A report on
Hydrology, Meteorology and Geology

(Course no:- 552, Practical)

FOR THE PARTIAL FULFILMENT OF THE MASTERS DEGREE IN ENVIRONMENTAL SCIENCE UNDER THE COURSE DESIGNED BY TRIBHUWAN UNIVERSITY

MODULE 1:- FUNDAMENTAL OF GEOLOGY, STUDY OF MINERALS AND ROCK

Introduction:-

Minerals are defined as the naturally occurring inorganic substances with definite and predictable chemical composition and physical properties (O' Donoghue, 1990). Minerals are always made up of the same materials in nearly the same proportions. For eg:- quartzite found in Nepal and somewhere in other country have same chemical composition. Minerals can be divided into two types on the basis of occurrence of silica composition.

1. Silicate Minerals
2. Non-silicate minerals

The basic building block for the silicate minerals is the silica tetrahedron. Silicate minerals are most abundant minerals crust accounting for more than 90% in the earth. Silicate minerals are the rock forming minerals. They are classified based on the structure of their silicate group which contains different ratios of silicon and oxygen. The basic building blocks of silicate minerals are silica tetrahedron. Silica tetrahedral, made up of silicon and oxygen, form chains, sheets, and frameworks, and bond with other cations to form silicate minerals. Silicate minerals are the most common minerals in the Earth, and include quartz, feldspar, mica, amphibole, pyroxene, and olivine. The amount of silica varies in silicate minerals with metal cations. The more the silica more will be covalent bonding and greater the stability to chemical weathering. The more cations and ionic bonding lowering will be the stability and weathering. Commonly occurring silicate minerals are quartz, feldspar, mica, amphibole, pyroxene, and olivine.

Non-silicates are minerals other than silicate minerals and are economically important minerals which can be extracted profitably. Non-silicate minerals required special purification for best economic uses. There are a few important groups of non-silicate minerals. Only the carbonates are significant as rock-forming minerals. The remaining mineral groups are often ore minerals and provide economic sources for various elements. The important non-silicate groups are:

- Carbonates
- Evaporite
- Oxides
- Sulphides
- Phosphates

Commonly occurring non-silicate minerals are apatite, chalcopyrite, Galena, Pyrite, Hematite, Magnetite, Bauxite, Calcite, Dolomite.

Physical properties:-

Minerals are distinguished by their physical and chemical properties. The same properties are responsible for the many of the mechanical characteristics of rocks. Most common minerals can be recognized from one or two characteristics. The major physical properties of minerals are color, streak, hardness, luster, crystal habit, specific gravity, cleavage, fracture. Some minerals have special characteristics that are diagnostic for only a few species. Refractive index (calcite), effervescence with dilute acids (calcite), fluorescence (fluorite), phosphorescence, piezoelectricity (quartz), resistivity (halite), taste (halite) and magnetic properties (magnetite) are all used to identify particular minerals.

Occurrence and Importance of minerals:-

Minerals are generally occurring in the form of ores and in rock masses. For the uses of it minerals are to be extracted and purify called smelting. Minerals are found in the Veins & lodes, beds or layers of rock, residual mass of weathered particles, alluvial deposits or placer deposits. Minerals are the part of our daily life. What we are consuming in our life have composition minerals. For e.g. talc is used for facial powder, Quartz is used for glass manufacture, clay minerals are used for ceramics and pottery, and silica minerals are used for construction uses.

Silicate minerals found in Nepal:-

Nepal lies in the central part of 2500km long Himalayan belt. Almost 83% of Nepalese territory is mountainous. Nepal is rich in mineral resource though detail study of occurrence has not done yet officially. For the economic development of the country exploitation and proper use of valuable resources, especially mineral resources, is extremely important. The mountainous region and the geological environment therein are suitable for metallic, non-metallic (industrial, gemstones and energy/fuel) mineral deposits as well as huge amount of construction materials, dimension and decorative stones. Continues efforts are required to find the more mineral deposits and exploit them for the benefit of the people (Prasad, 2014)

Nepal Himalaya can be divided into five distinct morpho-geotectonic zones from south to north. From mineral resources point of view, the southernmost Terai Plain is potential for gravel, sand, ground water, petroleum and natural gas, and the Sub Himalaya (Churia Range/ Siwalik foot hills) for construction materials, radioactive minerals, petroleum, natural gas and minor amount of petrified coal. Lesser Himalaya (the Mahabharat Range including midlands) for metallic minerals mainly Iron, copper, lead, zinc, cobalt, nickel, tin, tungsten, molybdenum, gold, uranium, rare metals and so on, and industrial minerals like magnesite, phosphorite, limestone, dolomite, talc, clay, kaolin, graphite, mica, silica sand and quartz, and

gemstones like, tourmaline, aquamarine/ beryl, garnet, kainite and quartz crystals, and fuel minerals such as coal, lignite, methane gas, petroleum and natural gas, hot springs and radioactive minerals, and voluminous construction materials crushed gravel as well as river boulders, gravel, sand. Some of the areas in Higher Himalaya are highly promising for precious and semiprecious stones like ruby, sapphire and emerald, and metallic minerals like lead, zinc, uranium, gold silver etc. Tibetan Tethys zone is prospective for limestone, gypsum, brine water (salt), radioactive minerals and natural gas.
However, because of rugged topography, difficult mountain terrain, complex geology, lack of infrastructures and financial constrain exploration and exploitation of these mineral resources is still challenging. (Prasad, 2014)

Rocks:-

The solid mineral material forming part of the surface of the earth and other similar planets, exposed on the surface or underlying the soil. Rocks have been used by mankind throughout the history from the stone age, rocks have been used for tools. Rocks are geologically classified as per their character such as mineral and chemical composition, permeability, the texture of constituent and particle size. Rocks are further classified according to their mineral composition and way which they formed.

a) Igneous Rock
b) Sedimentary Rock
c) Metamorphic rock

A) Igneous Rock

Igneous rocks are the first formed rock formed by the cooling and solidification of magma at the earth's surface or below it. The cooling of magma occurs due to change in temperature, pressure or composition. About 64.7% of earth's crust is constituent of igneous rock. Igneous rock can be identified from the following features:-

- Random orientation of minerals
- No bedding plane
- Massive and Hard

B) Sedimentary Rock

Sedimentary rocks are those rock which are derived from the consolidation of sediments of pre-existing rocks under the influence of mechanical, chemical or geological processes of earth. Sedimentary rock can be identified from following features:-

- Random orientation of minerals and cemented by fine materials.
- Thick bedding planes.

a. Metamorphic Rock

The rocks that are formed from pre-existing rocks by the process of metamorphism by the influence of temperature, pressure or both. Eg. Marble, Schist, etc. Metamorphic rock can be identified by following features:-

- Directional arrangement of minerals
- Thin layer of foliation plane
- Have rock cleavage

Objectives:-

a) Study of silicate mineral in hand specimen and interpretation of their uses and roles for rock and soil stability
b) Study of non-silicate minerals in hand specimen and interpretation of their economic importance and roles for rock and soil stability
c) Study of sedimentary rocks in hand specimen and interpretation of depositional environment
d) Study of igneous rock in hand specimen and interpretation of formational and environmental history
e) Study of metamorphic rock in hand specimen and interpretation of uses for environmental protection and development

Materials and Method

i) Rock and minerals hand specimen
ii) Literature study

Observations:-

a) Study of silicate minerals in hand specimen and interpretation of their uses and roles for rock and soil stability

i) Quartz

Properties of Quartz:-
Colour:- Dirty black
Lustre:- Vitreous
Streak:- Colourless
Transparency:- Translucent
Cleavage:- No cleavage
Fracture:- Concoidal
Hardness:- 7
Tenacity:- Brittle
Specific gravity:- 2.7
Chemical Composition:-SiO_2
Chemical reaction:- No reaction with acid and water but several reaction of other oxides of metallic ion
Diagnostic properties:- Concoidal fracture, glassy lustre
Rock stability:- It makes rock stable
Occurrence:- Occurs mostly in 250/270ºC and mostly found in intrusive igneous rock and metamorphic rock. It is found in crystal form as a diameter up to 2.5 meter.

Economic importance:- It has wide economic value because of its wide use in glass and petroleum industry. It is also used for decorative purpose so has high economic value.

ii) Feldspar
Colour:- White
Streak:- White
Lustre:- Vitreous
Fracture:- Uneven
Cleavage:- Two sets
Hardness:- 6
Specific density:- 2.7
Transparency:- Translucent
Chemical Composition:- $CaAl_2Si_2O_8$
Chemical reaction:- slightly react with acid, highly react with water, react with oxygen, acidic water, salty water and react with metal on high temperature.
Diagnostic Properties:- Colour, cleavage and tenacity
Occurrence:- Occurs in pegmatite, granite, gneiss, schist
Rock stability:- It have high weathering property make rock unstable while better for soil.

iii) Tourmaline
Properties:-
Colour:- Black
Streak:- white
Lustre:- Sub metallic
Transparency:- Opaque
Hardness:- 7
Fracture:- Concoidal
Specific gravity:- 3.2
Tenacity:- Brittle
Crystal structure:- Hexagonal
Chemical composition:- $(Mg,Al,Fe^{+3}V^{+3}Cr^{+3})_6$
Chemical reaction:- Doesn't react with acid, slightly dissolve in water, slightly react with oxygen
Diagnostic properties:- Colour, prismatic crystal structure
Occurrence:- Mostly occur in intrusive igneous rock (Pegmatite only)
Uses:- Used as gemstones and ornaments
Rock stability:- Unstable for rock and stable for soil

iv) Muscovite
Properties:-
Colour:- Black or brown
Streak;- White

Lustre:- Pearly
Transparency:- translucent
Hardness:- 3
Fracture:- Uneven
Specific gravity:- 2.8
Tenacity:- Brittle
Crystal structure:- Monoclinic
Composition:- $KAl_2(Si_3AlO_{10})(OH)_2$
Chemical reaction:-
Diagnostic properties:- Cleavage, Colour, Transparency
Occurrence:- found in all Rock
Uses:- Used for paints, joint compounds, Plastic rubber, asphalt roofing, electrical devices

b) Study of Non-silicate Minerals in hand specimen and interpretations of their economic importance and roles for rock and soil stability

Following minerals were studied and their properties are noted down.

i) Chalcopyrite

Properties:-
Colour:- brass yellow
Streak:- Greenish black
Lustre:- Metallic
Transparency:- Opaque
Cleavage:- Poor
Hardness:- 4
Specific gravity:- 4.3
Tenacity:- Brittle
Crystal system:- Tetragonal
Chemical Composition:- $CuFeS_2$
Chemical properties:-React with acid and water
Diagnostic properties:- Colour, streak,
Occurrence:- found in igneous rock, pegmatite dikes and metamorphic rocks.
Uses:- Important ore of copper.

ii) Pyrite

Properties:-
Colour:- Brass yellow
Streak:- Black
Lustre:- Metallic
Transparency:- Opaque
Cleavage:- Concoidal fracture
Hardness:- 6
Specific gravity:- 4.9

Chemical Composition:- FeS_2
Crystal structure:- Isometric
Diagnostic properties:- Colour, hardness and streak
Occurrence:- Occurs at high and low temperature in all Rock name worldwide
Uses:- Ore of gold as gold and pyrite are formed under similar condition and occur together

iii) Hematite
Properties:-
Colour:- Black to steel gray
Streak:- Red to reddish brown
Lustre:- Metallic, sub metallic, earthy
Transparency:- Opaque
Cleavage:- Non cleavage
Hardness:-5
Specific gravity:- 5.3
Chemical composition:- Fe_2O_3
Crystalstructure:- Trigonal
Diagnostic properties:- Red streak
Occurrence:- Most found in sediments and found in igneous or metamorphic rock
Uses:- Ore of iron, Used as gemstone and healing stone

iv) Dolomite
Properties:-
Colour:- White, grey
Streak:- White
Lustre:- Vitreous
Transparency:- Transparent
Cleavage:- Perfect, rhombohedra
Hardness:- 4
Specific gravity:- 2.9
Chemical composition:- $CaMg(CO_3)_2$
Crystal structure:- Hexagonal
Diagnostic properties:- Cleavage, powered form react with dilute HCl
Occurrence:- Sedimentary rock as dolostone, Metamorphic rock as dolomite marble
Uses:- Uses for construction aggregate, cement manufacture, dimension stone, calcined to produce lime, sometimes an oil and gas reservoir, a source of magnesia for the chemical industry, agricultural soil treatments, metallurgical flux.

c) Study of sedimentary rocks in hand specimen and their interpretation of depositional environment

Types of sedimentary rock studied on hand specimen.

i) Dolomite

Properties

Colour:- Light Gray

Texture:- granular

Fracture:- concoidal, uneven

Luster:- vitreous

Cleavage:- two sets

Hardness:- 4

Specific gravity:- 2.9

Acid test:- react with acid in powdered form

Chemical composition:- $CaMg(CO_3)_2$

Diagnostic properties:- Rhombohedral cleavage, Powered form produce effervesce weakly in dilute HCl, Hardness

Uses:-

- Uses for construction aggregate, cement manufacture, dimension stone, calcined to produce lime, sometimes an oil and gas reservoir, a source of magnesia for the chemical industry, agricultural soil treatments, metallurgical flux.

d) Study of igneous rock and interpretation of formational and environmental history

i) Pegmatite

Properties:-

Colour:-

Texture:-

Fracture:-

Lusture:-

Cleavage:-

Hardness:-

Specific gravity:-

Composition:-

Diagnostic features:-

Uses:-

e) Study of metamorphic rock and interpretation of uses for environmental protection and development

i) Rock name:- Quartzite

Properties

Colour:- black, brown, light gray
Texture:- foliated, granular
Fracture:- uneven, sharp edge
Luster:- vitreous
Cleavage:- indiscernible
Hardness:- 6-7
Specific gravity:- 2.6-2.8
Composition:- chlorite, hematite, quartz more than 90%, aluminum oxide, CaO
Diagnostic property:- Weathering, lusture, colour, hardness
Uses:-

- Used as a building stone, cement industry, monuments, sculpture
- Production of glass and ceramics
- Soil conditioner as a source of magnesia
- Used as weapon on ancient time
- Pure quartzite is a source of silica for metallurgical purposes, and for the manufacture of brick

ii) Slate

Properties

Colour: - silvery gray
Texture: -foliated, foliation on mm scale
Lusture :- dull
Fracture: - platy
Cleavage: - parallel orientation
Hardness: - 4
Specific gravity: - 2.7-2.8
Composition: quartz, muscovite, biotite, chlorite, hematite
Diagnostic property:- Texture, grain size, fracture
Uses:-

- Historically extensively used for roof and floor tiles, and blackboards; standard material for the beds of pool, snooker, billiard table

iii) Rock name:- Phyllite

Properties

Colour:- Silvery White
Texture:- Phyllatic Sheen
Fracture:- Concoidal
Luster:- Phyllitic
Cleavage:- Two Sets
Hardness:- 1-2
Specific Gravity:- 2.72
Composition:- Muscovite, Biotite, Quartz, Plagioclase
Acid Test:- No Reaction
Diagnostic property:- Soapy touch after introduced in water, lustre, hardness

Uses:-

- Dimension Stone, Building Houses Or Walls, Cement Manufacture, Raw Material For The Manufacture Of Mortar,
- Uses At Interior Decoration , Artifacts, Sculpture

iv) Gneiss

Properties:-
Colour:-Light to dark black, brown
Texture:-Interlocking texture
Fracture:- Irregular
Lustre:- Dull to pearly
Cleavage:- poor
Hardness:- 7
Specific gravity:- 2.5-2.7
Composition:- Hornblende, plerigioclas, Garnet
Diagnostic property:- Banded, Wavy structure
Uses:- Road construction, floor tiles,, monument, sculpture

Result and discussion

Silicate minerals are most abundant minerals accounts 90% on earth crust. The stability of rock depends on the composition of minerals and their chemical activities. Among silicate minerals Quartz is most abundant and has high economic value as used in glass manufacture and petroleum industry. Feldspar has high weathering property and makes rock unstable while better for soil. Tourmaline is used as gemstones and ornaments. It makes rock Unstable and stable for soil. Muscovite has high weathering behaviour and makes rock unstable. Its hardness is so less that is can easily break into piece. Muscovite is mostly used in paints and used for insulating material.

Non-silicate minerals are ore forming minerals. They have high economic value if well purified. Among other group of non-silicate carbonates are rock forming minerals.

The different rock shows different properties. The rocks are formed due to change in environmental condition of temperature and pressure. Two rocks forming at same time having same mineral composition they might have completely different from each other and have different properties. Rock named dolomite can be considered as both rock and independent material.

Sedimentary rocks are formed by the sedimentation of pre-existing rock and minerals under the influence of mechanical, geological and chemical composition of earth. Studied rock dolomite can be dissolved slightly by acidic water, it contribute mostly on Karst formation and important as aquifer.

Igneous rocks are formed by the cooling and sedimentation process of magma materials that comes along with the lava during volcanic eruption at or below earth surface. The formation and ordination of minerals in igneous rock is not in regular fashion. The unequal distribution of minerals accounts the deposition of erupted lava in different time interval. Igneous rock doesn't have any fossils. Studied rock pegmatites are sometimes found as the valuable minerals such as spodumene and beryl that are rarely found economic in other types of rock. Pegmatite can also be a source of gemstone as world best tourmaline, aquamarine and topaz deposit have been found in it.

Metamorphic rocks are formed by the metamorphism of pre existing rock by the influence of temperature or pressure or both. Metamorphic rocks have high economic uses.

Conclusion

Hence, fundamental of geology, study of minerals and rocks were studied.