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Sedimentlogical Study of Chack Hydropower Reservoir, Wardak, Afghanistan

Hafizullah Rasouli[1]*, Ashok Vaseashta[2], Mohammad Hamid Hamdard[3]

[1]*Department of Geology, Geoscience Faculty, Kabul University, Jamal Mina 1006, Kabul, Afghanistan*
[2]*Applied Research, International Clean Water Institute Manassas, VA, USA*
[3]*Water, Energy and Environmental Engineering Research Unit, Faculty of Technology, University of Oulu, Pentti Kaiteran Katu 1, 90570 Oulu, Finland*

INFORMATION

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Contact
*Hafizullah Rasouli
hafizullah.rasouli133@gmail.com

ABSTRACT

This sedimentlogical research is carried out aimed at Chack Dam reservoir sediments study, in Chack, Wardak Province. For completion this investigation we used dissimilar samples of Chack Dam reservoir. The stratigraphy of dam reservoir is situated at the different width, and have its place to the discharge of River at the snowmelting seasons. Normally at those years' extra precipitation the thickness of layers is additional, but in those years there are drought the thickness of layers is thin. Since that we can find the climate change, because in Afghanistan from 1980 we not having more precipitation. These more aquifers are between different sizes of sediments (sands and gravels). In the dam reservoir we can find different sizes of clay, silt and sands, granules. In this research we found different formation of stratigraphy in profile is consisting different layers like sand, silty clay, gravel, sand, clayey loam, loam and silty clay, gravel with different types of heavy and light minerals. Overall the aquifer is belonging to bigger sizes of sands and gravels. This research is therefore essential to study the different layers in profile, with no or rare previous research's.

1. Introduction

The Chack Sedimentary Basin belonging to the diverse sizes of deposits that are positioned spreading mountain range in longitudinal valley. The depth and deepness of residues are related to the slope and distance from mountain range, generally close to mountain and slope areas there are gravels and angular materials, but far from mountains are rounded and fine materials like bolder, cobble, pebble, granule, sands and silts (Rasouli et al, 2020b). In Chack Dam sediments transferring elongate valley, and these valleys involved of Konghare, Alishang, Araban, Gardammujed, and Abkazar. Also, in Chack Sedimentary Basin, some sediments transported from Araban, Khalili, Madu, Alisha, Bigsamand are usually brought by surface streams (Bohannon, 2005).

In the Chack Basin, all sediments belong to newer sediments transported from different parts of the mountain ranges. Their depth and composition are different according to the locations, for instance the upper and steep areas of this basin are not very thick and these sediments belongs to the Quaternary period and generally consistence conglomerate but the lower basin consisting of young tertiary sediments. Generally consisting of diverse clay, silt, sand and gravels (Arian et al., 2015).

This research is about different soil profiles and river sediments and geology of neighboring mountain rocks. The landforms within the Chack Basin are typical of an arid to semiarid, tectonically active sections. In the central plains of the Chack Basin are local depositional centers for sediments derived from the surrounding surficial deposits and bedrocks outcrops (Rasouli, 2021b). The central plains gently slope up to the together mountains and hills to piedmonts. Sedimentary fans have developed on the flanks of the mountains surrounding the Chack Wardak Basin and on interbrain ridges (Rasouli and Safi, 2021a). The alluvial fans

usually grade from coarse materials close the source to finer materials at the distal edge.

Physical weathering persuaded by extreme temperature fluctuation has produced pronounced breaks in slope at the edge of the basin (Rasouli, 2020a). This continuing weathering process maintains the steep, rugged mountain slope. The Chack Basin is part of the tectonically active of Kabul block in the transpressional plate boundary region of Afghanistan (Rasouli, 2021c). The East eastern edge of Chack Basin is defined by Paghman Fault system (Rasouli, 2019).

The Paghman Fault trends north to northeast and is evident in the continues fault scarp and piedmont alluvium along the north eastern boundary of Chack basin. The Chack Basin can be described as a valley fill basin and range setting where the valleys are filled with Quaternary and Tertiary sediments and the ranges are composed of uplifted crystalline and sedimentary rocks (Shamal and Rasouli, 2018).

Quaternary sediments are typically less than 80 m thick in the valleys (Rasouli, 2020c). The underling tertiary sediments have been estimated to be as much as 800 m thick in the city of Kabul (Rasouli, et al, 2015). As well as maybe more than 1000 m thick in some areas of the valley (Rasouli et al, 2021c). The younger deposits, reworked loess series, are described as reworked loess, gravel, sand and talus. The gavel and were deposited mainly in the river channels (Rasouli, 2022).

1.1. Brief Information about Chack Hydropower

The Chack Dam is one of the very significant hydropower of Afghanistan, its build on the Loger River at Chack District. The mean height of is hydropower is 16m and the diameter is 5 m, and the total length of canal to the hydropower is 3.9 km.

The survey of this hydropower was done by Germany Semins Company, in 1936 and it's contracted in 1937, and at the same year started its practically work. Unfortunately, from starting second ward of the world the work of this hydropower was stopped, but in 1938 the work of it's started again by Indian company and at 1941 the work of this hydropower completed.

This factory of hydropower having three generator of turban, which have at the first time produced 3.3 Megawatts electricity. The electricity of this hydropower between village of Chack and some parts of NW side Kabul, government of Afghanistan. This was normal curated to 1964 year, but after continues clashes the turbines of factory hydropower eroded, and cut the electricity to the Kabul city and it is now only electricity some villages of Chack Wardak.

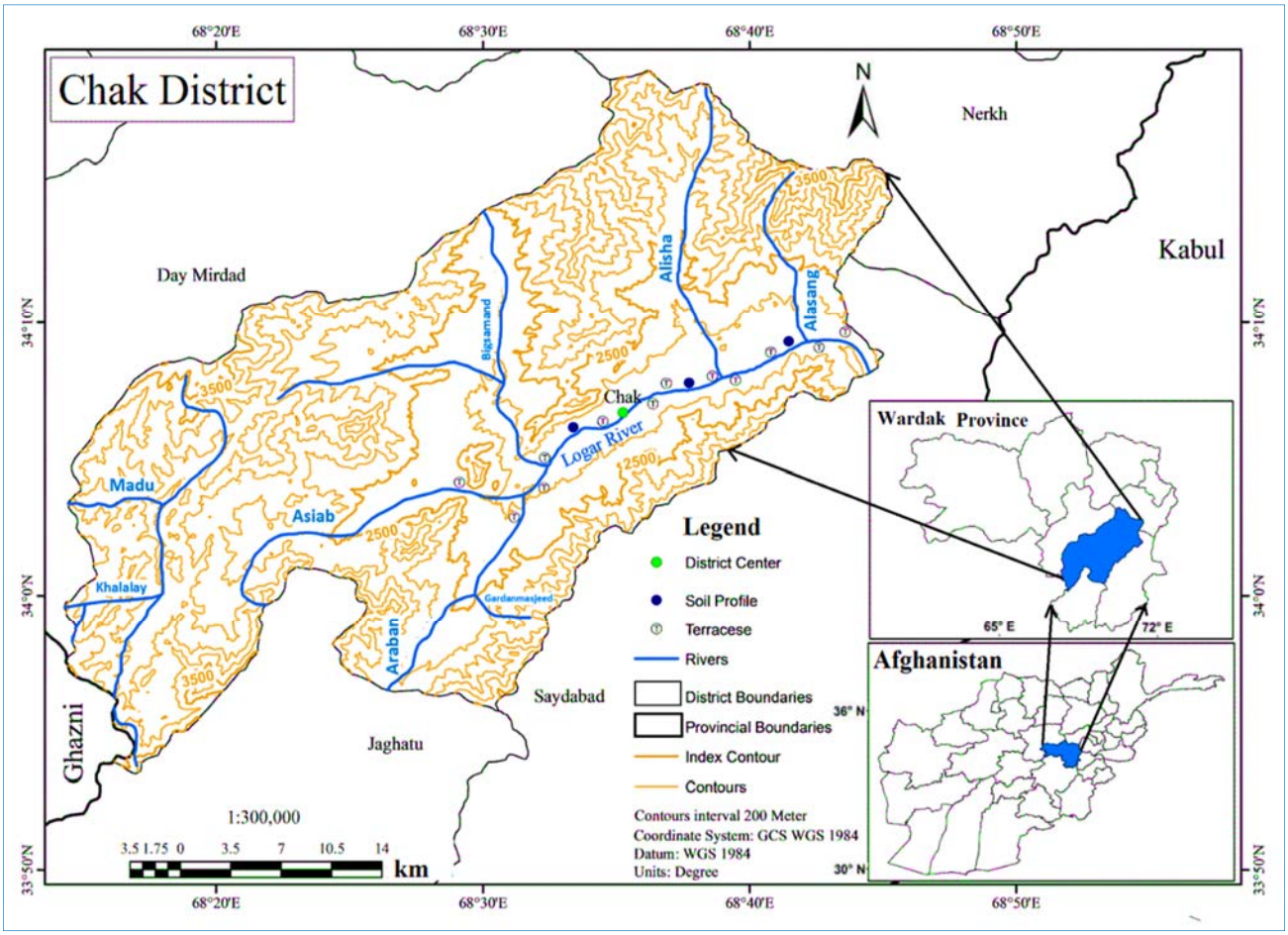

Fig. 1. Location map of Chack District

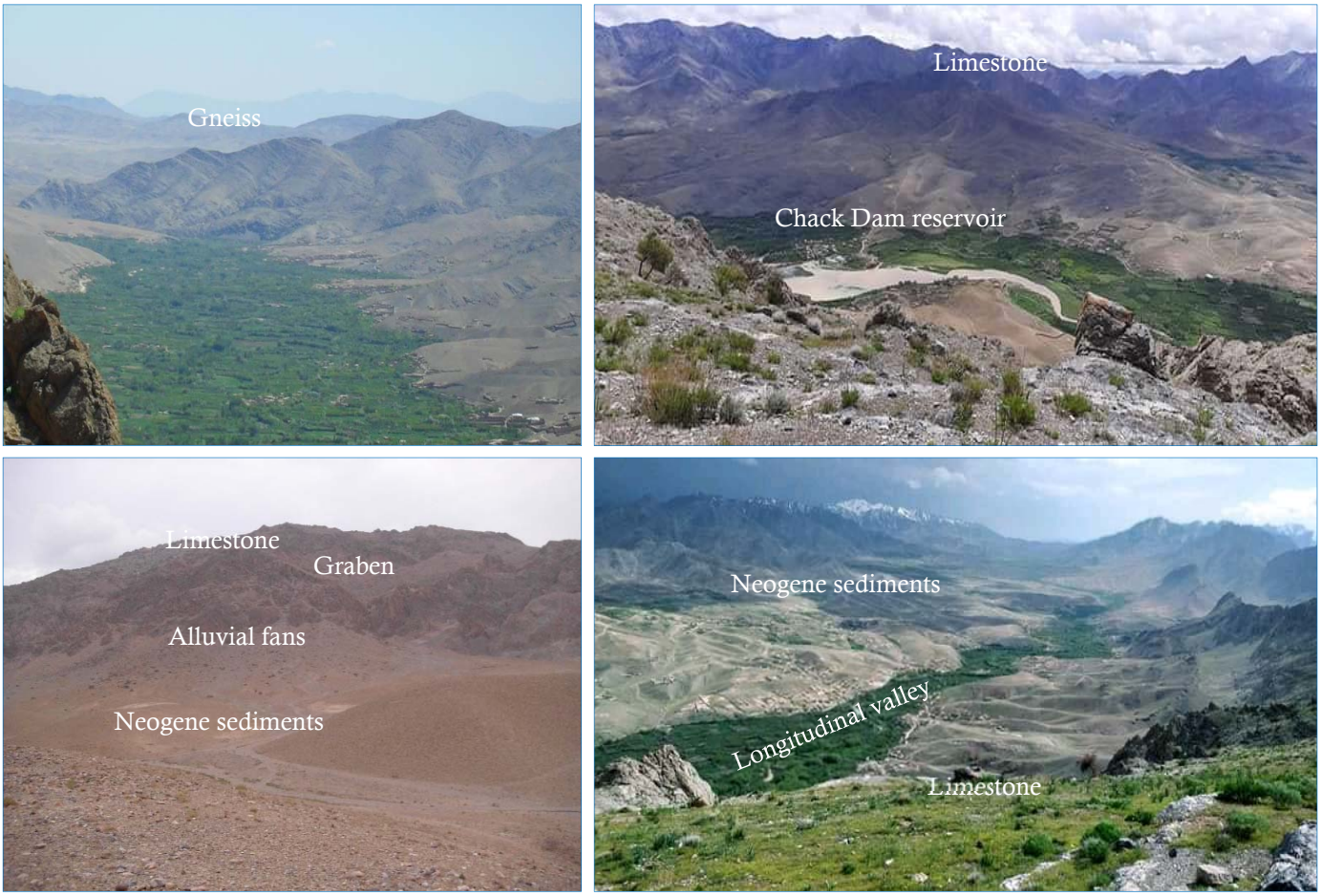

Fig.2. Geological unit images of Chack District Mountains

1.2. Calculation of Sediments

$V = 152 \times 2000 = 304000\ m^2 = 8.5 \times 304000 = 2584000\ m^3$

When the reservoir of hydropower 20% must be excavated, in this case:

$V = 2584000 - 516800 = 2067200\ m^3$

In this case very important to every year must doing the reservoir must be cleaning the reservoir at the snowmelting season from sediments to find most place for water reservoir. In this time the reservoir of Chack Hydropower 70% filled from gravel, sand, silt and clay and it's the main reason of lowering of reservoir. If the all reservoir clean from all sediments, it will good way for producing electricity at the all village of Chack District. When we calculated the total height of sediments it was 8.5 m, and it's made in 1941, its about 80 years old, and when we divided for every year 0.10625 cm transporting for every year. As well as if we looking to the profile of stratigraphy, the thickness of layers is different from view point of thickness, from 1900 last years the thickness its thick but after 1900-2022 the thickness of layers is smaller its shows that at the last years the precipitation is smaller, and we not having any more discharge in the rivers to transport more sediments.

2. Location Map

The Chack Wardak Basin covers an area of 9772 km^2 (Hamdard, 2022), with a maximum elevation of 4500 m, in Wardak Daimirdad mountain range and minimum elevation is 2092 m located in Ambokhak (Summerfield and Hulton, 1994). Loger River is one of the very important rivers of this district and it's started from (4.500-meter average sea level) Daimirdad Mountain (Wardak range related Hindu Kush Mountain range in Afghanistan) belong to Wardak Province (Rasouli et al, 2015). All sediments of this basin are transported along of valley by Loger River flows and made different terraces and aquifers by one another's (Fig. 1).

2.1. Geology of Chack Sedimentary Basin

Generally, the geology of Chack Basin consisting different type of rocks, such as granite, gneiss, gchist, limestone and reefs, as well as near to the lateral we can find different types of conglomerates, sandstone, siltstone, shale. In the plain areas consisting sediments of Neogene and its thickness at the plain areas it's about 1000 m thick but in the mountain areas the thickness of sediments is smaller.

The sizes of sediments belonging to the slope and plain areas, generally in slope areas the sizes of sediments belonging to the gravels such as boulder, cobbles, pebbles and granules, but in the plain areas generally consist of sand, silts, and clay. As well as in some places we can find loam, sandy loam, silty loam and clayey loams. The more than aquifers are located along the rivers streams, and there are more swamps and marshland areas (Fig. 2).

2.2. Geology of around Chack Dam

The geology of around reservoir of Chack Hydropower, generally involve different types of conglomerates (basal and surface) and its made different types of river terraces, and made terraces like walls. In the surface of these terraces we can see a kind of caves, its shows in the upper part of these terraces the consolidation of surface conglomerates are different, but in the basal the degree of consolidation are higher and its strength is high at the water solution. Generally, at the water reservoir in the dam the capacity of solution in the conglomerates are very high.

From that we can find that at the previous geological river streams very upper and after more time it's down cutting. The gravels transported by streams and after it's cemented by silts, clay and iron oxides (Fig. 3).

Fig. 3. The geology of Chack Hydropower around areas

Fig. 4. Neogen sediments at the Chack District

2.3. Neogene Sediments

In around areas of the Chack Hydropower more sediments hill shapes its belongs to Neogen and its consisting gravels (boulder, cobble, pebbles and granules), sands (course, medium, fine), silts (medium and fine), clay, loam, sandy loam, silty loam and clayey loam. When we done the gravels analysis method, I found different types of gravels (granite, quartzite, gneiss, limestone, granite, pegmatite). As well as from view point of sieving analysis in this area we found different type of heavy and light minerals (tourmaline, rutile, hornblende, zircon, apatite, quartz, biotite, garnet, amphibole, muscovite, epidote, kayanite, staurolite, plagioclase), as well as from view point sieving analysis method in *i* found different sizes of sediments such as 6.3 mm, 2 mm, 1 mm, 500 µm, 250 µm, 125 µm, 6.3 µm and rest and the thickness of sediments are belonging to the slope and distance from mountains areas. In the Neogen sediments, we can see one historical place it is about 3000 years old and more tourist came for see this historical place (Fig. 4).

As well as the shape of gravels belonging to the process of transport, and those materials transported by water its always rounded and consisting quartzite, granite, limestone, but in the slope and mountains skirt consisting angular materials that transported by gravity. In the mountains areas consisting talus and accumulated in the mountains slopes.

Fig. 5. Different parts of Chack reservoir at the various seasons of year

These Neogen sediments year by year transported by water to the hydropower reservoir and made by one another different types of layers and terraces at the different thickness and now about more parts of reservoir filled by sediments.

2.4. Location of Chack Hydropower Reservoir

The dam reservoir is located at the width valley in the Chack district its, in the Jawharkhel, Chack, Dawrankhel and Ghanikhel Villages. The wide of this reservoir is about 500 m and the length is about 1500 m. the thinness of sediments in this reservoir is different according to the slope locations generally near to the dam the thickness of sediments is more but fare from dame the thickness smaller. As well as the sizes of sediments are also changing generally in the slope areas bigger sizes such as gravels and course sands, but in the plain areas are more fine sands, silts and clays. If we look the stratigraphy of layers, in this case we can found different thickness of beds and layers, the some layers are having very smaller thickness about 1 cm, but the some layers are having more thickness about 1.5 m its belonging to the different factors, one is the velocity of streams generally in the flooding time will be transported more volume and bigger sediments, but in more years continues drought the river discharge is very smaller and transporting smaller sediments such as fine sand, silts and clay. As well as near to the dam more than smaller sediments, because there are no any velocity and all waters are standing and smaller sediments sedimentation (Fig. 5).

2.5. Hydropower Construction

The construction of dam was made basal conglomerate material. It's one side is terrace of basal conglomerates but the other side is unconsolidated materials. In this, protection wall was built having about 3 m wide and about 300 m length. Mean height of dam is 6m, and having four tower of concrete, three dore, at the bottom of dam is for drain water during flooding season. As well as there is one way to the channel to running water to the electricity three turbines. On this dam we having one main road between Kabul and some district of Wardak Province (Fig. 6). But unfortunately, from last 40 years clashes in Afghanistan, now some parts of this dam is damage (eroded).

2.6. Canal of Electricity Factory

The length of this canal is 3.9 km, and the width is 8 m, this canal is made on basal conglomerates. This canal from many years' floods and turbidity of water filled by different sediments such as clay, silt, sands. But in some places by mountains floods filled by different types of gravels such as boulder, cobbles, pebbles, granules, sands, silts and clay (Fig. 7). But some time by some organization untechnical cleaning and all smaller sediments they putting near to the length of canal, and after drying it's transported by wind, gravity, water again to the canal and some of carrying in atmosphere to the houses, agriculture lands.

2.7. Reservoir for Sedimentation at the End of Canal

In the canal of Chack Hydropower there is one sediments pool for cleaning water to go the clear water to the electricity turbines. This reservoir of sediments 10m depth and the area is 200 × 200 m^2.

Fig. 6. Different parts of Chack Dam construction

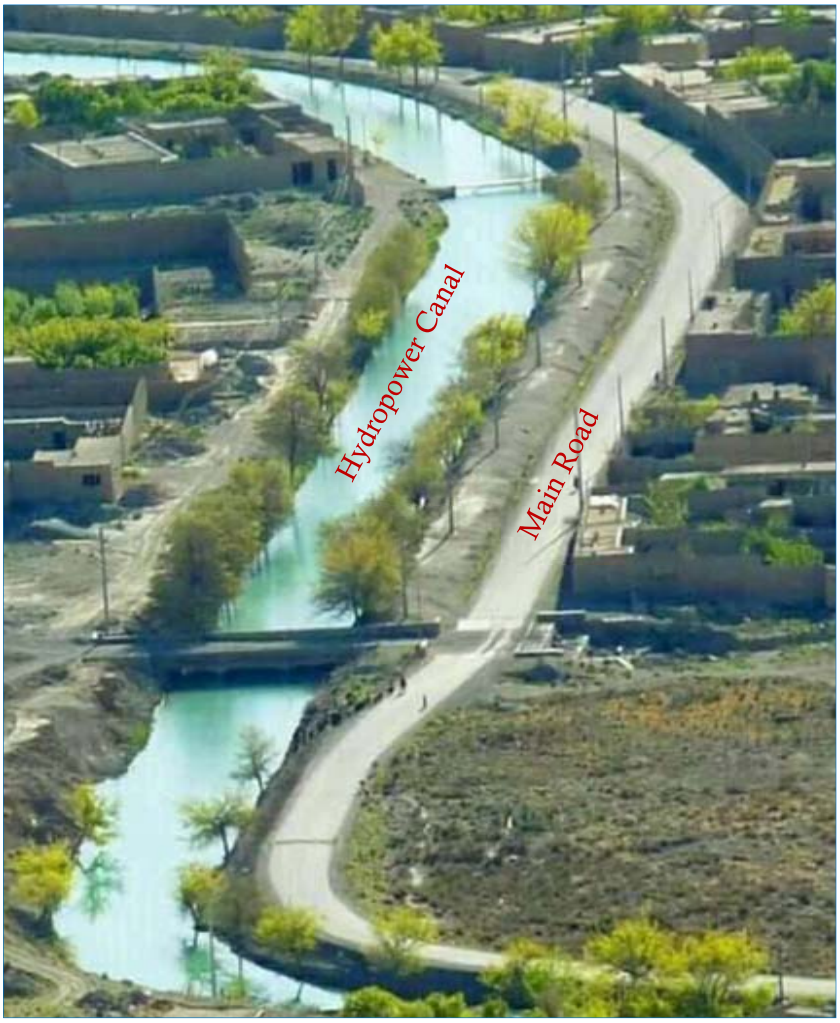

Fig. 7. Chack Hydropower canal

Fig.8. Reservoir that is located at the end of canal for sedimentation sediments

In the last 30 years is more than filled by different types of sediments such as gravels, sands, silts and clays. As well as this reservoir from three sides surrounded by slope areas and there are more talus materials and it's transported by different types of process such as gravity, surface streams (gully, rain rills). Now in this reservoir stand only 0.5-1.0 m water and

all sediments transported to the turbines of factory. The hydraulic head of water to the turbines is about 45° angle. From this reason the solution materials and loads (bed load, suspended load and solution load) eroded the metals. In solution load consisting clays, carbonates, but in bed and suspended loads consist of sands and silts (Fig. 8).

3. Method and Materials

In this research, we study different river terraces in the Chack Hydropower reservoir, from every terrace we got 1 kg sample and analyzed in the Test Room of Geology, Kabul University. The bigger size is boulders (10×30 cm) and smaller size is silt.

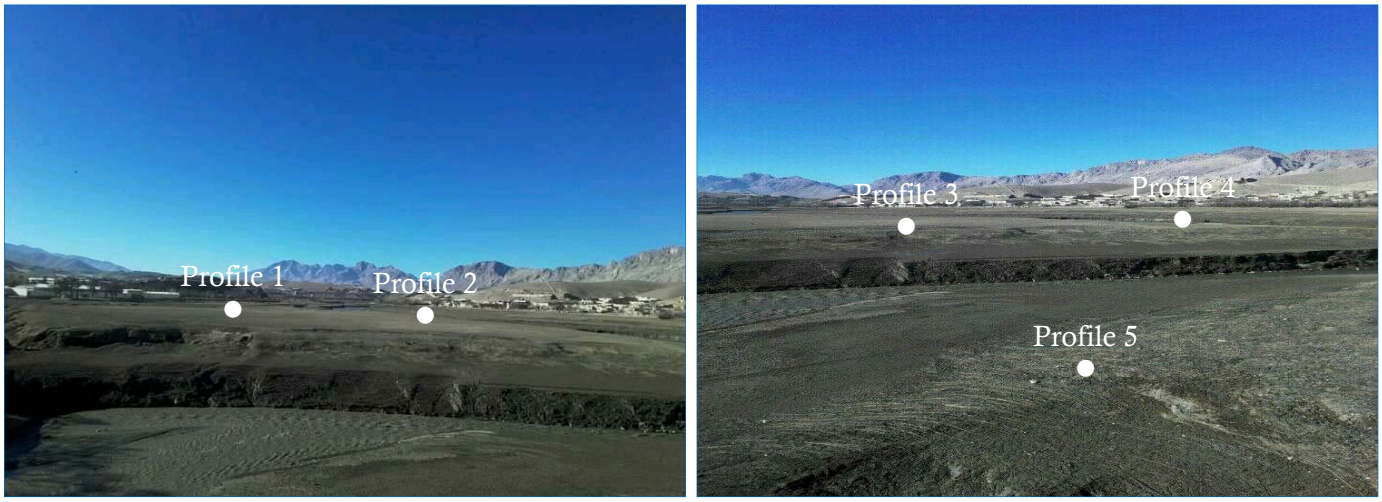

Fig. 9. Two location at the Chack Dam reservoir for find histogram and cumulative curves

4. Results and Discussion

Small and bigger tributaries at the different locations of Khawat Olya and Sufla junction with Loger River streams, normally these flows after west to east. The diverse kinds of sediments inter mountain backing basin accumulation and one by others making different kinds of terraces. The sediments inter mountain basin belonging near the tertiary (Ioncene and Oligocene). It is about 20 – 45 million years old and its name is tertiary formation. At the higher parts of these sediments found not the same terraces it's related to the lower tertiary (Pleistocene) and it's younger than lower sediments.

The slopes of Chack Basin are in north west to south east that belong to the relief of this basin from Daimirdad 3.500 m to Ambokhak 2.092 m (Horikawa and Ito, 2009).

The thickness of younger sediments between inter mountains backing basin belonging to the form of basin and distance from mountains ranges. The depth of sediments closes to the source consolidated angular gravels and at the plains areas generally soft clay, silt, sand and some rounded gravels. The thickness of sediments at the plain areas at the Chack Dam is more than 1500 m and generally its clay, silt and sand.

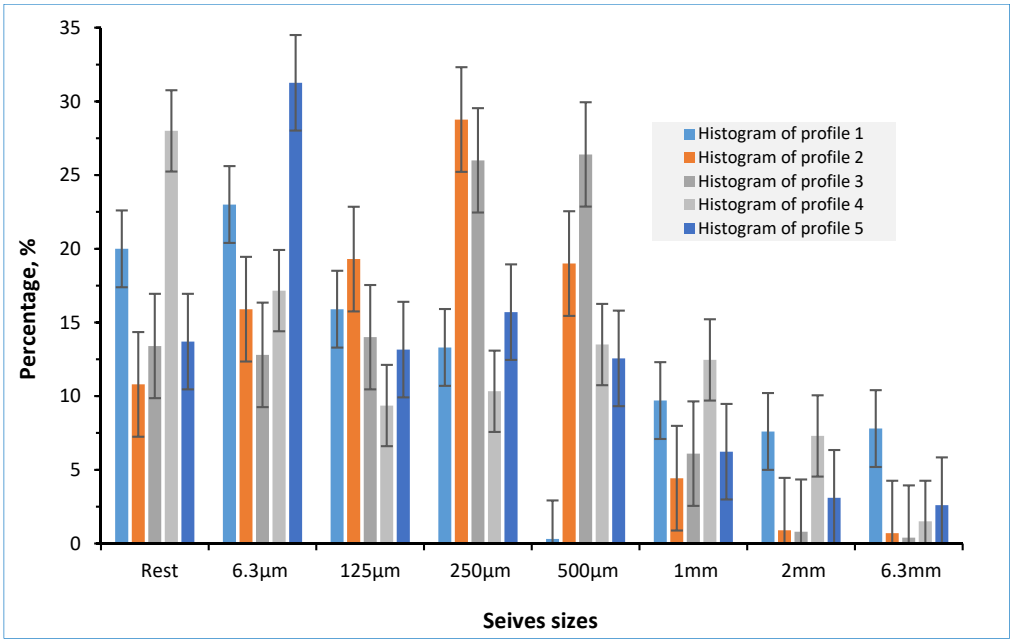

Fig. 10. Histogram of sediments at the Chack Hydropower reservoir

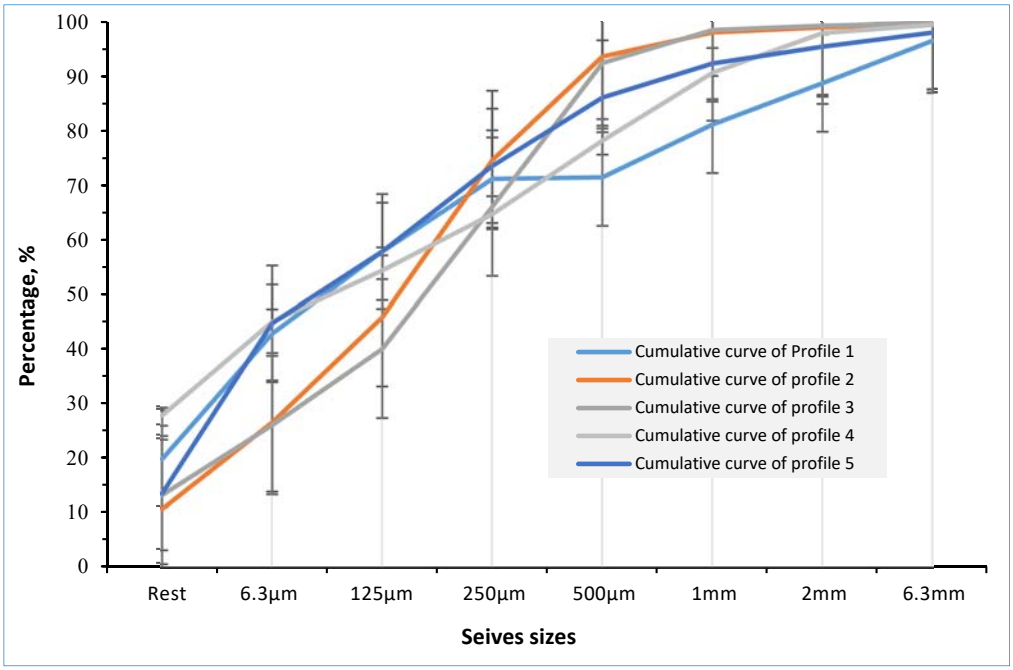

Fig. 11. Cumulative curve at the Chack reservoir for finding sizes sediments

The quality and quantity of deposits in Chack Basin belonging near the adjacent mountains and that weathered by exogenic force and transported by different phenomenon of gravity, waters, winds and made different types of sediment layers at the different location of basin. From sediments samples we found epidote, kayanite, muscovite, biotite and garnet minerals belong to all metamorphic rocks that are located in surrounding mountains, others minerals rutile, Biotite, and zircon because its belong to igneous rocks.

4.1. Sieving Analysis

In sieving analysis method, we pass the fine material such as sand, silt and clay from the different sizes of sieves (6.3 mm, 2 mm, 1 mm, 500 µm, 250 µm, 125 µm, 6.3 µm and rest). For this method, we used for find histogram and cumulative curve. For histogram, we used the weight percentage and for cumulative curve, we add percentage by one another's.

After gravel analysis method we done sieving analysis method in this method we prepared different sizes and we got at the weight of 300 gr from every terraces and analysis different sizes by sieving analysis method. In this method, we collected the following different samples from different locations (Fig. 9).

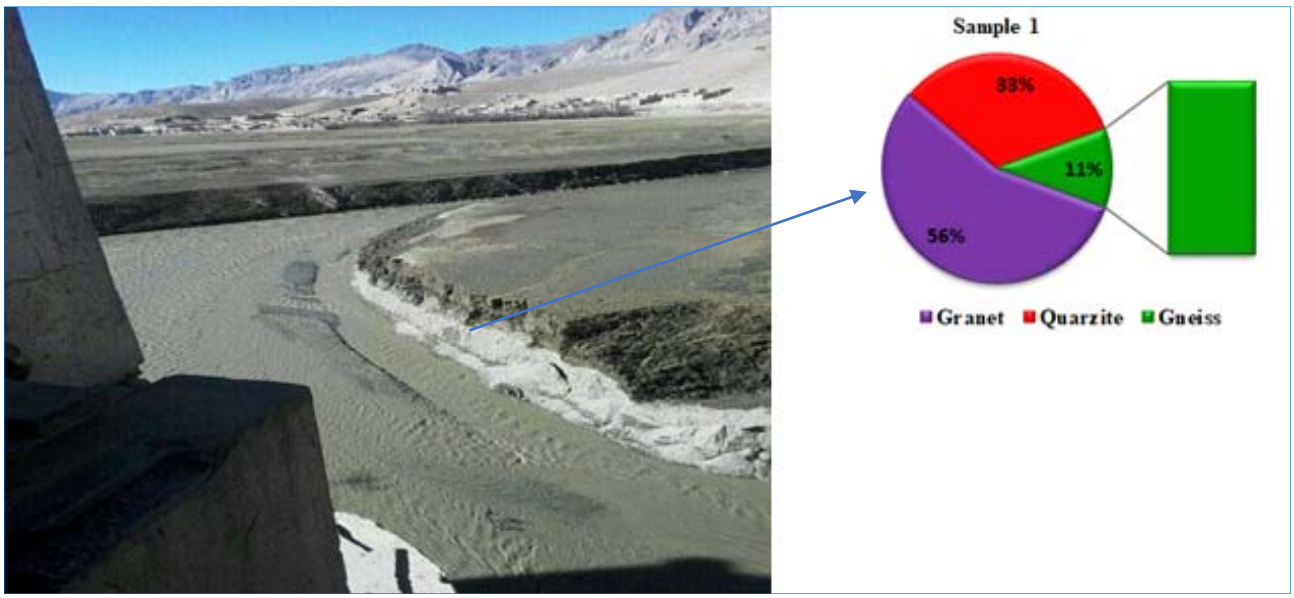

Fig. 12. Gravel analysis in point1 and find different types of rocks in sediments

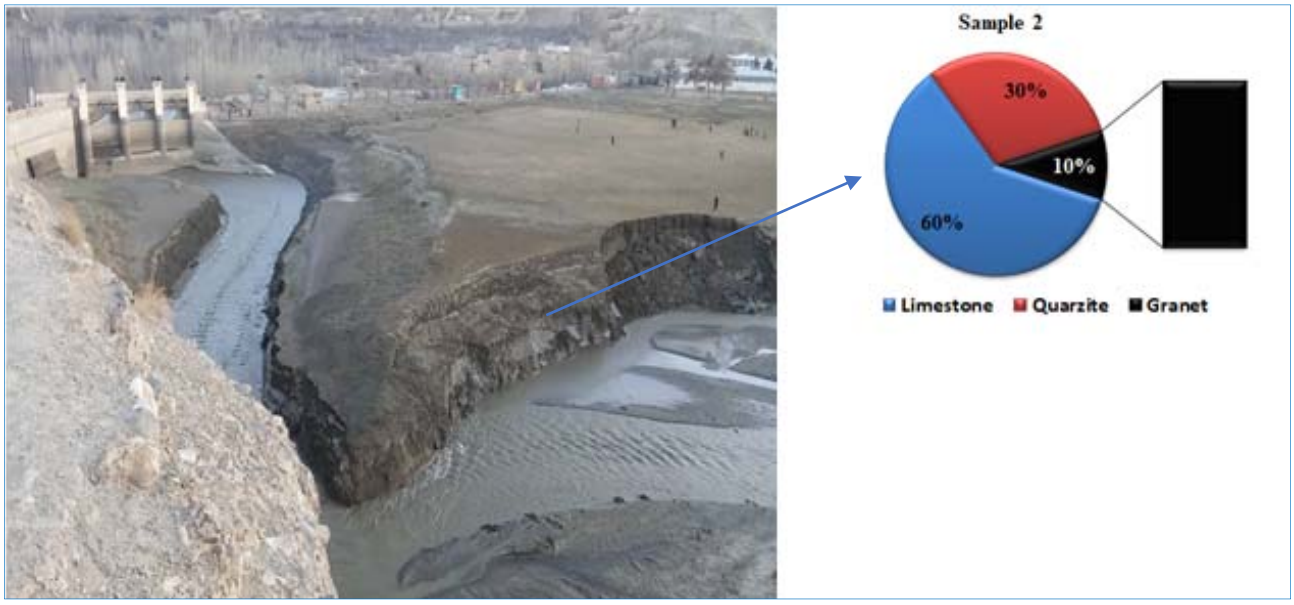

Fig. 13. Gravel analysis in point 2 and find different types of rocks in sediments

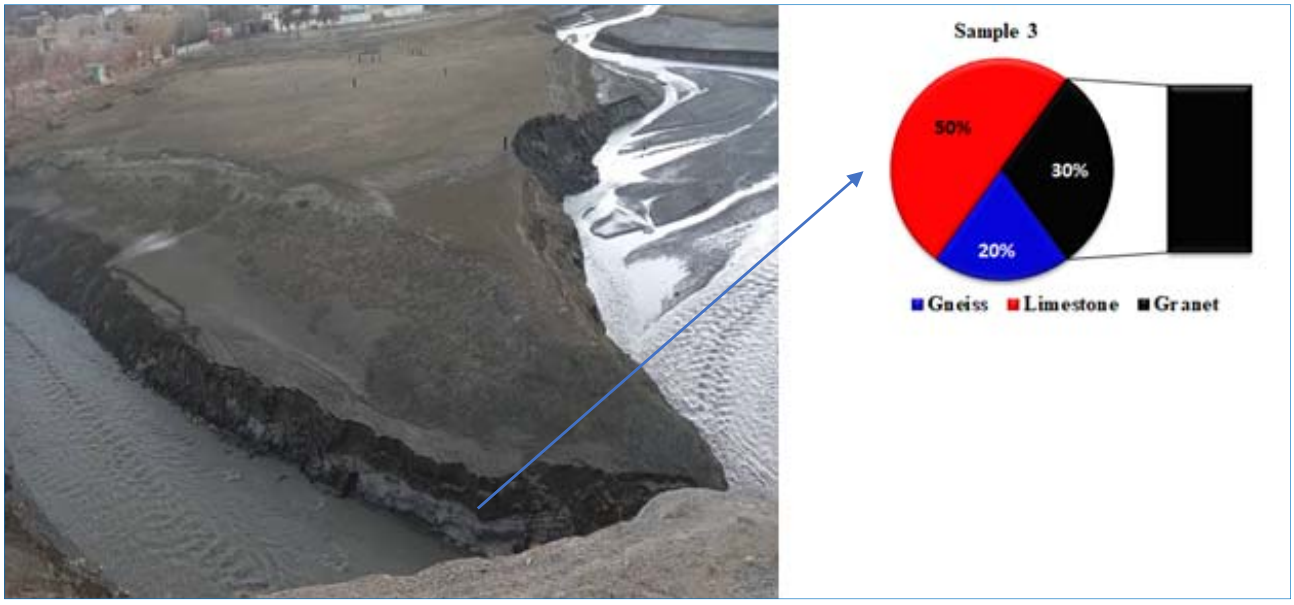

Fig. 14. Gravel analysis in point3 and find different types of rocks in sediments

4.2. Histogram

For find of histogram we got five samples from at the weight of 1 kg and these samples we passed from different sizes of sieves such as (6.3 mm, 2 mm, 1 mm, 500 µm, 250 µm, 125 µm, 6.3 µm and rest). For histogram, we used the weight percentage. In this method, we done sieving analysis method in this method we prepared different sizes and we got at the weight of 300 gr (gram) from every terraces and analysis different sizes by sieving analysis method. In this method, we achieved the following percentage of different sizes (Fig. 10).

4.3. Cumulative Curves

After find histogram we found from same samples cumulative curve, for cumulative curves we add percentage by one another's. In this method we achieved the following percentage of different sizes (Fig. 11).

4.4. Gravel Analysis

In this part of research, we got from five terraces different bigger sizes of gravels (cobbles, pebbles, granules, grits). The sizes of terrace gravels belong to the slope and distance from mountains ranges, the formations of that terraces located near to the mountains and slope areas.

Generally, there is bigger sizes in terraces, but appositely those are far from mountain ranges and plains areas composites from smaller sizes of gravels.

4.4.1. Sample 1

From gravel analysis of sample 1 we find different kinds of gravels according to the location of terraces. In this terrace 56 % garnet, 33% quartzite and 11% gneiss (Fig. 12). Size bigger is 11×10 cm and smaller is 5×6 mm.

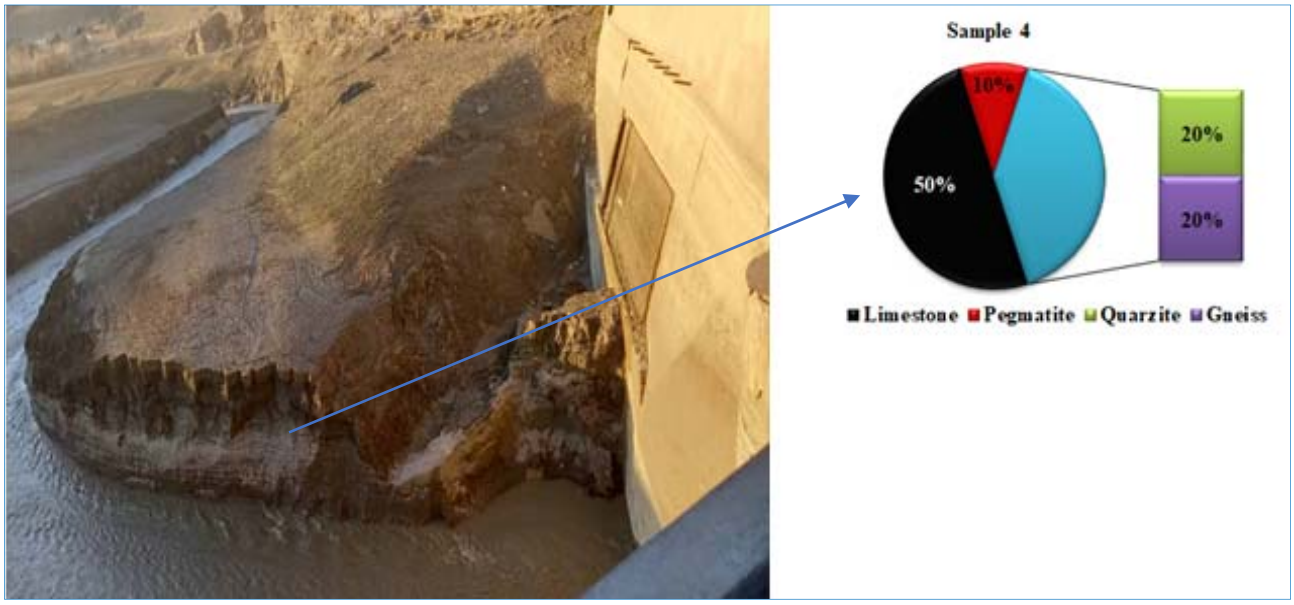

Fig. 15. Gravel analysis in point4 and find different types of rocks in sediments

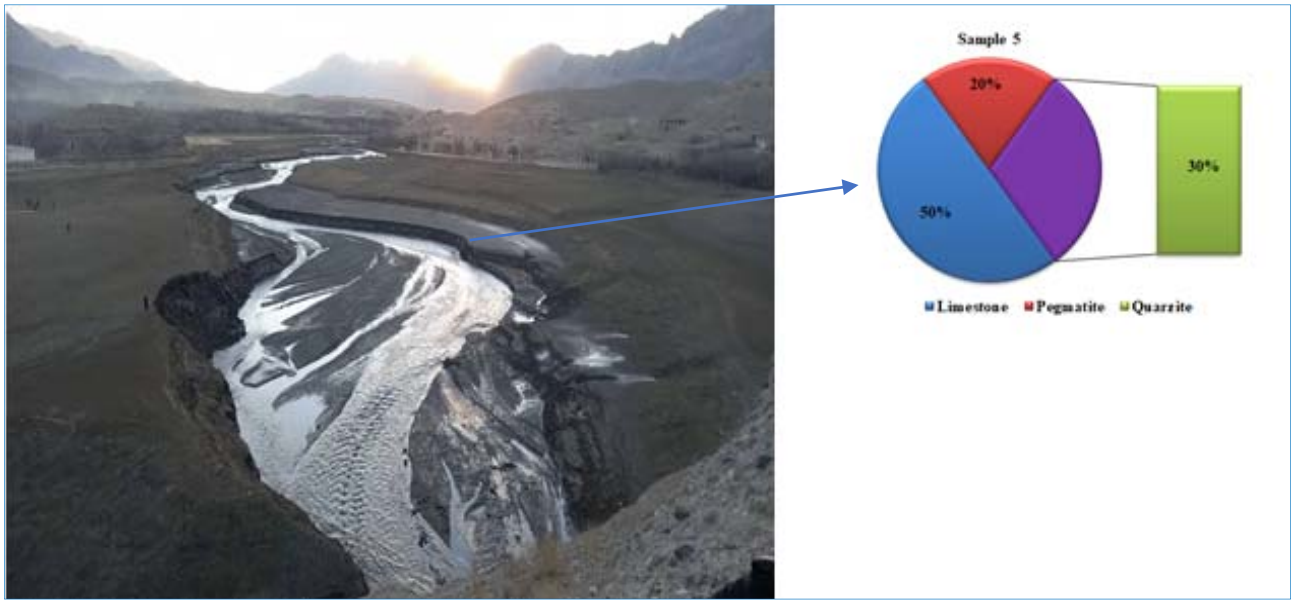

Fig. 16. Gravel analysis in point 5 and find different types of rocks in sediments

4.4.2. Sample 2

In this, limestone 60 %, quartzite 30 % and granite 10 % (Fig. 13), the bigger size is 9×8 cm and smaller is 5 × 4 mm. If we compare two terraces, we can find more limestone because of surrounding mountains of Bomb, and that are transports by water and deposited in these terraces. In this existing more than bigger particles on the river bed slope.

4.4.3. Sample 3

In this sample, being gneiss 50 %, limestone 10% and granite 30% (Fig. 14), bigger is 9×8 cm and smaller is 6 ×7 mm, in this terrace the percentage of gneiss is more than others rocks, because of surrounding mountains that are transported by water from south west and north west mountains of Wardak Province, Afghanistan.

4.4.4. Sample 4

In this part, being pegmatite 10%, limestone 50%, quartzite 20% and gneiss 20% (Fig. 15), from these sizes the bigger one is 10× 8 cm and smaller one is 4× 3 mm.

4.4.5. Sample 5

In this limestone being 50%, pegmatite 20 % and quartzite 30 % (Fig. 16), bigger one is 8× 9 cm and smaller one is 5 × 4 mm. If look here, in these two terraces, we can find more metamorphic rocks there because these also transport from surrounding metamorphic (crystalline) of Kabul by water on that time.

5. Conclusion

The height of sediments in Chack Hydropower Reservoir are 8.5 m (h=8.5 m), in this case as height of sediments in Chack Hydropower Reservoir are 8.5 m, and this dam made at 1942,

and there are pass about 80 years, 0.10625 cm per year transported by waters and floods. From gravel analysis we find different types of gravels such as tourmaline, rutile, hornblende, zircon, apatite, quartz, biotite, garnet, amphibole, muscovite, epidote, kayanite, staurolite, plagioclase, as well as from view point sieving analysis method in *i* found different sizes of sediments such as 6.3mm, 2 mm, 1mm, 500 µm, 250 µm, 125 µm, 6.3 µm and Rest and the thickness of sediments are belonging to the slope and distance from mountains areas.

The Chack Reservoir is about 70 % filled by different types of sediments such as gravels, sands, silts and clay. When this reservoir cleans from these sediments, in this case will be all villages of Chack Districts benefits from electricity and distributes between these villages.

This geological research used to distinguish different sediments sizes, rock and minerals types in river sediments that are transported at snowmelting season by Loger River discharges from different parts of surrounding mountains in Chack District (from chemical analysis-Bromoform solution). In these research we found different kind of heavy and light minerals of epidote, garnet, staurolite, rutile, hornblende, zircon and tourmaline, muscovite, biotite, tourmaline, zircon.

In this research some heavy minerals such as; epidote, garnet and staurolite related to metamorphic rocks, rutile, hornblende, zircon, amphibole and tourmaline minerals are related to igneous rocks. Some light minerals such as; muscovite, Biotite exist in all terraces, because these two minerals exist in both metamorphic and igneous rocks. All these minerals belong to the surrounding mountains rocks, those transferred by Loger River in the snowmelting seasons. This research is about sedimentlogical characteristics of Chack Hydropower Reservoir and for next I plan to do detail research about soils, petrography, engineering geology, mining, and groundwater and surface waters. The results attained propose that the sedimentlogical analysis can be used professionally for petrographical, aquifer, geological mapping, stratigraphy, geochronology and engineering geological studies for other mountain basins in Afghanistan.

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Conflicts of Interest
The authors declare no conflicts of in interest regarding the publication of this paper.

References

Arian, H., Kayastha, R.B., Bikas, C.B., Ahuti S., Rasouli, H., Armstrong, R., 2015. Application of the Snowmelt Runoff Model in the Salang River Basin, Afghanistan Using MODIS Satelite Data. Journal of Hydrology and Meteorology 9 (1), 109-118. https://doi.org/10.3126/jhm.v9i1.15586.

Bohannon, R.G., 2005. Geologic map of quadrangle 3468, Chak-e-Wardak (509) and Kabul (510) quadrangles: Afghan Open-File Report (509/510) 2005-1001).

Hamdard, M.H., Soliev, I., Rasouli, H., Kløve, B., Belhassan, K., 2022. Groundwater Quality Assessment in Chak Karstic Sedimentary Basin, Wardak Province, Afghanistan. Central Asian Journal of Water Research 8 (2), 102-109. https://doi.org/10.29258/CAJWR/2022-R1.v8-2/110-127.eng.

Horikawa, K., Ito, M., 2009. Non-uniform acrossshelf variations in thickness, grain size, and frequency of turbidites in a transgressive outer-shelf, the Middle Pleistocene Kakinokidai Formation, Boso Peninsula, Japan. Sedimentary Geology 220 (1), 105-115. https://doi.org/10.1016/j.sedgeo.2009.07.002.

Rasouli, H., Safi, A.G., 2021a. Geological, Soil and Sediment Studies in Chelsaton Sedimentary Basin, Kabul, Afghanistan. International Journal of Geosciences 12, 170-193. https://doi.org/10.4236/ijg.2021.12201120.

Rasouli, H., Sarwari, M.H., Khairuddin, R., Said, A.H., 2020a. Geological Study of Tangi Mahipar Mountain Range along Kabul Jalalabad road, Afghanistan. Open Journal of Geology 10, 971-980. https://dx.doi.org/10.4236/ojg.2020.1010044.

Rasouli, H., 2020b. Application of soil physical and chemical parameters and its Comparing in Kabul Sedimentary basins, Kabul, Afghanistan. International Journal of Recent Scientific Research 11 (2), 37368-37380.

Rasouli, H., 2021b. Analysis of Groundwater Quality in Jabal Sarage and Charikar Districts, Parwan, Afghanistan. Journal of Geological Research 3 (4), 45-55. https://doi.org/10.30564/jgr.v3i4.3717.

Rasouli, H., 2019. A Study On Some Rıver Sedıments, Hydrology and Geologıcal Characterıstıcs In Chak Sedımentary Basın, Wardak, Afghanıstan. International Journal of Geology, Earth & Environmental Sciences 9 (2), 49-61.

Rasouli, H., 2020c. Well Desıgn And Stratıgraphy Of Sheerkhana Deep Well In Chak Dıstrıct, Wardak, Afghanıstan. International Journal of Geology, Earth & Environmental Sciences 10 (2), 54-68.

Rasouli, H., Kayastha, R.B., Bikas C.B., Ahuti S., Arian, H., Armstrong, R., 2015. Estimation of Discharge from Upper Kabul River Basin, Afghanistan Using the Snowmelt Runoff Model. Journal of Hydrology and Meteorology 9 (1), 85-94. https://doi.org/10.3126/jhm.v9i1.15584.

Rasouli, H., Qureshi, R., Belhassan, K., 2021c. Investigations on River Sediments in Chak Sedimentary Basin, Wardak Province, Afghanistan. Journal of Geological Research 3 (4), 21-29. https://doi.org/10.30564/jgr.v3i4.3574.

Rasouli, H., 2022. Climate Change Impacts on Water Resource and Air Pollution in Kabul Sub-basins, Afghanistan. Advances in Geological and Geotechnical Engineering Research 4 (1), 11-27. https://doi.org/10.30564/agger.v4i1.4312.

Rasouli, H., 2017. Study on River Terraces in Upper and Middle Partsof Kabul Sedimentary Basin, Afghanistan. nternational Journal of Science and Research 6 (10), 1696-1704. https://dx.doi.org/10.21275/ART20177497.

Shamal, S., Rasouli, H., 2018. Comparison between pH, EC, $CaCO_3$ and mechanical analysis of Qala Wahid and Company Areas soil, Kabul, Afghanistan. International Journal of Science and Research 8 (5), 429-433.

Summerfield, M.A., Hulton, N.J. 1994. Natural controls of fluvial denudation rates in Major world drainage basins. Journal of Geophysical Research: Solid EarthVolume 99 (B7), 13871-13883.