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Geological Investigation and the Occurrence of Heavy Minerals Around Kayle Area, Konso Regional State, Southern Ethiopia

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***Abstract*— A county like Ethiopia which is endowed with rich diverse of geological resources can associate future development in the aspect of socio-economic development to mining industry. Heavy mineral deposit mapping is essential for sustainable and eco-friendly exploitation of natural resources. This research is interest on the detail geological investigation and heavy mineral deposits of surface and subsurface sediments has been investigated in the Kayle prospect were undertaken systematically. The study area is located in southwest of Segen zone, in South Nation, Nationality and People Regional State, Southern Ethiopia. The geology of the study area belongs to Mozambique belt basement rocks which were known to host most of the heavy mineral deposits in Ethiopia. Heavy mineral assemblages in the coarse sand fraction of sediment samples were identified using petrography microscope and minerals which have specific gravity of >2.8 g/cc^3 presented as residual grains in sediments. Heavy minerals which are identified in study area are limonite, magnetite, garnet tourmaline, sphene, zircon, epidote, pyroxenes & amphiboles and most of the minerals are angular to rounded shape.**

Keywords*— *Heavy minerals, Stream sediments, Petrography microscope, Field investigation and GIS.

I. INTRODUCTION

Ethiopia has a varied geology and spectacular topography with the major East African Rift cutting its plateau into two halves. The geology of Ethiopia ranges from the oldest Precambrian to recent volcanic and sedimentary formations. The Precambrian basement rocks are known to host for most of the economic metallic mineral deposits which includes primary and secondary enriched metallic minerals, placer gold and heavy minerals. Heavy minerals are important economic resource as they are useful in many industries for various purposes. The low metamorphic grade of Precambrian basement rocks and structural features favourability has encouraged mineral exploration activities by the Ethiopia Institute of Geological Surveys since 1970 and 1972 [1 and 2]. Basement rocks of low grade metamorphic rock of Precambrian are considered to be the host rocks for placer gold and heavy metals in Ethiopia.

Generally, the heavy mineral assemblage in sediments usually reflects their parent rocks as well their origin and it have high density minerals with respect to specific gravity [3]. The factors which influence the assemblage of the heavy minerals include weathering at different stages between the original source rocks and sedimentary environments, mechanical abrasion during transportation, physical sorting and digenetic processes during buried [4]. The degree of alteration due to weathering is significant and is independent of the provenance. Hence, it attracts the attention of scientists in different disciplines with totally different approaches [5]. Many researchers mention that the study of heavy minerals provides information about the origin of the sediments and their economic important. Therefore, this study should be focused on creating a detail geology map and structural map in scale of 1:15000, Heavy mineral desperation through geochemical analysis and to judge the sources (provenance) of heavy metallic minerals deposits.

II. MATERIAL AND METHODS

A. Study area

The study area is located about 620 km from south-western direction of Addis Ababa, capital city of Ethiopia, and 120 km towards S - SE direction from Arba Minch town. Total areal coverage of the study area is 40 km². Geographically the area is bounded between 316000 m E to 326000 m E and 0595000 m N to 0599000 m N (Fig.1). The study area can be accessed easily by asphalted road, gravel road and foot trail with some difficulties. It can be reached by the asphalted road which runs from Addis Ababa to Jinka through Konso. From Konso it is accessible via the gravel road which extends from Konso to Kayle bisecting the study area, and all parts within the study area are accessible by using foot trails.

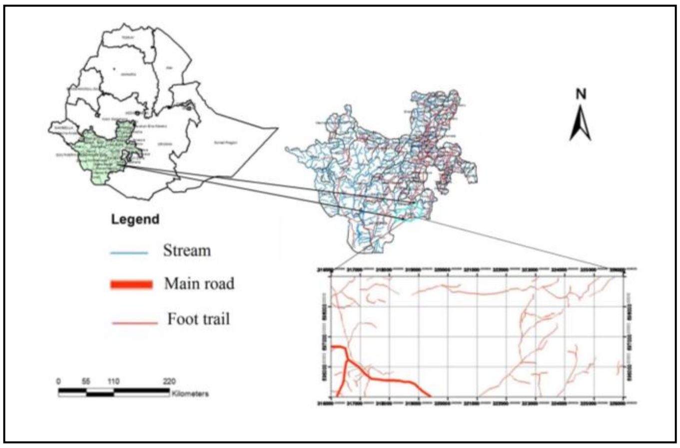

Fig: 1. Study area boundary map

B. Physiographic of the study area

The topography of the area is characterized by highly rugged which includes mountains, hills, and valleys. The maximum elevation of the study area is found to be 1440 m

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and its minimum elevation 1200 m. The general characteristic of climate in the study area is arid. The rainy season of the study area is from June to August and the dry season is from January to March. The vegetation cover of the study area shows variation in its different parts, some parts are sparsely vegetated and others are densely vegetated. In the southern and eastern parts are densely vegetated and the other parts are sparsely vegetated. The dominant vegetations in the area are cactus tree, acacia, moringa (shiferaw) and dwarf plants.

C. *Geological setting*

In Ethiopia, the Mozambique belt is exposed in the south and southwest and forms a front with the Arabian Nubian Shield (ANS) to the north [6]. [7] He explored metamorphic complexes of the country in to Lower and Middle Complex which correlated with the Mozambique belt, and the Upper Complex is correlated with ANS. The Lower complex is consider to be Achaean comprises high-grade gneisses, granites, granulites and migmatites [8]. This lower complex is further subdivided into five groups of gneissic rocks. These are from the oldest to the youngest: Konso, Alghe, Awata, Yavello and Baro gneisses. The study area mainly belong to konso gneissic groups and it has initially interpreted as the lowest litho-stratigraphic unit in the lower complex because of its similarity to relict high grade Archean terrains in the Ugandan basement. However, these units which show no comparable evidence of reworking probable represent a localized geothermal peak of the culminatory Mozambiquean metamorphic whose isograds transgressiveely overprint the primary layering [9].

The konso group is comprises of four main rock types: biotite, granite, hornblende granite and monzodiorite. Biotite leucogranite occurs in the western peripheral part as an arcuate mass of grey massive nearly homogeneous medium grained rock. They are equigranular to sub porphyrtic and essential composed of quartz coarpethic microcline sodic plagioclase feldspar and biotite. Biotite granite forms the larger centre part, whereas biotite- hornblende-granite occurs as a smaller body in the eastern end of the pluton. It composed similar to botite leacegranite quartz and high plagioclase biotite. Monzodiorite forms mino, up 10m sized, darker masses scattered all over the biotite-hornblende granites. The monzodiorite exposures are restricted to lowest elevation indicating that they window to unexposed larger mafic plutonic bodies as already described elsewhere in the world. They are fine grained to subporphyritic with coarse grained bitotite (10-35%) amphibole (15-40%) some clinophyroxen (5-10%) and magnetite (5-10%) set in a finer matrix of quartz (<10%), K-feldspar (<5%) and plagioclase (An14,15-30%). Biotite is less aluminous (Altot=2.31-2.40 apfu) and less ferric (XFe= 0.78) than that of the granites whereas amphibole corresponds to ferro-hornblende.

D. *Method of investigation*

The field investigation is one of the techniques for the preparing a detail lithology and structural map in the scale of 1:15000. Stream sediment samples are collected in main river such as Kayle, Bebeka and their tributaries of third order and second order stream position. The stream sediment samples were collected randomly from the bottom of active stream channels using a spade onto a stainless steel, flat-bottom conical pan. A total of 17 samples were collected (Fig. 2). The heavy mineral concentrates were extracted from the placer by circular and pendulum motions of the pan under the water level. During repeated shaking cycles, the lighter particles were washed away whereas the heavier ones settled down the pan. This process was repeated until a residue of heavy minerals was obtained. These concentrates were then air dried for four days before submitted for analysis. After drying, meshing is carried out in different mush size such as 1.8mm, 600µm, 500µm, 300µm, 150µm and <150µm for separating heavy minerals. Finally, microscope was used for scanning electron microscopic studies of each sample in order to find the heavy minerals and understand mineral alteration and micro morphology.

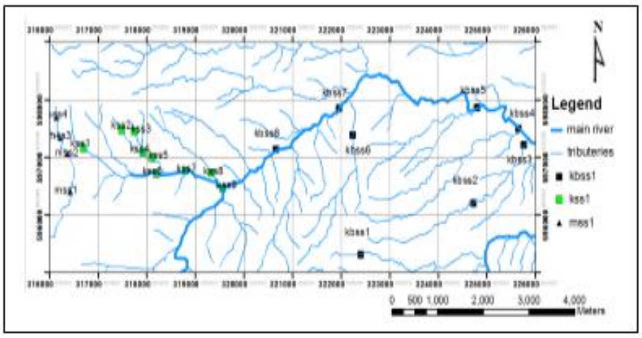

Fig: 2. Sample location in the study area

III. RESULTS AND DISCUSSION

A. *Lithology map*

The detail (1:15000) litholgy map of the study area is accomplished with the help of field investigation. The lithological units presents in study area are basalt, dolerite, granite, amphibolites, gnessis and granulites (Fig.3). The basalt and dolorite rock is exposed in eastern parts and outcrops emerge near to river cut and hill side. Basalt rock is characterized by light to dark grey, aphanetic in texture and massive nature and the columnar basalt have columnar joints. Dolorite rock appears in weathered colour is light brown and fresh colour is dark grey. Both rocks are composed of pyroxen, plagioclase feldspar and quartz. The outcrop of granite is mainly present in northwestern, southwestern and central part of the study area and it is characterized by dark grey and light color. The texture of the rock is phaneretic and it is composed of quartz, feldspar and biotite. The amphibolite rock which is found dominantly in contact with granulite unit which covers a small area and outcrop is appear in north, eastern and southeastern sides of the study area. It is composed of amphibole, plagioclase feldspar and quartz. This rock unit is observed intruded by pegmatite and quartz veins of different thickness. Amphibolites gnessis is exposed in eastern part and found along the river and stream cut. Its appear in weathered colour in dark grey, fresh colour in black and white forming banding. Texture of the rock is gneissic and it is composed of amphibole, feldspar and quartz. Granulite covers large part of the study area and colour of the rock is dark and dark gray weathered colour. This litholgy unit is high grade metamorphic rock. Texturally this rock unit is coarse grained and it contains of mineral assemblage of pyroxene, feldspar, and small amount of quartz.

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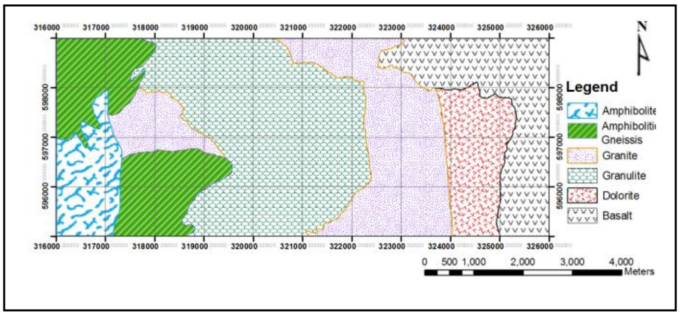

Fig: 3. Lithology map of the study area

B. Structural map

Different geological structures are observed in study area namely joints, faults, foliations, folds, dykes and veins (Fig :). These geological structures are dominantly found in metamorphic rocks and developed in different units with diverse orientations. Joint aperture and spacing varies significantly with respect to 1cm to 1.5m. Fault is a planar fracture or discontinuity in a volume of a rock and it has significant displacement. The study area is dominated by a reverse fault, where as hanging wall moved upward relative to the footwall. Foliation is any penetrative planar fabric present in rocks and planar arrangement of minerals due to changes in the effect of high temperature, pressure and metamorphism. In study area, foliation is well developed in high grade metamorphic rocks which has easily identified preferred orientation of minerals and well developed bands. Generally anticline fold are appearing in the study area and it occurs due to applied stress in both direction of the lithological unit. Dyke intrusions and quartz vein are observed in the study area having different thicknesses and rock structures. Intrusions of dykes which reaches upto 1.5 m and it appear in white fresh color and grey weathered color. Quartz veins are appears in white color and overall thickness ranges from 5 cm to 1m. The pegmatite vein is composed with minerals like plagioclase feldspars, quartz, biotite mica and other felsic minerals and thickness ranges from few cm to 1 m in study area. In shear zone, high fractured and fragment are observed in study area which could be formed by tectonic activities.

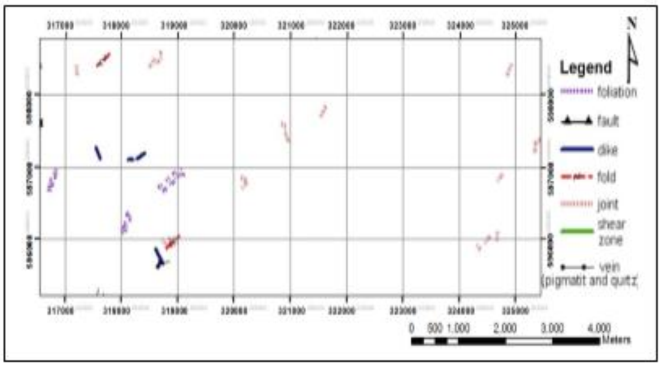

Fig: 4. Structural map of the study area

C. Geochemistry analysis for stream sediments

The microscopic inspection of the stream sediments samples showed (Table 1) that the heavy minerals included in the study area are zircon, Ilmenites, magnetite, garnet, epidote, tourmaline, and sphene (Fig.5). . Zircon are observed in sample code such as kss8,kbss2,kbss5 and mss2.Its grains are found as prism, dipyramid and ditetragonal dipyramid in irregular shape, brown to orange in color, different sizes and inclusions. Its widely distributed as accessory mineral in granite, granodiorite, syenites , monzonit and rarely in nephelilen. Tourmaline is the most abundant ultrastable mineral in the study area, found as prismatic, elongate, indigo to dark black grains and observed in all sediments. Garnet mostly relatively resistant mineral and the grains were found as cubic, red, brown, yellow, white, green, black color were observed in mss3,kss1,kss2,kss3 and kss4. Hardness of Mohs scale ranges from 6.5 to 7.5 and it is often alters to talc, serpentine, chlorite minerals. The garnets fractions are characterized by subhedral form, brown to orange in color, absence of cleavage; some grains are bright red color and based on color the garnets are identified as grossularite.

TABLE I.
RESULTS OF STREAM SEDIMENTS SAMPLES

No	Sample code (mss1)	Total weight (200g)	Sieve number in mesh	Fraction weight (g)	Magnetic mineral (g)	Mineral identification in stream sediment samples by using high magnify power Hand lens (X100)
1	mss1	"	150	93.5	<1	Small amount of Hornblende, Tourmaline, Pyroxene, plagioclase feldspar and quartz
2	mss2	"	300	58	<1	Small amount of Hornblende, Tourmaline, Epidotic, Plagioclase feldspar, K feldspar and quartz
3	Mss3	"	150	66.5	26.5	Small amount of Zircon, Garnet, spine, Tourmaline, quartz, Plagioclase feldspar and K feldspar
4	(kss1)	"	300	75.5	37	Small amount of Garnet, tourmaline, illuminate, magnetite, spine, K feldspar, more Plagioclase feldspar and, less quartz
5	(kss2)	"	150	61.5	7.5	Small amount of Garnet, Epidotic, tourmaline, illuminate, magnetite, Hornblende, K feldspar, Plagioclase and feldspar
6	(kss3)	"	300	56	5.5	Show Garnet, Epidotic, tourmaline, illuminate, magnetite, K feldspar, Plagioclase feldspar and more quartz
7	(kss4)	"	300	57	5	Show Garnet, Epidotic, tourmaline, illuminate, magnetite, K feldspar, Plagioclase feldspar and more quartz
8	(kss5)	"	300	43.5	10.5	More amount of magnetic mineral but the other similar to the above
9	(kss7)	"	1.18	36	-	More magnetite and illuminate the other is similar
10	(kss8)	"	1.18	33	-	Show white quartz, more K feldspar, little tourmaline, Hornblende and Zircon
11	(kbss1)	"	1.18	22	-	Show illuminate, magnetite, Plagioclase feldspar, little pyroxene and Amphibole
12	(kbss2)	"	1.18	58	-	Show Zircon, Tourmaline, illuminate and magnetite
13	(kbss3)	"	150	41	7.5	Magnetite, illuminate, Plagioclase feldspar, Amphibole and little pyroxene
14	(kbss4)	"	150	87	12	Magnetite, illuminate, Plagioclase feldspar, Amphibole and little pyroxene
15	(kbss5)	"	150	51.5	12	Zircon, Tourmaline, illuminate and magnetite
16	Kbss6	"	150	24.5	9.5	Zircon, Tourmaline, illuminate and magnetite
17	(kbss7)	"	150	40.5	10	More Tourmaline, illuminate and magnetite

Illuminate are observed in kss1, kss2, kss3, kss4, kss7, kbss2, kbss3, kbss4, kbss5, kbss6 and kbss7 sample codes. The grains are characterized by subhedral form, angular to tabular and black in color and absence of cleavage. In study area, small grains of magnetite occur in almost all sample codes which includes kss1, kss2, kss3, kss4, kss5, kss7, kbss1, kbss2, kbss3, kbss4, kbss5, kbss6 and kbss7. It appears in black or brownish black color with a metallic luster and it has a Mohs hardness of 5 to 6 with black streak. The magnetite fractions are characterized by absence of cleavage subhedral form and grain are not tabular like ilmenite. Epidotic are observed in mss2, kss2, kss3 and kss4.Its characterized by its pistachio green color and one perfect cleavage, piemontite by its pink, rose color and cleavage. It forms under condition of regional metamorphism of the epidotic to amphibolites facies. It also forms during retrograde metamorphism and as reaction product of plagioclase, pyroxene and amphibolites. Spine fractions are characterized by its bow like shape, deep brown color fractures and present in only one sample in kss1. The heavy mineral fractions in study area are frequently found as a rounded grain in steam indicates a relatively long distance of transport as well relatively strong reworking and probably from metamorphic rocks.

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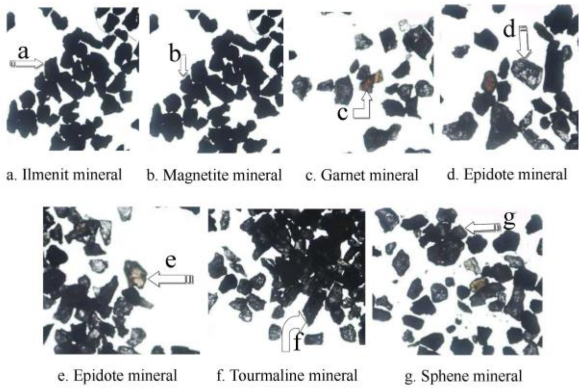

Fig: 5. Polarizing microscope photomicrographs (Mag. ×100) of selected heavy minerals identified in the sediments of the study area.

IV. CONCLUSIONS

The study area is located in E (316000-326000) - N (595000-599000) and characterized by its high grade of metamorphic rocks. The lithological maps represents study area belongs to basalt, dolerite, granite, amphibolites, gneisses and granulites. Structural data suggests that the area has experienced five phases of deformation. The complex structures in the study area are joints, veins, (pegmatite, quartz), fault, fold, dyke, shear zones. The dendritic drainage pattern of the study area also has good contributions for mineral transformation from one place to other place. From the microscopic inspection of the stream sediments samples showed that the heavy minerals included in the study area are zircon, Ilmenite, magnetite, garnet, epidote, tourmaline, and sphene. Heavy minerals are found in stream sediments in the study area but there is variation in quantity of distribution and which have specific gravity of >2.8 g/cc^3 presented as residual grains in sediments. The occurrences of heavy mineralization are associated with veins is observed in the study area. Most of the heavy minerals are angular to rounded shape in stream indicates a relatively not so long distance of transport as well relatively strong reworking and probably from metamorphic rocks. However detail investigation should be carried out to understand the genetic aspects, extent and economic viability of the mineralization in the study area.

REFERENCES

[1] Jelene, A. Mineral occurrences of Ethiopia.Ministry of Mines, Addis Ababa, 1966. 720p.

[2] Abraham, A., Hassen, N., Yemane, T., Genzebu, W., Seyid, G.,Mehari, K., Alemu, T., The geological evolution of the Proterozoic of southern Ethiopia, Abstract. In: 29th International Geological Congress 2, Kyoto, Japan, 1992,13p.

[3] Muller, L.D. Laboratory Methods of Mineral Separation. In: Zussman, J., Ed., Physical Methods in Determination Mineralogy, 2nd Edition, Academic Press, London, 1997, pp1-34.

[4] Jacobs Morton, A.C. and Hallsworth, C.R. Processes Controlling the Composition of Detrital Heavy Mineral Assemblages in Sandstones. Sedimentary Geology, 1999, 124, 3-29.

[5] Suresh Babu, D.S., Thomas, K.A., Mohan Das, P.S. and Damodaran, A.D., Alteration of ilmenite in the Manavalakurichi deposit, India. Clays and Clay Minerals,42, 1994, pp. 567–571.

[6] Vail J.R., Late Proterozoic tectonic terrain in the Arabian-Nubian shield and their characteristic mineralization. Geol J Winer Them Iss, 1987, 22: 161-174.

[7] Kazmin, V., The Precambrian of Ethiopia and some aspects of the geology of the Mozambique Belt.Geophysical Observatory Bulletin, vol. 1. Addis Ababa, Ethiopia, 1975, 14 p.

[8] Kazmin V. The geology of Ethiopia. Note No. 821-0610-12, Ethiopian Institute of Geological Surveys. 1972,. 208p.

[9] Davidson, A, Reconnaissance Geology and Geochemistry of parts of Ilubabor,kefa, Gemu Gofa and Sidamo Ethiopia. Addis Ababa, EIGS, 1983 Bulletin No. 2.