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Full length article

COMPARATIVE ANALYSIS OF MECHANICAL STRENGTH AND PETROGRAPHIC FEATURES OF ANDESITE AND BASALT FROM SAWABI AREA, N-W PAKISTAN: IMPLICATIONS FOR CONSTRUCTION ENGINEERING

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ABSTRACT

This study delves into a comparative analysis of the mechanical properties and petrographic characteristics of andesite and basalt from the Sawabi area in North-West Pakistan, with a focus on uniaxial tensile strength (UTS) and uniaxial compressive strength (UCS). Mega-porphyritic and badinage textures, as well as a huge, fine-grained structure, define the basaltic rocks of Swabi. These rocks are mostly composed of ferro-magnesium minerals such as olivine, pyroxene, and amphibole; as accessory minerals, they also include quartz, plagioclase, and alkali feldspar. On the other hand, the andesitic rocks in the area have anhedral structures that are extremely fine-grained and have a variety of textures, including trachytic, porphyritic, dendritic, and graphic. These rocks are mostly composed of orthoclase and fine- to medium-grained amphibole, with other features including quartz phenocrysts and altered perthitic alkali feldspar. A thorough examination of the samples' mechanical and physical characteristics, such as their porosity, specific gravity, and water absorption, was conducted. The results showed that andesite, with its better mechanical strength and good petrographic features, was the better option than basalt for construction. When choosing suitable rock materials for regional infrastructure projects, engineers and construction professionals can benefit greatly from the insights provided by this research.

KEYWORDS: Andesite and basalt, petrography, mechanical properties

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1. INTRODUCTION

In modern engineering, rocks are employed extensively throughout the entire construction process, not just for creating roads and rail lines. such as building supplies, railroad tracks, highways, building-related concrete aggregates, mine entrances, pillar-style supports, linings and fillers [1]. Numerous varieties of rocks, such as marble, limestone, and Slates, quartzite, schist, sandstone, granitic gneisses, and in the northern part of in Pakistan, granite is substantially mined and use for different engineering initiatives [2]. Due to the great strength and petrographic significance, andesite, granite and basalt are widely used in many different technical applications worldwide. The belt of alkaline volcanic rocks that is exposed along the northern edge of the Indian plate is known as the Peshawar Plain Alkaline Igneous Province (PPAIP)[3]. PPAIP is made up of a range of igneous rocks that are exposed in various places in northwest Pakistan [3].

Geologically, the Peshawar Plain Alkaline Igneous Province (PPAIP) includes the study region. The rocks within the study area are identified to be of Permian age, as supported by the research conducted by [4]. Alkaline granites, microgranites, syenites, albites rhyolites, and carbonatites make up the majority of PPAIP [4], [3], [5], all volcanic rocks, both acidic and basic, and all plutonic rocks alkaline solutions are related to basic compositions. About PPAIP peralkaline rocks [3], majority of the rocks are used in construction and engineering tasks.

A significant amount of compression, tension, and consequently, before using any rock for shearing, their mechanical qualities, and their use in construction study should be done. The mechanical characteristics and petrographic significance of rocks like granite and rhyolite from various locations in northwest Pakistan were only partially determined by researchers [2, 3, 6] But regrettably, not many of the rocks have been the subject of scientific investigation for the majority of these rocks as well as those in northern Pakistan are utilized and exploited without the correct knowledge of which is not a cost-effective or safe practice given their mechanical qualities.

As earlier mentioned, Andesite and basalt are widely employed for a variety of technical applications because of their relevance for petrography and great strength, all over the world. As previously indicated, PPAIP includes a range of igneous rocks that are exposed at various locations in northwestern Pakistan. Even though a thorough study of the mechanical characteristics of andesite and basalt has recently been conducted. Regarding their engineering character, these rocks contained in PPAIP have received little attention. In this context, the goal of the current study is to clarify the differences in petrography and mechanical properties of andesite and basalt found in the Swabi region of northern Pakistan.

2. GEOLOGICAL SETTING

The Lower Swat-Buner schistose group and the Swabi-Chamla sedimentary group have been utilized by the Peshawar Plain Alkaline Igneous Province (PPAIP) in this region as country rocks for the alkaline magmatism (Fig.1).

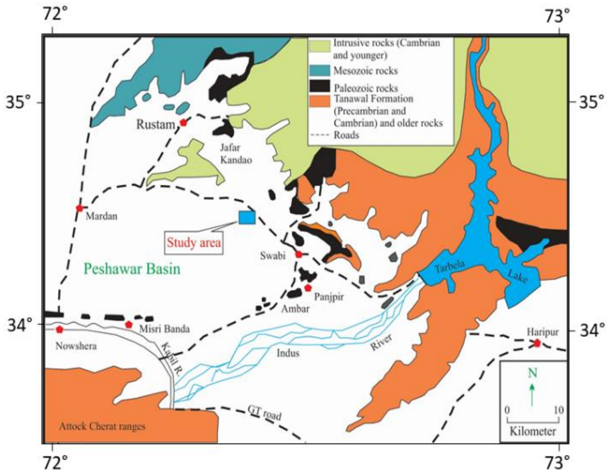


Figure 1. Generalized geological map of Northern Pakistan showing the main alkaline igneous complexes (Redrawn from [7]), The inset in the map shows the study area.

[8] gives a thorough description of an instance of the alkaline province in northern Pakistan. According to [9], PPAIP stretches from Tarbela in the east to the Pak-Afghan border in the west. Carbonatites and silicate rocks are among the PPAIP constituent rocks. Alkali granites, porphyritic granites, quartz syenites, syenites, nepheline syenites, and ijolites make up the latter class. While the localities of Loe Shilman, Sillai Patti, Jawar, and Jambil have carbonatites, Warsak, Shewa-Shahbaz Ghari, Ambela, Tarbela, and Malakand are the locations with significant alkaline silicate rock exposure [10], Among the rocks that make up the PPAIP are carbonatites and silicates. The Ambela granitic complex, the largest part of PPAIP, covers 900 km2.

The rocks in the Ambela region can be classified into three groups, according to [11], (1) granites, alkali granites, and micro-porphyrites; (2) quartz syenites, alkali quartz syenites, syenites, feldspathoidal syenites, Ijolites, lamprophyre, and associated pegmatites and fenites; and (3) basic. Group I appears to be the first magmatic occurrence in the Sawabi region. Gohati volcanoes are visible in the District Swabi's western region [3]. They have trespassed on the Carboniferous-era Jaffar Kandao Formation Basalt and andesite like these are generally found in the Peshawar Plain Alkaline Igneous Province (PPAIP).

Gohati rhyolites, Sawabi basalt, and andesite are members of the PPAIP, although nothing is known about their mechanical characteristics. [4]have examined only the petrography of the Shewa–Shahbaz Garhi complex, Mardan, Sawabi area N-W Pakistan, to establish if basalt and andesite may be utilized together for engineering and building applications, this research compares their mechanical qualities.

3. MATERIALS AND METHODS

As a result of geological fieldwork in the area, fresh bulk and first-size samples of rocks were gathered. Three of the bulk samples obtained to ascertain the physio-mechanical characteristics are representative of basalt and andesite exposed at the Sawabi area. Chips from each of the bulk and first-size samples were cut and made into thin sections in the rock-cutting laboratory Department of Geology, University of Peshawar and studied in the petrography laboratory of the Department of Geology, Bacha Khan University Charsadda.

A total of six thin sections were studied prepared and used for detailed petrographic studies. Three typical bulk samples from various textural varieties of Swabi andesite and basalt were assembled. In the rocks-cutting laboratory of the Department of Mining, University of Engineering and Technology, Peshawar, these bulk samples were cored with the use of core drilling equipment. Each bulk sample has two core samples taken from it.

The uniaxial compressive strength (UCS) and uniaxial tensile strength (UTS) of the cylindrical samples were measured by the ASTM requirements. The Material Testing Laboratory, Civil Engineering Department, University of Engineering and Technology, Peshawar, is where these strength tests were conducted. The Gemology Department at the University of Peshawar also analyzed the physical characteristics of each sample, such as water absorption, specific gravity, and porosity.

3.1. PETROGRAPHY

3.1.1. Andesite

Textural and modal mineralogical characteristics within a rock of the Sawabi region are accurately defined with the help of petrographic research. Andesitic rocks of the Sawabi areas are porphyritic, massive, fine grained, foliated varieties are determined both in the field as well as in thin section studies. Furthermore, Hypidiomorphic granular texture, fine-medium grained size varieties are observed in fine-grained groundmass. Most of the perthitic alkali feldspar which are the accessory minerals of the sample show lamellar twining. Biotite minerals are observed during petrographic detail studies of the sample but are mostly curved.

Ground mass is glassy and is covered by fine-grained alkali feldspar. Anhedral to subhedral fine to medium-grained amphibole (Fig. 4k and l) is the second most abundant mineral after alkali feldspar occurring in this rock-thin section and shows a wide range of modal proportion (15-25%). At places iron leeching (Fig. 4k and l) containing more than 7% in this rock sample thin section. However, some of the studied samples display cluster of medium to coarse-grained amphibole. Alkali feldspar is dominant mineral constituent is more than 35% proportion of the rock sample. In (Table 1), the modal abundance of these minerals is depicted and placed on the appropriate IUGS categorization triangle (Fig. 2).

Crystallinity of the studied sample is hypo-crystallinity and grain size are ranging from fine to medium-grained. Hypidiomorphic granular texture is observed in thin sections in which most of the minerals are anhedral. The following Inequigranular textures are determined during the thin section study of the sample.

(a) Porphyritic texture

(b) Poikolitic texture

(c) Vitrophyric texture

Altered perthitic alkali feldspar is the dominant features in this specimen which is identified by clay mineral development following the phenomena of Chloritization (Fig. 4i and j).

Laths of plagioclase are also dominant features in this specimen. Amphibole minerals are zoned along margin but some of the phenocrysts as plagioclase are not conspicuously zoned. Amphibole is green showing moderate to high interference color and low angle of extinction 5-10°, intergrowth of amphibole is a common feature observed in this thin section specimen (Fig. 4m and n).

Oikocrysts of this rock consist of Alkali feldspar, Plagioclase, and Amphibole. Most of the alkali feldspar displays cloudy appearance by clay development while alkali feldspar is commonly colorless in thin sections. Relief and birefringence of all micro-phenocrysts are low to moderate. The Interference color of alkali feldspar is gray and dark brown while plagioclase displays first order yellow interference color. Phenocrysts quartz is embedded in fine-grained groundmass and shows undulose extinction. Quartz displays lack of alteration in plane polarized light properties (PPL). The first-order interference color of quartz is yellow.

Quartz crystals are anhedral to subhedral in most of the veins. The glassy texture is more common in andesite flow and this flow reflects also trachytic texture (Fig. 4o). Primary twining is very commonly observed in feldspar is an example of Carlsbad twining (Fig. 4p). Flow banding in thin section view (Fig. 4o) displays lava flow within a melt around the plagioclase and Alkali-feldspar in both rocks' samples. Alkali feldspar is distinguished from plagioclase micro-phenocrysts by having Carlsbad twining and chlorite development in the form of Topotaxial growth.

3.1.2. Basalt

Basalt has a boudinage structure and Tectonic stylolite is perpendicular to bedding and are observed clearly in thin-section studies (Fig. 4c). Some of the iron-fearing amphibole mostly show twinning phenomena during stage rotation (Fig. 4b). Perthitic alkali feldspar altered to chlorite by Chloritization phenomena (Fig 4d). The preferred orientation micro-badinage structure and transformation of orthoclase to chlorite represent low-grade metamorphism. Various plagioclase grains have cloudy appearance by partial alteration (Fig. 4d). Quartz veins are dominantly existent in this rock sample thin section.

Most of the plagioclase is elongated in nature in this specimen (Fig. 4g). An elongated grain of perthitic alkali feldspar with flakes of Biotite is discerned. Exsolution phenomena are common in orthoclase. Plagioclase and amphibole constitute the dominant composition of the rock sample. Amphibole is the most pre-dominantly microlite embedded in fine-grained groundmass. Plagioclase display periclinal twining (Fig. 4g). Basalt shows different elongate shape amphibole in a dense network of lath-shaped micro-phenocrysts plagioclase.

Clusters of amphiboles embedded in fine-grained groundmass of basalt shows glomeroporphyritic textural behavior (Fig. 4f). Some of the oikocrysts of Alkali feldspar display antipathitic behavior medium size discrete grains of quartz are observed along the fractures and iron veins in thin section view. Optically quartz is distinguished from feldspar by undulose extinction observed in thin sections under low magnification power 10x. At places small grains of sphene are also observed in rock samples in thin section.

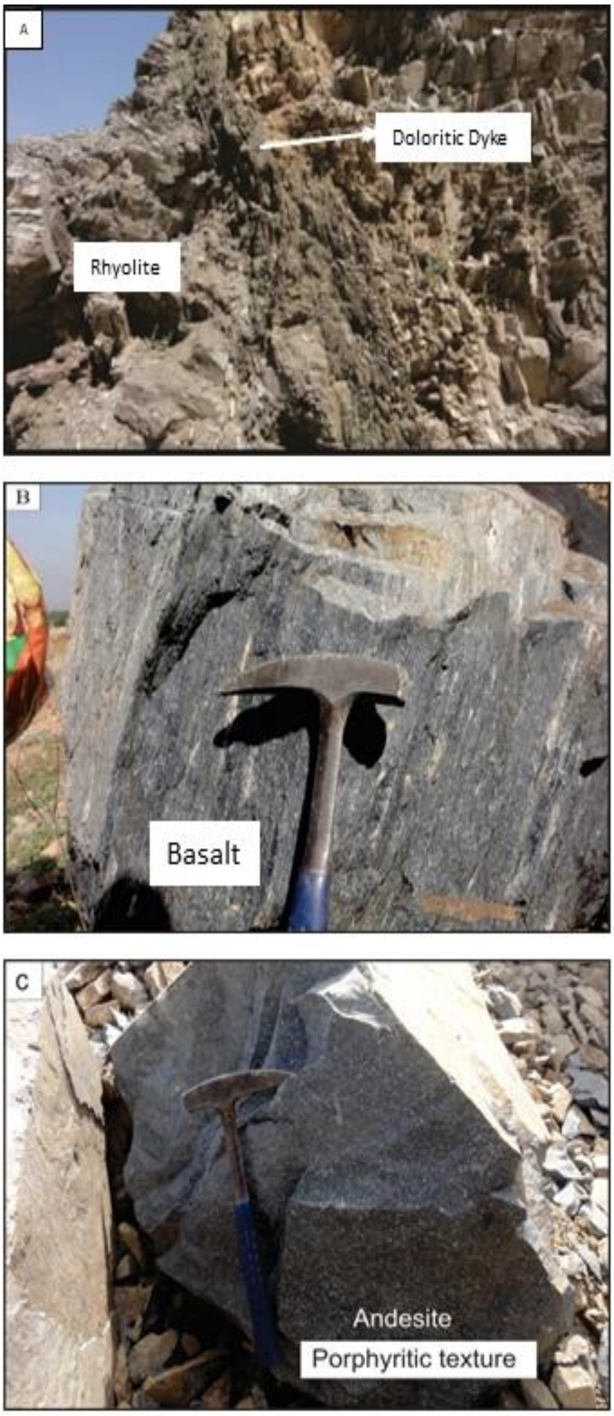
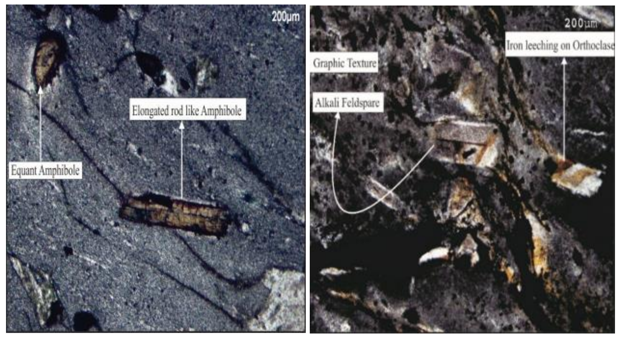
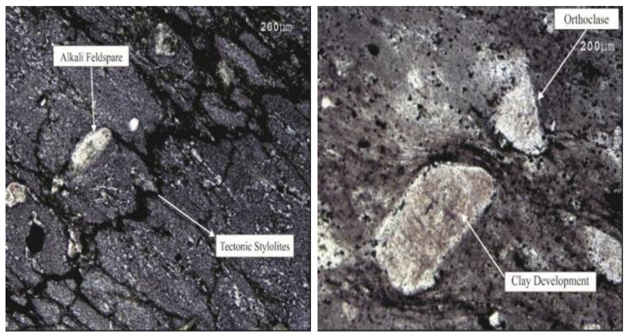


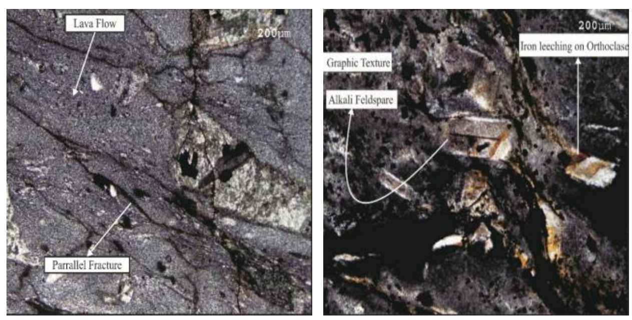
Figure 3. Field photographs: (a) Doloritic dykes cross cut he rhyolite (b) Badinage structure in fine-grained basalt (c) Fine-grained mega-porphyritic andesite.



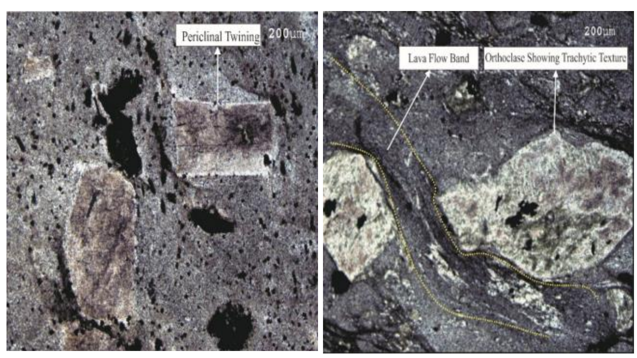
a (PPL) b (XPL



c (PPL) d (XPL)



e (PPL) f (XPL)



g (PPL) h (XPL)

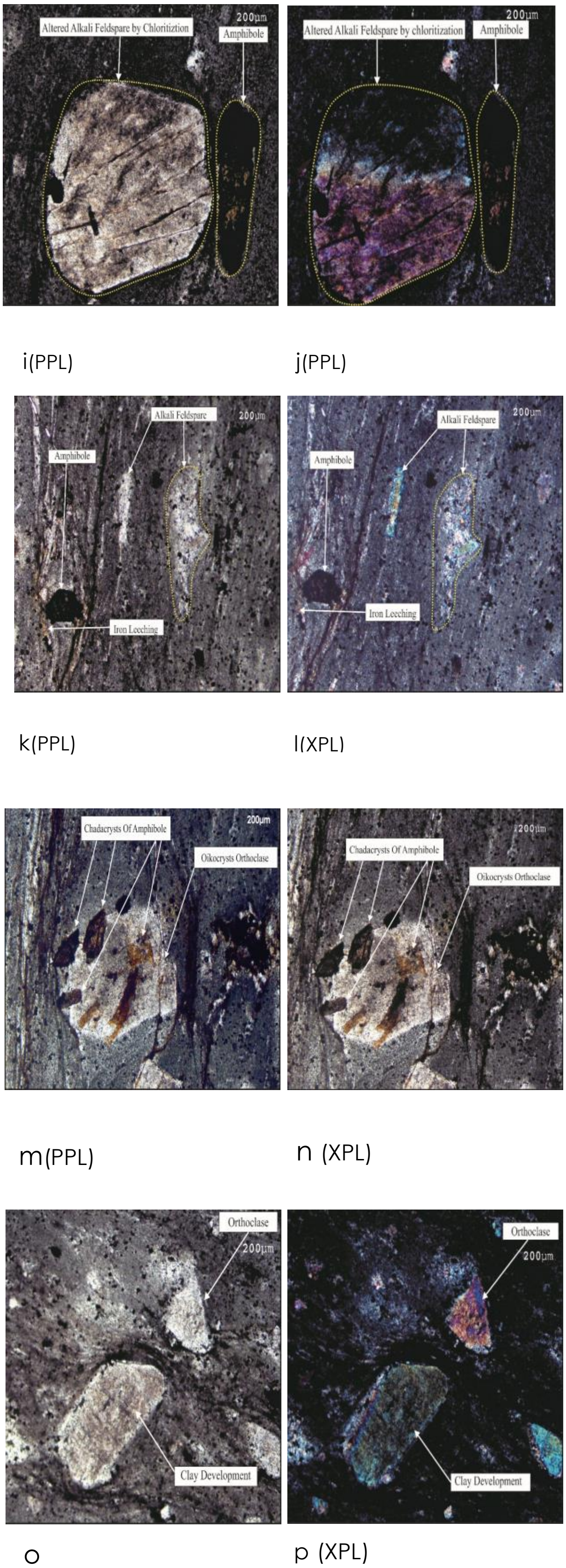


Figure 4. Photomicrographs of the examined samples of Sawabi andesite and basalt showing the petrographic characteristics. (a) Elongated Amphibole, Equant Amphibole (b) Graphic Texture, Iron leaching Orthoclase (c) Tectonic stylolite, Alkali Feldspar (d) Orthoclase, Chloritization and Carlsbad Twining (e) Lava Flow band, Fracture (f) Cluster of Amphibole, Laths of plagioclase (g) Periclinal Twining (h) Lava Flow Band, and Orthoclase showing Trachytic Texture (i) PPL & (j) is the XPL of the same image shows Chloritization at the margin, Parallel elongated Amphibole (k) is PPL image & (l) is the XPL image shows antiparallel Amphibole, Iron leaching and fine Alkali Feldspar (m & n) Both shows Chadacrysts of Amphibole in fine-grained Orthoclase Oikocrysts. (o & p) Both Show subhedral orthoclase, lava flow and Chloritization showing Carlsbad twining.

Table 1. Common textures of studied rocks

Rock name	Andesite	Basalt
Grain size	Fine-grained	Fine-grained
Fracture	Slightly Fracture	Filled with iron leaching
Matrix	Fine-grained feldspar	Fine-grained feldspar + Pyroxene
Shape/ form	Hypidiomorphic	Ipidiomorphic
Texture	Perthitic, Trachytic, Poikolitic, Graphic, Vitrophyric.	Porphyritic, Glomeroporphyritic, antiperthitic
Locality	Sawabi	Sawabi

Table 2. Modal mineralogical composition of studied rocks.

Andesite	%	Basalt	%
Alkali feldspar	50%	Plagioclase	50%
Amphibole	25%	Amphibole	27%
Quartz	9%	Biotite	5%
Biotite	5%	Quartz	6%
Muscovite	8%	Opaque	2%
Opaque	3%	Ground Mass	10%
Grand total	**100%**	**Grand Total**	**100%**

3.2. PHYSIO-MECHANICAL PROPERTIES

3.2.1. Strength Tests

UCS and UTS were determined directly by the strength testing machine while cohesion and angle of internal friction were derived from the values of UCS and UTS. Uniaxial Compressive Strength (UCS) and Uniaxial Tensile Strength (UTS) are the two types of strength testing. According to the [12] requirements, using a universal testing machine (UTM), cylindrical core samples were subjected to the UCS test. To determine UTS, the Brazilian test or split tensile test was conducted [1] Direct measurement of tensile strength has proven difficult since it is difficult to retain the specimen without adding bending force [13].

The specifics and outcomes of the UCS and UTS tests of the examined core specimen are presented in Tables 6. Cohesion and angle of internal friction were calculated from the values of UCS and UTS whereas UCS and UTS were directly obtained by the strength testing equipment. The following lab tests are run as part of the presence investigation.

1. Andesite from Sawabi area
2. Basalt from Sawabi area

The values of UCS and UTS were calculated using core samples from each bulk sample.

1. Uniaxial compressive strength (UCS)
2. Uniaxial tensile strength (UTS)
3. Specific gravity
4. Water absorption
5. Porosity

3.2.2. Unconfined Compressive Strength (UCS)

The unconfined compressive strength of a rock is thought to be the maximum stress that it can withstand when a unidirectional load is applied, frequently in the axial direction to the

ends of a cylindrical specimen [13]. The failure of the rock specimen under a compressive load in one dimension is thus defined by the UCS. Water was able to enter the core barrel through a swivel to clean drill bits and cool the bit. Since the specimen's moisture content at the time of the test can have an impact on the designated strength of the rock, the samples were first dried at 90 to 100°C [12].

A polishing/grinding machine was used to polish the core's end surfaces. With the help of a strength testing machine, the UCS of the cylindrical cores was calculated. The testing apparatus was loaded with the core samples, and the load was continually subjected without shock. The load at the point of failure was observed, and the following formula was used to get the uniaxial compressive strength:

$UCS=P/A=P/\pi /4D^2$ (KN/m²)

P=Load at failure (KN)

A=Cross-sectional area of the rock core (m²)

Table 3. Grades of Uniaxial Compressive Strength

Geological Society (Anon, 1977)			
Description	UCS (MPa)	Description	UCS (MPa)
Very weak	<1.25	Very weak	<1.25
Weak	1.25-5.00	Weak	1.25-5.00
Moderately weak	5.00-15.50	Moderately weak	5.00-15.50
Moderately strong	12.50-50	Moderately strong	12.50-50
Strong	50-100	Strong	50-100

3.2.3. Unconfined Tensile Strength (UTS)

The Maximum weight that a rock can bear before breaking when stretched, divided by the initial cross-sectional area of the substance, is regarded as the tensile strength of the material. Rocks' tensile strength, which can be measured directly or indirectly, is significantly lower than their compressive strength [13]. The direct measurement of tensile strength has frequently been found to be difficult since it cannot hold the specimen without providing bending force [13]. Due to its simplicity and low cost, the Brazilian method or indirect splitting tensile method [12] seems to be a desirable alternative. This approach was employed in the current investigation. The specimen was a disk-shaped specimen with a thickness-to-diameter ratio of approximately 0.5 was selected to meet the requisite criteria. The UTS test used two specimens from each type of rock. The testing apparatus was then loaded with these samples, and the load at the moment of failure was noted. The UTS was then determined using the following formula:

$UTS = 2P/\pi DT$

Whereas

P=Tensile load at failure (KN)

D=diameter of the rock specimen (m)

T=Thickness of the rock specimen(m)

Table 6 shows the UTS value of studied rocks

3.2.4. Water Absorption (WA)

The mechanical disruption of a tiny part of rock close to the exposed surface caused by repeated hydration and dehydration allows water to penetrate the rock, speeding up the rate of weathering [13]. Water absorption, often known as the water absorption test, is a measurement of how much water a rock can easily absorb. The samples under investigation were first dried at 105–110°C, chilled, and then weighed (W1) after being submerged in distilled water for 24 hours. Then, these moist samples were weighed again (W2) after drying. The formula was then used to calculate the percentage of water the specimen absorbed.: percentage of water absorbed (%) = (W2-W1)/(W1)100. Table 6 displays water absorption values for the examined samples of studied rocks

3.2.5. Specific Gravity (SG)

The weight of a solid divided by the weight of distilled water in an equivalent volume is known as specific gravity. It is a measurement of the difference between the weights of a volume of rock sample and a matching volume of water. Laboratory measurements were made of the andesite and basalt samples' specific gravities. For this purpose, an electric balance was used. The weight of the rock sample was first measured in air and given the designation "dry weight" (W1); the following measurement was made with the sample suspended in water, and the result was given the designation "wet weight" (W2). The following formula was then used to determine the sample's specific gravity:

Specific gravity=W1/ (W1-W2)

Engineered materials have undergone several compressive softening tests [14] discovered that the rate of rock samples submerging in water depends on their source. They slowly swell, though, losing density and strength as a result. In terms of regulating the engineering qualities of rock, the ensuing decrease in strength is highly substantial. According to [5], rocks with specific gravities of less than 2.55 are appropriate for heavy construction applications. Table 7 provides the specific gravity test results for the investigated andesite and basalt. The two fundamental characteristics of rock are density and porosity. A rock's density is determined by how much mass it has per unit volume. On the one hand, mineral composition has a major impact, and on the other, space is a major factor. The density drops as the percentage of Porosity rises. Additionally, a rise in porosity will enhance water absorption, whereas a fall in density will result in a fall in specific gravity. Thus, the relationship between specific gravity and water absorption is inverse. As illustrated in Table 5, [15] categorized rocks' porosity and dry density

3.2.6. Porosity

It can be described as the proportion of a rock's overall void volume. The size, shape, and mineralogical composition of the grains, particularly the presence of clay minerals, are factors that determine the porosity of rocks[16]. The rock's strength declines in direct proportion to the level of porosity. Using the saturation approach[17], the porosity of the samples under examination was calculated using the formula below. Table 6 displays the relevant information and findings.

P= (Weight in the air)−(Dry weight) ×100/ (Weight in the air)−(Weight in water).

Table 4. Porosity values of the studied samples.

S. No	Rock name	Porosity
1.	Andesite	0.191%
2.	Basalt	0. 244%

Table 5. Dry density and porosity values [15].

Class	Dry density	Description	Porosity	Description
1.	Less than 1.8	Very low	Over 30	Very high
2.	1.8-2.2	Low	30-15	High
3.	2.0-2.3	Moderate	15-5	Medium
4.	2.2-2.55	High	5-1	Low
5.	2.55-2.75 Over 2.75	Very high	<1	Very low

4. RESULTS AND DISCUSION

The primary focus of this work is on the petrographic and physio-mechanical analyses of the volcanic igneous rocks from the Swabi region. The results of this research are used to predict these rocks' petrogenetic, tectonic, and mechanical histories. These have Plagioclase, elongated amphibole, mega-porphyritic petrography and altered perthitic alkali feldspar phenocrysts. Plagioclase and alkali feldspar make up the majority of the groundmass. In this rock, the plagioclase and alkali feldspar phenocrysts show varying degrees of alteration. The most prevalent mineral in the examined rocks is amphibole.

The alignment of all Phenocrysts along the flow bands of lava indicates trachytoidal textural behavior. Basalt shows different elongate shape amphibole in a dense network of lath-shaped micro-phenocrysts plagioclase. Clusters of amphiboles embedded in fine-grained groundmass of basalt show glomeroporphyritic textural behavior. Badinage structure is only found in basalt (Fig. 3b). The metamorphosed nature of the studied rock samples contributes further evidence that suggests the latter have also undergone a modest degree of metamorphism[18]. The occurrences of chlorite along the phenocryst direction of alkali feldspar display Topotaxial behavior [19]. An in-depth analysis suggests that the following petrographic studies are crucial for monitoring and limiting the strength of the analyzed sample.

1. Modal mineralogical composition.
2. The dimensions, shape, and range of grain variation.
3. The preferred orientation and division of mineral grains.
4. The number of voids.

The major aim of this study was to determine the mechanical characteristics of the various textural grains found in the Sawabi region and to assess their suitability for use as building materials. Table 3 standard scale shows comparing UCS values and grading materials based on compressive strength. This scale characterizes all of the examined rock samples of andesite and basalt as moderately strong-strong (77.01-40.48 MPa; Table 6) even the badinage and mega-porphyritic basalt, whose UCS value is the lowest of all. The UCS and UTS data for the rocks shown in Table 6 were examined. Most experts agree that Rocks' UCS is 8–10 times their UTS [8].

Statistics are used to calculate the mean values and standard deviation of the observed physio-mechanical characteristics of different textural variants of Sawabi andesite and basalt (Table 3 and 6) (Fig. 5). The coarse-grained plutonic rocks are substantially weaker than the fine-grained volcanic igneous rocks [13]. However, comparing the results of the current observation yields very different findings. That is, the andesite and basalt strength values of the fine-grained mega-porphyritic Sawabi area (Table 6) (fig 5). Although the conclusion may seem strange, it is consistent with the low porosity and water absorption values of the fine-grained kind, as previously said that increased porosity and water absorption capacity adversely affect rock strength. The strength of a rock that contains an excessive amount of a physically robust mineral is obvious, but it can also be influenced by the texture of the rock's surrounding minerals. The examined area has a high concentration of feldspar (average grain size: 25), which has high strength values compared to the other rocks. The higher components of all fine-grained micro-phenocrysts are what give the Investigated andesite and basalt their high strength ratings.

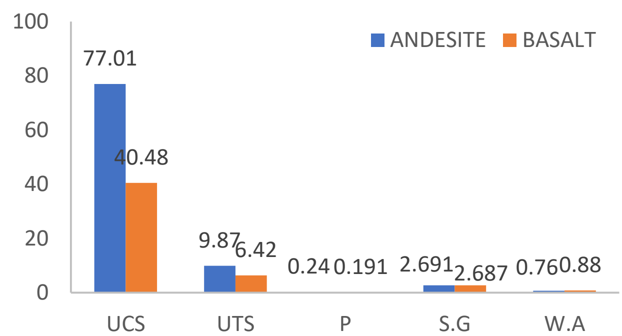


Figure 5. Average values of UCS, UTS, P, S.G and W.A.

Table 6. Average values of UTS, UCS, porosity, specific gravity and water absorption of the studied samples.

S. NO	UCS	UTS	P	SG	WA
1 Andesite	77.01	9.87	0.244%	2.691	0.76%
2 Basalt	40.48	6.42	0.191%	2.687	0.88%

As previously shown, this means that these fine-grained rocks have somewhat high strength values due to the presence of strong minerals. It is believed by [20] that "not only the grain size but also the grain size distribution is very significant, with the influence that a large size range gives high strength and enhances resistance to scattering or shattering into pieces to more equigranular or idiomorphic rock". The discussion also included many petrographic, field-related findings, and mechanical characteristics of volcanic igneous rocks from the Sawabi area. The volcanic igneous rocks of the Sawabi area are broadly divided into four categories.

Rhyolite: Rhyolite is fine-grained and foliated varieties are also exhibited along the shear zones. Besides doloritic dyke also cut this rock at place (Fig. 3a).

Dyke: Doloritic dyke is intermediate in composition having brownish color (Fig. 3a).

Basalts: Basalt is mega-porphyritic dark black fine-grained in nature.

Andesite: Andesite is found dark greenish.

Strength values of andesite is higher than basalt because of:

Very fine-grained nature.

The irregular shape of mineral grains.

Extreme variation in grain size distribution.

As previously mentioned, the examined samples can hardly be separated based on their modal mineralogy. Their opposing textural traits are the only explanation for the variation in their strength values. The weathering and alteration processes have a significant impact on the strength of rock as well. Weathering causes a noticeable decrease in a rock's strength [13]. The alteration product of plutonic rocks typically contains a lot of clay [10]. Although the examined samples contain alteration features, their rarity prevents any potential negative impact on the geotechnical qualities.

The studied samples' specific gravity, porosity, and water absorption values are all within the acceptable range for usage as building materials (Table 6) (Fig. 5). Calculated average values for both kinds are 2.69 and 2.68 respectively. The distinctive petrographic characteristics of the volcanic igneous rocks of the Swabi region include altered perthitic alkali feldspar phenocrysts, elongated amphibole, and plagioclase. The rocks' metamorphic makeup and altered characteristics also point to the influence of tectonic deformation [3, 4], hydrothermal alteration, and regional metamorphism on the evolution of the Swabi rocks over time. Additionally, they exhibit different mechanical characteristics; basalt and andesite are moderately to very strong.

The range of rock types found here demonstrates the complexity of the tectonic history of these rocks, which includes magma evolution, volcanic activity, and crustal interactions. Swabi rocks differ from those in other areas in their textural characteristics and mineral compositions, indicating a variety of tectonic settings and geological processes were involved in their genesis and evolution [7]. The study provided comprehensive insights into the petrographic and physio-mechanical characteristics of volcanic igneous rocks from the Swabi region, highlighting their suitability for various engineering applications. The findings underscored the importance of considering textural traits and mineral composition in determining the strength and suitability of these rocks for construction purposes.

5. SUMMARY AND CONCULSIONS

The analysis of volcanic igneous rocks from Swabi provides valuable insights into their composition and mechanical properties. Petrographic examination highlights the prevalence of plagioclase, amphibole, and alkali feldspar, with varying degrees of alteration. Textural behaviors such as trachytoidal and glomeroporphyritic structures are observed, alongside the presence of boudinage in basalt. Mechanical testing indicates a wide strength range in andesite and basalt, with fine-grained variants showing unexpectedly high strength due to robust mineral presence, particularly feldspar. Grain size distribution and mineral alignment are identified as key factors influencing rock strength.

Despite weathering and alteration, the samples maintain acceptable geotechnical qualities for construction. Categorization into rhyolite, dyke, basalt, and andesite aids in understanding the region's geological diversity. Overall, this study enhances our understanding of Swabi's volcanic rocks, laying groundwork for future research and practical applications in construction and geotechnical engineering.

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Authors' contributions:

Bilal Jan Haji Muhammad: Conceptualization, Methodology and laboratory analysis. **Wang Ping**: Field data Supervision, Writing, Original draft preparation. **Muhammad Jalal**: writing reviewing, **Ihtisham Islam**: Data Interpretation and editing.

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