readers can refer to the appendix to see the geological formations from the oldest to the most recent and the thickness of each formation, as well as the type of rock that forms them (Vaslet et al., 1991).

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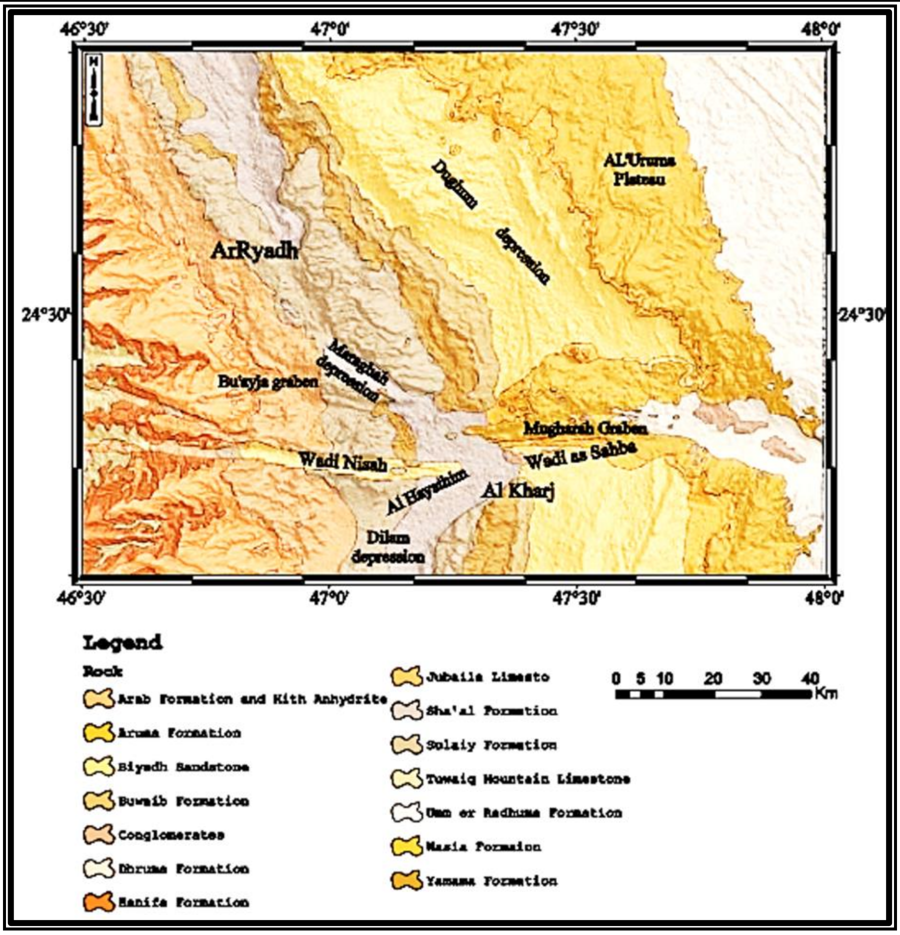

Figure 4. Study Area geological map, *(After Al-Ghamdi, 2007)*

2.3. Biogeography:

2.3.1. Vegetation:

The vegetation in this area is considered to be poor, and the plant environment in Saudi Arabia has been covered by a significant amount of research and contributions by a number of different researchers interested in botany. To establish the ratio of vegetation in the basin and its area, they used Landsat 8 OLI and its imaging mechanism. An analysis was conducted using ArcGIS 10 software. This software has eight domains, of which the fourth and fifth domains have been used for this purpose. This is in addition to applying the normalized difference vegetation index (NDVI) equation, which is the index that identifies the difference in vegetation. Map 2.3 was obtained to show the vegetation in the Wadi Nisah basin area. This index is one of the most useful methods for plant control. It is a technique based on the relationship between nearby infrared (NIR) and visible red rays (R). This relationship is due to the high reflectivity of the plants (NIR) and the low reflectivity in the red range (R) (Shalaby, 2006).

Shalaby (2006) noted that a study of the adjusted vegetation index gives the same results as the application if it is done in one of the known programmes, such as ERDAS and ArcGIS (7). Therefore, the study software used for the Wadi Nisah basin was ArcGIS 10. The NDVI index is useful for describing the spatial distribution of crops through the chlorophyll in the leaves of the plants, which absorbs visible light. It absorbs it less in the areas with low refraction or where there is little vegetation; hence the absorption amount depends on the spectral fingerprint of each colour. Each colour has a spectral fingerprint, the refraction of which can be captured by the space sensor, which is shown in different colours with different degrees.

Green colours absorb visible light (R) and reflect about 20% or less in the range of 7.0–5.0 microns (green to red), while semi-infrared radiation reflects about 60% in the range of -1.0–0.7 microns (semi-infrared). These spectral reflections represent ratios for the rays reflected in each spectral range individually and, in turn, concentrate on the value between zero and 1. This means the NDVI indicator is between the values -1 and 1. The programmes calculate the vegetation index as per the following mathematical formula: Then: $NDVI = \frac{(NIR)-(R)}{(NIR)+(R)}$

In turn, if the equation reflects a positive NDVI indicator, this indicates the existence of vegetation, while a negative value reflects the lack of vegetation. When processing the NDVI data results using the Spatial Analyst Tool, the Raster Calculator and Map Algebra have been used. Each category was separated into categories of cultivated areas and uncultivated, and the areas of each place were calculated in relation to the total area of the basin. The total cultivated area, according to the NDVI index, located between -0.4 and -0 in the Wadi Nisah basin was 7.1 km^2, and forms 0.37% of the total. The total area of the basin is concentrated in the eastern depressions of the basin, and in the western depressions. In contrast, the barren spaces that were between -0.24 and -0 constitute a total area of 1,937.66 km^2 occupy 99.63% of the basin total area. This illustrates that the basin is an area of poor vegetation resulting from the scarcity of rain, in addition to the high temperatures mentioned previously. However, it benefits, relatively speaking, from the underground water reservoir, which is clearly shown in the indications of vegetation in the Wadi Nisah basin, where the cultivated sites are 5.6 km^2 from the mouth and form the total cultivated area in the basin (Figure 5).

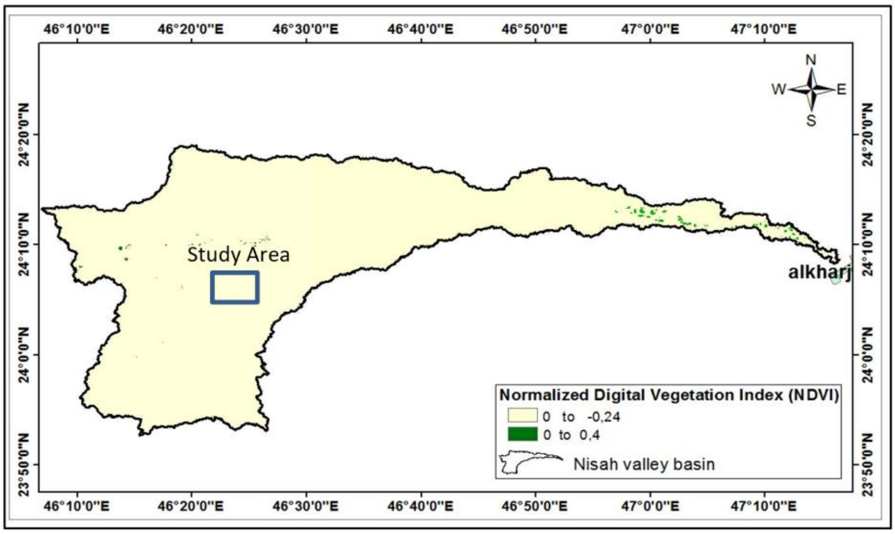

Figure 5. Vegetation indicator of Nisah Valley

2.3.2. Soil of Wadi Nisah

Soil is one of the main factors in agricultural production, into which a plant extends its roots to find the necessary nutritional resources. Soil is the fragmented part of the land; it covers the surface and includes plant and animal residues. It is also influenced by climatic phenomena. Soil is also where the major chemical changes take place as a result of the water running through it, resulting in the dissolution of metals, which are part of the soil (Nduwumuremyi, 2013). Therefore, the soil implicitly contains organic materials and the necessary elements for plant nutrition. Each soil type has its own texture. The grains forming the soil can be either coarse or soft. Soil is divided into two types, local and transferable.

The research discusses the geochemical equations that interpret how the water affects the soil and the dissolution of the main metals by hydrolysis. To realise this objective, thirty samples of soil have been analysed using field methods, from different sites along the Al-Shoeb stream bank from west to east. The analysis results indicate that the ratio of sand in the samples differ from 78% to 96%, whereas the silt ratio differs from 1% to 12% and the mud ratio from 2% to 10% from the total granular composition of the samples under study. The laboratory investigations indicate that the size of the sand grains in different samples differs between 0.5 to 0.63 mm and the results confirm that about 66.7% of the samples analysed are formed of sand at a ratio of more than 90%. The rest is represented by samples in which the sand ratio ranges between 78% and 88% of the total granular composition of the samples under study.

From such results, it is noticeable that the Al-Shoeb soil is generally the same, characterised by its sandy texture in which the silt and mud are reduced. Therefore, using this type of soil requires a mix of sand and a large quantity of silt and mud to be suitable for agricultural production (loamy soil). The process of mixing requires specialised technical efforts and funding. Yet, the costs of agricultural production are high and the characteristics of this soil would not hinder agricultural production in the area. Nisah soil is currently suitable for cultivating several types of vegetable and plants, such as corn, that tolerate a medium level of salinity and alkalinity, which characterises the Al-Shoeb soil. However, it lacks organic matter. To use such soil in agriculture, it needs chemical and organic fertilisers. One of the local practices in this area is using green fertiliser, such as clover, which is cultivated after ploughing and planted a second time before flowering. This type of agricultural practice leads to a high level of soil fertilisation with a high organic matter content, which gives it the ability to retain a great deal of water. Nisah soil experiences

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many chemical changes as a result of the presence of many farms and the large amount of water. As a result, many elements in the Al-Shoeb soil are dissolved by the water and leached out through the soil that has a high sand content, moving the elements to the lower sand layers far from the crops' roots. This process is called the leaching process, which means that the soil elements are dissolved in the water until they reach the soil section that is called (b). Thus, it is necessary to link the soil study in Al-Shoeb with the study of water chemical characteristics. It is also necessary to link the study of the soil with how soil metals and elements dissolve in the water. It is noticeable that sodium leads to the deflocculation of silt and mud particles that form part of the Al-Shoeb soil, and, as a result of the composition, it is not suitable for agriculture. The research, in addition, indicates that sodium probably affects the silt and mud in Al-Shoeb. This probability is weak because the ratio of silt is less than that expected in the soil composition. The results indicate that bicarbonate generally increases compared to calcium and magnesium. Therefore, water is said to include bicarbonate residue.

3. Material and methods:

3.1. Creation of a database and information processing

The processes of decision-making, collecting geological and spatial information on limestone in a database accessible to all is very important. A geological map of the rocks in the peninsula is created based on information from geological reports and scientific studies. Furthermore, limestone properties are identified according to size, degree and spatial distribution. Rather than viewing this guidance as final product containing basic information on limestone, it should be considered a basic guidance for users in need of spatial and geological data, saved and upgraded to improve information in relation to related issues, as per the research objectives. To search for the site in the old maps, it is necessary to depend on the old topographic and geographical maps, so that the area of study may be determined on the map and the location to be studied using the map key and the colour and symbol indicators. Hafirat Nisah area located within Dhurma is chosen; Figure 7 map GM101C- and Figure 6, showing Lithostratigraphic column of Paleozoic and Mesozoic of Nisah valley, considering Dhurma's geology in the Jurassic period. The average limestone in this area is suitable for economic use, so it can be transferred directly to the crusher.

Figure 6. Lithostratigraphic column of Paleozoic and Mesozoic of Nisah valley

(After Saudi Geological Survey, GM-101, 2007)

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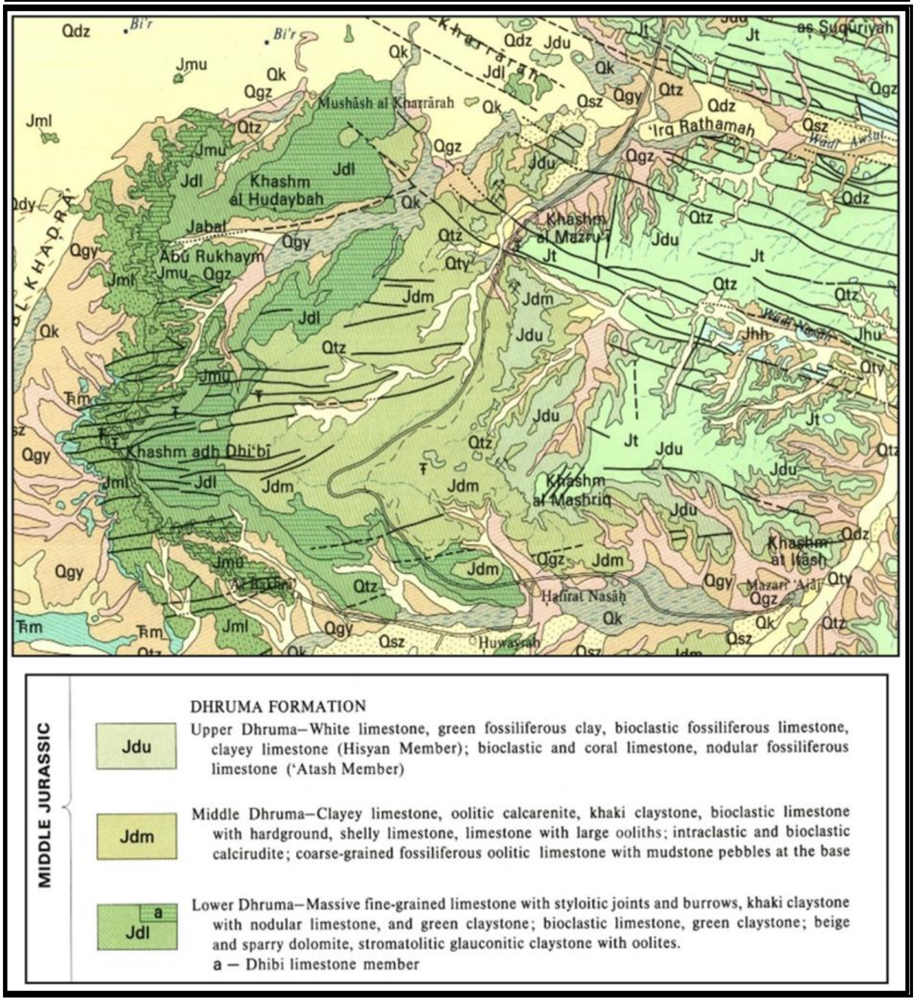

Figure 7. Dhurma formation *(GM – 101C)*

3.2. Data digitized (Limestone, Roads, Urban area)

The GIS programme; ArcGIS, added images taken from old maps and applied the WGS1984 geographical system (Figures 8 and 9). A geographic information system (GIS) is a system that creates, manages, analyzes, and maps all types of data. GIS connects data to a map, integrating location data with all types of descriptive information. This provides a foundation for mapping and analysis that is used in science and almost every industry. GIS helps users understand patterns, relationships, and geographic context. The benefits include improved communication and efficiency as well as better management and decision making (Pro.ArcgGIS.com, 2021).

Also added are images taken through the programme, then a database containing the regions that looked promising in terms of limestone, in which the dolomite and carbonate ratios are high, and the extraction of which would be cost-effective. The location of the limestone in the Wadi Nisah basin was determined. It covers 383.5 km, equal to 20% of the total area of the basin. Such areas are represented by the places of highest elevation in the middle and west of the basin. The limestone is concentrated in these areas because the depressed lands are suitable for agriculture and irrigation and, generally, have less rock (Figure 10).

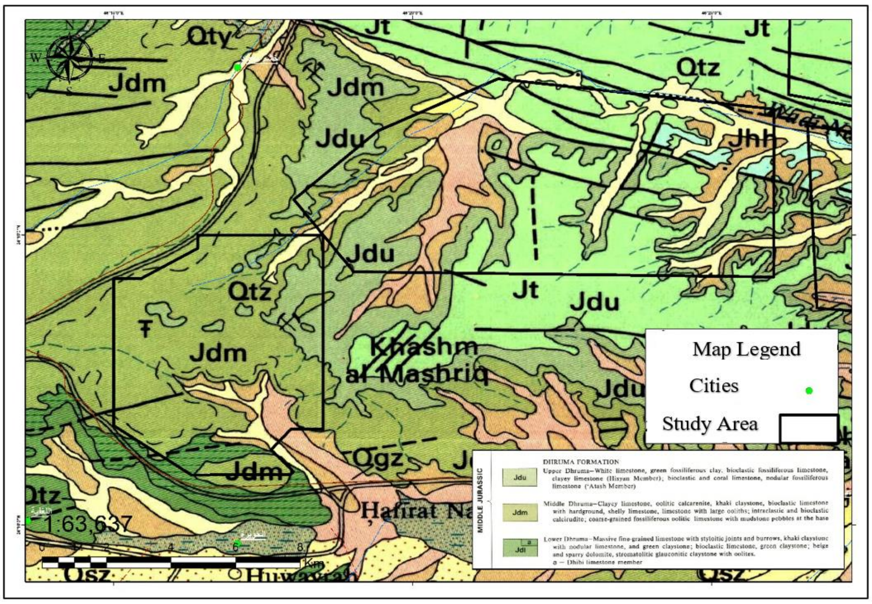

Figure 8. Old geological maps through ArcGIS

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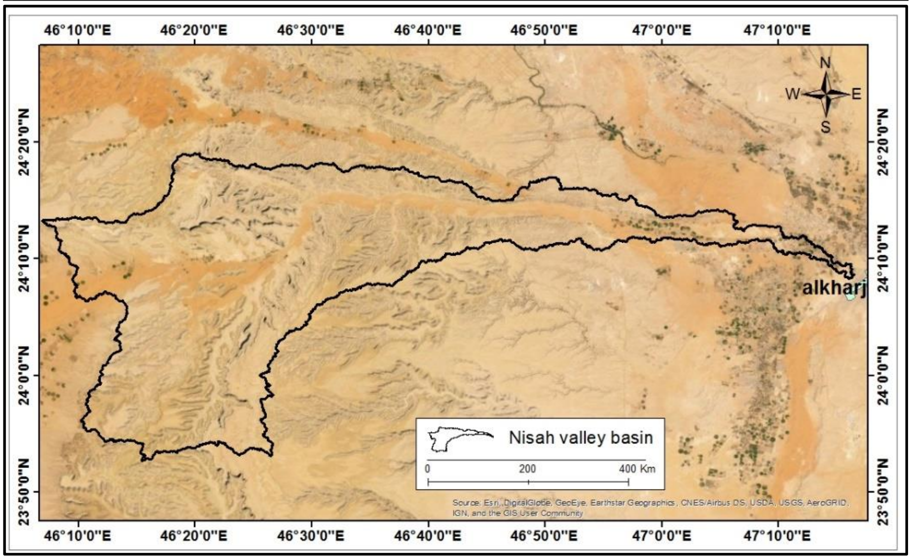

Figure 9. Satellite image of the sand and limestone formations of Wadi Nisah

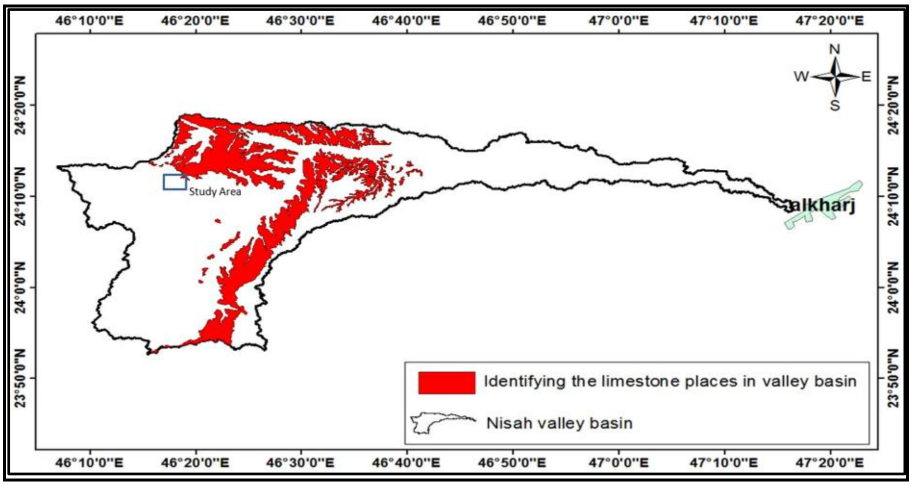

Figure 10. Limestone rocks within Nisah basin, produced by ArcGIS

Multispectral imagery is a powerful tool for distinguishing different types of materials and features in the landscape. Natural and man-made materials often have unique spectral signatures that can be used to identify them quantitatively. Spectral profile charts allow us to select areas of interest or ground features on the image and review the spectral information of all bands in a chart format. A spectral profile consists of geometry to define the pixel selection and an image with key metadata from which to sample. These selections determine what data is processed and displayed in the spectral profile chart and how the data is visualized. When the spectral profile is defined using a collection of pixels, the default visualization is a line chart (Pro.ArcGIS, 2019).

1. **X-axis:** The x-axis displays the bands and wavelengths of the electromagnetic spectrum for each band. When plotting Boxes, Boxes and Mean Lines, and Consolidated Mean Lines, the x-axis is determined by the number of bands in the image, not the wavelength.
2. **Y-axis:** The y-axis is used to measure pixel or ground feature values composed of statistical measurements for minimum, first quartile, median, third quartile, and maximum values. Default minimum and maximum y-axis bounds are based on the range of data values represented on the axis (Figure 11).

To extract value of Reflective band DN's can be converted to TOA reflectance using the rescaling coefficients in the MTL file:

$$\rho\lambda' = M\rho Qcal + A\rho$$

where:

$\rho\lambda'$ = TOA planetary reflectance, without correction for solar angle. Note that $\rho\lambda'$ does not contain a correction for the sun angle.

Mρ=Band-specific multiplicative rescaling factor from the metadata (Reflectance_Mult_Band_x, where x is the band number) and it's equal (Reflectance_Mult_Band_x = 2.0000E-05 = 0.00002)

Aρ =Band-specific additive rescaling factor from the metadata (Reflectance_Add_Band_x, where x is the band number) and it's equal (Reflectance_Add_Band_x = -0.100000)

Qcal = Quantized and calibrated standard product pixel values (DN) which samples are taken.

To calculate TOA reflectance with a correction for the sun angle is:

$$\rho\lambda=\rho\lambda'/\sin(\theta SE)$$

where:

ρλ= TOA planetary reflectance

θSE = Local sun elevation angle. The scene centre sun elevation angle in degrees is provided in the metadata (Sun_Elevation) and its Equal (Sun_Elevation = 67.14093359).

Figure 11 shows the spectral reflection, extracted by software ArcGIS. The physical properties of the investigated limestone rocks, such as bulk density and effective porosity, were determined using the techniques. Reflectance values of limestones in samples (5 and 6) are lower than other values reported for limestone rocks. This means containing less limestone and more other element like sand and gravels.

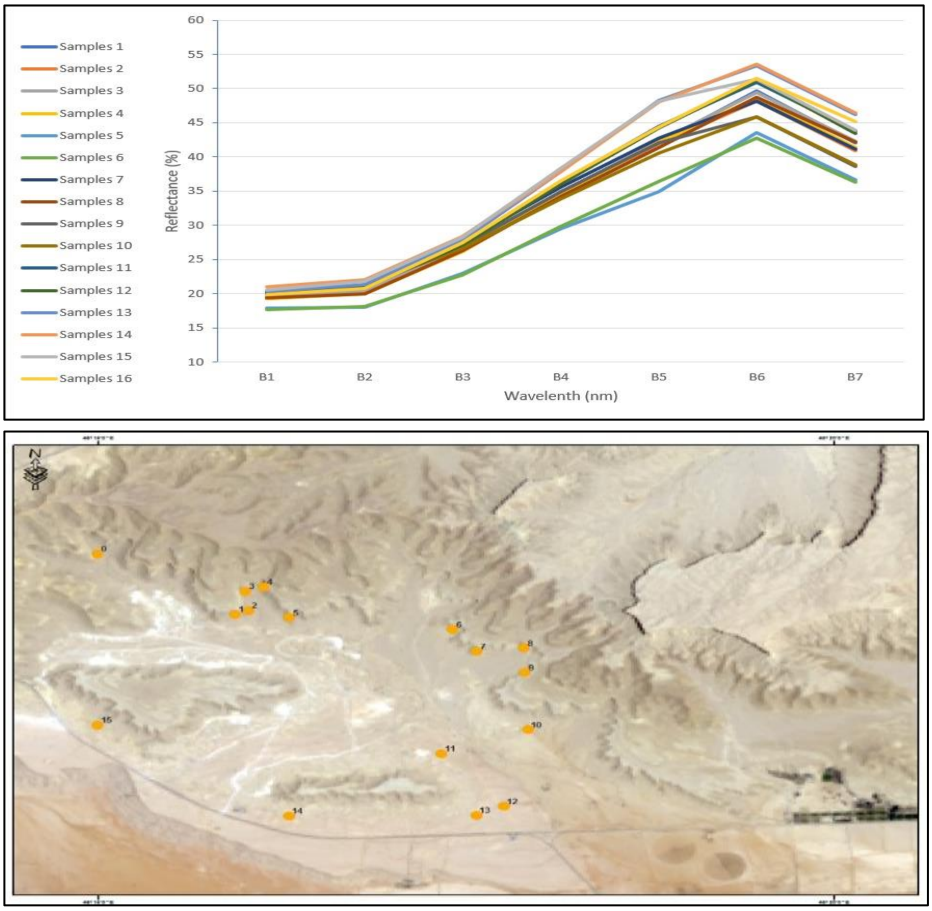

Figure 11. Spectral values of the Limestone rocks samples, produced by ArcGIS

3.3. Satellite imagery processing:

The suitable locations are sought using satellite images, relying on satellite and Spot Moon photos from both 2000 and 2016. This shows the environmental changes that have emerged during this period, and processed the satellite images using ERDAS software to convert it to Raster, utilising metadata (Figure 12).

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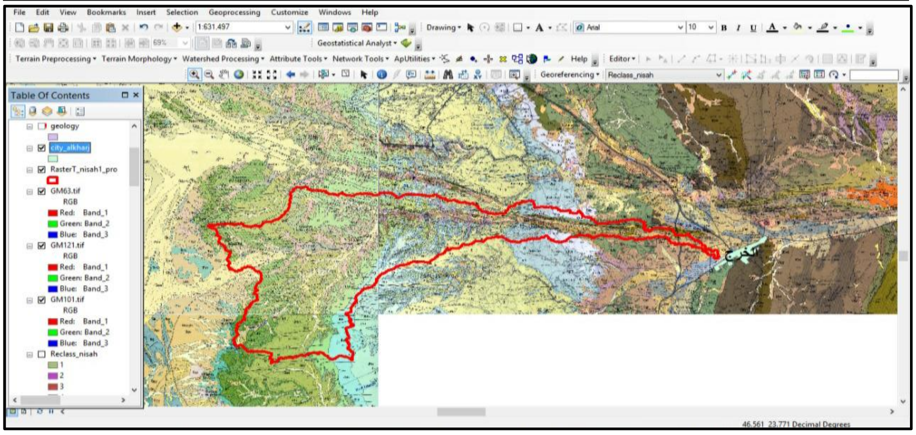

Figure 12. Wadi Nisah′s Digital image of the geological map (type: TIFF), *produced by ArcGIS*

3.4. Multi-source data fusion

The field work in valley was an important part of data sources. Creating a database using ArcGIS requires the identification of suitable sites and visits to explore the region. Following the process of identification, the study area, where a high percentage of dolomite and calcium carbonate was found, was visited and samples analysed in order to find the best sites that would afford the least time and cost in terms of the process of limestone extraction. Several images displaying sections of the limestone rocks in the Wadi Nisah study area have been taken (Figure 13 A, B, C). The sediments of a rocky cover formed by Dharma (Tuwaiq Mountains), and Dhurma layers appear clear: the upper, middle and lower. Each has its own geo-tectonic nature. It is a thick, complex limestone with thin layers of friable rock at the bottom. The Dhurma Formation is mainly composed of a thick carbonate sequence with a thin bedded clastic sequence in the basal part. These units are developed on a homocline carbonate ramp system. Porosity and permeability results showed that the

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highest values and the most likely high-quality reservoir is the burrowed wackestone in which the dolomite calcitization (dedolomitization) process generally occurs. Micritization, dolomitization, and cementation processes in mudstone and peloidal skeletal wackestone reduce porosity and permeability values (Aviandy et al., 2018).

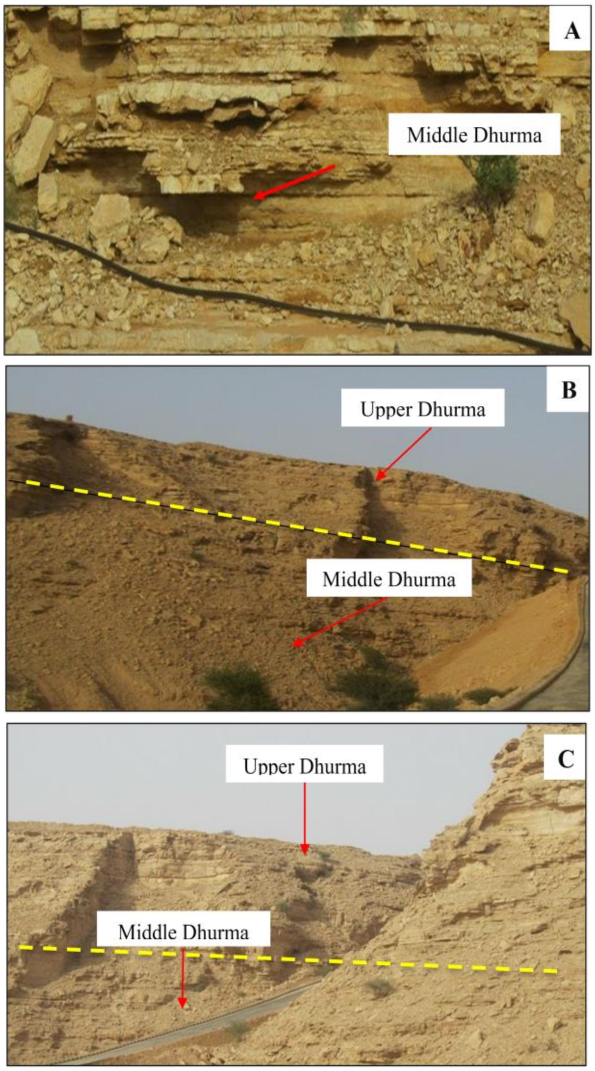

Figure 13. Apart from the limestone rock in Nisah valley.

4. Results and discussion:

4.1. Nature and occurrence:

Limestone is a sedimentary rock composed mainly of calcium carbonate ($CaCO_3$), usually in the form of calcite or aragonite. It may contain considerable amounts of magnesium carbonate (dolomite $CaMg[CO3]_2$) (Lewicka et al., 2020) the most common of which is silica. With increasing amounts of dolomite, limestone grades into dolomitic limestone and calcareous dolomite, and with increasing impurities into calcareous sedimentary rocks, such as marl. Marble is limestone which has been recrystallised through metamorphism. In many applications, marble and limestone are interchangeable (Resource Sand Geoscience, 2006). Minor constituents commonly present include clay, iron carbonate, feldspar, pyrite, silica, and quartz. A peculiar variety of limestone rock, owing both to its genesis as well as properties and uses, is chalk (Lewicka et al., 2020).

Limestone is a vital resource for the construction industry and can be divided into three main groups depending on the environment and method of sedimentation: organic, chemical and detrital. It is a sedimentary rock formed by the chemical deposition of calcite with other carbonate minerals (dolomite, siderite). Limestone reservoirs were searched for using satellite Shuttle Radar Topography Mission (SRTM) and digital Landsat 8 over 20% of the basin area. To collect spatial and geological data, several steps were implemented as follows: search for the site in the old maps, search for the site using satellite images, use of ERDAS software to convert the images to Raster using metadata, use of GIS software and finally use of the ArcGIS programme to add images taken from the old maps introducing them to the

WGS1984 geographical system. Then we created a database containing promising areas for limestone ore, which contain high dolomite and carbonate ratio. Also, the extraction does not cost time and effort. The database was created using ArcGIS, so that it would be easy to identify appropriate locations and visit the area.

4.2. Processing the limestone area:

Firstly, the Nisah Valley is located in the Dhurma formation, which contains mineral deposits of different concentrations in the rocks. The Al-Arma plateau (Al ‘Urumah near its western edge, occupies about 40.85 km^2 in the shape of a rectangle). Its longest axis extends in a northwest–southeast direction and the area dips slightly and gradually towards the northeast. Secondary Wadi Nisah water follows the layers of Al-Munjoor and continental Dhurma, with bases of quartz sand, which is characterised by a strong fragmentation and a rough to acutely rough texture, over which there are thin layers of limestone, clay, gypsum and various blocks. In turn, the salinity increases with the increase in the downwards dip. Thirdly, the study area is located in a dry, tropical climate and, because it is far from any large water bodies, rain is scarce and irregular, but there may be heavy rainfall of short duration. The maximum evaporation rate in July (summer) is 213.8 mm. Moreover, the relative humidity, in general, decreases in the study area. Fourthly, the best areas for extracting limestone ore are in the Middle Dhurma area, because it is not necessary to use a furnace for extracting limestone. This reduces the amount of effort and environmental pollution, which is generally produced by factories. Fifthly, through what has been accomplished in this dissertation, this method can be used for extracting any mineral based on data, such as old maps and aerial photographs. Last, it is possible to use aircraft equipped with cameras. This approach has a high degree of accuracy and development. The plane can be sent to points covering the area of study to capture images of areas that are not easily accessible.

4.3. Economic importance of limestone

Limestone is a rock with an enormous diversity of uses. Most limestone is made into crushed stone and used as a construction material for road base and railroad ballast as well as an aggregate in concrete. Some additional but also important uses of limestone include dimension stone for use in construction and in architecture, roofing granules applied as a weather and heat-resistant coating on asphalt-impregnated roofing, flux stone in smelting and other metal refining processes, as well as the production of Portland cement (Lewicka et al., 2020). A large resource base of limestone rocks are found, but only some deposits can be utilized in the lime industry, in particular for the production of limestone flour.

More sophisticated are the products obtained by grinding to the required granulation of limestone, called limestone flour or powdered limestone. They are primarily applied in: the glass-making industry as a stabilizer of molten glass parameters and calcium oxide supplier, the paper industry as a filler and coating pigment, in the production of stone-mastic asphalt and building materials as a filler, in the power industry as a sorbent to desulphurization of flue gases, in the plastic industry and rubber products as filler or extender, and in the fodder industry as a component of fodders and premixes (Wyszomirski and Galos, 2007). Kandos limestone quarry is used in cement manufacture on-site. The ideal grade of limestone for cement manufacture is around 70-80% calcium carbonate (Resource Sand Geoscience, 2006).

It was found that raw material of the best quality can be found in deposits mainly of Jurassic and Devonian origin located in the study area to the production of Portland cement. Calcium carbonate is one of the most cost-effective acidneutralizing agents. Mineral resources are important sources of income for primary producing countries. The Kingdom of Saudi Arabia covers a large area with multiple geological environments containing various metals that allow for the development of investment opportunities in the mining industry. This industry is important for achieving development plan objectives and strategies that lead to the diversification of the production base and the development of economic resources. This will lead to the diversification of income sources that do not rely on the production and export of petroleum. Moreover, exploration and excavation activities are being performed by the Ministry of Petroleum and Mineral resources to identify many sites of mineral ore with high economic feasibility to form an important and diverse source of income. Riyadh is located in the middle of Saudi Arabia and is one of the most important areas due its distinguished geographic sites between the Tuwaiq Mountains and the Najd plateau, and it is surrounded by the Al-Dahna desert and the Empty Quarter (Al Yamani, 1993).

In many essentially chemical applications, such as the manufacture of cement and lime, limestone is used, while in applications such as fillers or whiteners where limestone is used for its physical characteristics, limestone or dolomitic limestone can be used.

The geology of the spread and distribution of minerals has become a separate science, and the minerals have become important for the national wealth, playing a vital role in the country's economy. In addition, modern technologies facilitate the discovery of and search for different minerals, each with its own economic value. It is essential to find commercial quantities of these minerals. Remote sensing systems help researchers search for minerals and rocks by improving their performance and increasing their interaction with other disciplines, such as mining geology and mineral discovery, rock geology and so on. Development projects, environmental impact studies and industrial projects are important to achieve sustainable development. Furthermore, the use of clean production technology is important, as well as studying the impacts on the surrounding environment, identifying ways necessary to avoid or limit negative impacts, reaching decisions on the establishment and operation of different development projects and contributing to development without compromising the balance of the environment. An overview of limestone and its economic and industrial importance is provided, and the distribution of limestone throughout Saudi Arabia is discussed. Then, satellites are discussed and their importance in the advancement of the experimental sciences and the renaissance of states. The satellite mechanisms and operations necessary for illustrating land topography are set out, and the analysis of the metals for scientific and technical accuracy and the need to avoid mistakes to maintain scientific value are established.

4.4. Limestone in Saudi Arabia:

In a world of limited resources, with many species and neighbourhoods that need protection, prioritisation is essential. However, we cannot give priority effectively if historical and current information relating to a source or type remains insufficient. There is a significant amount of data that has been created to help users find, use and create biodiversity information. Data for the exchange of information on sources for economic systems are available but are threatened and unconnected. Limestone is an example of a threatened economic system that contains unique geological diversity, but it faces disruption from humans and animals. Since limestone is a vital resource for the construction industry, it is not possible to stop the deterioration of life and the exploitation of quarries in developing countries such as Saudi Arabia. Generally, limestone can be divided into three main groups as per the environment and the method of sedimentation: organic, chemical and detrital.

Chemical organic limestone is called ‘autoctonwas’ due to its sedimentation in water environments, whereas detrital limestone is called ‘aloctonwas’ due to its formation in this environment. Limestone indicates the sedimentation environment, which is either a river or a marine environment, but it also indicates a warm, clear, water sedimentation environment. Several limestone types contain chemical and organic detrital sediments, such as calcite and aragonite. Aragonite decomposes easily and transforms into calcite; therefore, it does not exist in the old types of limestone. In addition, it changes easily through the recrystallisation of aragonite during the process of re-sedimentation, during which it loses its distinguishing features (civilizationlovers, 2012).

Portland Limestone Cement (PLC) is used in building graves and temples in several countries of old civilisations and industries. It is also used as an assistant factor for iron ore, and clear crystallised calcite is used for some ophthalmological and scientific purposes. It is a red brick substitute, where its size is eight times that of a normal red brick, and it has better properties for thermal isolation. However, its size is matched by its heavy weight, so it is not preferable for high-rise building but can be used in new, tourist and village buildings. The cement industry in which limestone is used is considered the main industry in the construction and building sector, and any shortage in the production quantity can hinder projects.

The cement industry is also considered to be one of the largest strategic industries because it is directly related to construction and building. In light of the commitment of the Government of the Custodian of the Two Holy Mosques to search for and explore local mineral ores, the vice-presidency has set aside more than 400 sites of limestone ore for mineral resources and produced over 50 geologically inspired reports for areas and locations of these materials, including the following:

A. Om Al-Gorban: It is 50 km east of Al-Kharj city. The raw thickness is 20 m with 54% calcium oxide and the stock is estimated at 145 million cubic meters. Studies have indicated the suitability of these raw materials for use in the manufacture of auxiliary material in the smelting field.

B. Siddus: About 8 km west of the city of Siddus, which is west of Riyadh, its ore contains a white limestone with a thickness of 30 m, and the stock is 10 million tonne. Studies indicate the high quality of the ore in white cement manufacturing.

C. Khashm Al-Mazalij: It is 25 km southeast of Riyadh. The ore is of high purity, with 55.6% calcium oxide, and its thickness ranges from 5 m to 9 m. The raw material is suitable for the manufacture of auxiliary materials for smelting and in the glass industry, white rubber, plastics and paints.

D. North of Diriyah: It is 20 km north-northwest of Riyadh in a narrow region containing 55.2% calcium oxide.

E. Wadi Hanifa: It is 10 km north-west of Riyadh within the Jubaila formation and contains 99.24% calcium carbonate.

F. Al-Ha'ir: It includes four sites in the north and south of Al-Ha'ir. Its ore contains up to 99.46% calcium carbonate.

G. North Juffair: It is 7 km north-northeast of Juffair, where the ore reaches 97.10% calcium carbonate.

H. Wadi Al Tarabah: The Tarif Al Harra area contains pure limestone in which the amount of calcium oxide is 55%, with no more than 2% magnesium oxide and no more than 2% iron oxide. The ore covers an area of 40 km in length and has an average thickness of 3 m. The stock is estimated at 200 million tonnes and studies have proved its suitability for steel, glass, white cement and rubber, plastic and paint. Limestone is also located within the rocky escarpments of the western side of the Dammam dome. About 20 m in thickness, this layer is currently extracted for concrete purposes. The ore is also suitable for the manufacture of metal auxiliary materials used for smelting. Non-pure limestone is present in the concrete mountain with a calcium oxide ratio of 32.54%. This ore is used in the cement industry. It is also found in Jabal Al-Abd within the Al-Jouf formation, and its calcium oxide content ranges from 46.5% to 54.5%.

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Limestone exists in the form of sedimentary rocks. It is formed by the chemical deposition of calcite onto small carbonate minerals, dolomite and siderite and the mechanical sedimentation of fragments, sand and clay (quartz, flint, fluorine, sulphate, piretite, iron oxides and kaolinite) and organic matter from the remains of living organisms.

a. Soft solid limestone.
b. Cretaceous limestone composed of fine psoriasis residues.
c. Fossil limestone made of bones and shells.
d. The kikina, made up of shell fragments on the seafront.
e. Oolite limestone composed of deposits of calcium carbonate around sand granules and detrital shells.
f. Travertine.
g. Marlstone, which has two forms: Metamorphic rock, igneous rock, and carbonate.

4.5. Environmental impact:

This is based on the proportions of dolomite and carbonate calcium in the region, taking into account their whereabouts, how they are extracted and how close they are to protected areas and residential areas. What matters is that the extraction of this crude limestone does not harm the environment and makes it easier to study and analyse.

Limestone used to make lime must not produce a large proportion of fines on calcining. Demand for agricultural lime has grown in recent years and is creating opportunities for the development of new resources to meet regional demands. Other markets for limestone-based products, such as fillers and glassmaking, are highly competitive. Domestic markets are relatively small, making entry difficult for new producers. New producers would probably need to develop overseas markets to succeed (Resource Sand Geoscience, 2006).

5. Conclusion and recommendations

- ✓ Establishing a cement factory in Wadi Nisah so that it can supply the local and regional market with Portland Limestone Cement (PLC) and other materials. It will contribute to the development of the industrial base in Saudi Arabia, in particular the field of construction materials, through the increase and development of national exports, including construction and building products. This will create new jobs in the field of industry and human resource development.
- ✓ Using modern techniques in geomorphologic studies helps overcome many difficulties and provide the precision necessary for taking decisions and evaluating the establishment of development projects, such as cement plants.
- ✓ Promoting tourist places in the southern part of the valley as they are not well known. However, they can be used to prepare the valley for that purpose, which is beneficial to the national economy and internal tourism.

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بنك المعرفة المصري

مستخلص البحث:

استخدام نظم المعلومات الجغرافية لتوزيع مواقع الحجر في وادي نساح، جنوب الرياض، المملكة العربية السعودية

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تعتبر الثروات المعدنية من أهم مصادر الدخل في الدول المنتجة لها. ونظرا لأهمية هذه الصناعة في تنمية الموارد الاقتصادية وتنويع مصادر الدخل وعدم الاعتماد على البترول كمصدر رئيسي للدخل، برزت جدوى الدراسات الجيومورفولوجية لسطح الأرض، بنتائجها العلمية ذات البعد الاقتصادي والتقني الذي يمكن الاعتماد عليه في وضع الخطط التطويرية والمستقبلية. وحرصاً على المساهمة الفاعلة للجانب الجيومورفولوجي ذي البعد الاقتصادي لأماكن تواجد الحجر الجيري في منطقة وادي نساح جنوب غربي مدينة الرياض، إعتماداً على مجموعة من الأدوات والتقنيات العلمية الحديثة ونظم المعلومات الجغرافية في تحديد وإبراز أماكن تواجد هذا النوع من التكوينات الجيولوجية، إرتا الباحثان اختيار هذا الموضوع بهدف جمع المعلومات المكانية والجيولوجية عن الحجر الجيري في قاعدة بيانات، وتحديد أماكن تواجد الحجر الجيري، ذات الجدوى الاقتصادية العالية باستخدام بيانات الاستشعار عن بُعد ونظم المعلومات الجغرافية.

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وتوصلت الدراسة إلى أن منطقة وادي نساح ذات جدوى اقتصادية عالية الواقعة ضمن مربع تكوين ضرما. وأوصت الدراسة بتوجيه الجهات المعنية بأهمية إنشاء مصنع للإسمنت في وادي نساح، بحيث يعمل على تزويد السوق المحلي والاقليمي بالإسمنت البورتلاندي وغيره.

واستخدام التقنيات الحديثة في الدراسات الجيومورفولوجية، لما تقوم به من إعطاء الدقة المطلوبة التي يمكن الاستناد عليها في اتخاذ القرارات وتقييم إقامة المشاريع التنموية، والتي تعود إيجابياً على الاقتصاد الوطني.

الكلمات الدالة: الثروة المعدنية، الحجر الجيري، الاستشعار عن بعد، نظم المعلومات الجغرافية، وادي نساح، الرياض، المملكة العربية السعودية.