1. Introduction

Geological mapping of Metima subsheet (subsheet K of Yabello sheet)(NB37-14) was carried out by a group of geologists from the Regional Geology & Geochemistry Department (RGGD) from early Feb. 2000 to late Mar. 2000. It is part of the activities going on to map the entire map sheet (Yabello), which commenced in late 1998 and will extend to 2001. This work is mainly refers to the geological map covering approximately 750 km^2area (Metima subsheet).

1.1. Objectives and Scope of the Work

The primary objectives of the Geological Survey of Ethiopian are: -
-To conduct geological mapping activities and collect geological data in different part of the country;

-Search & locate different mineral resources (metallic, Industrial, construction etc.) and delineate promising areas for detail exploration;
-Carry out various research works, which are related to the earth science.

Based on the fore going objectives of the GSE, the Department of Regional Geology and Geochemistry had planned and commenced the mapping of Yabello map sheet since the late 1998 & continue to present. Therefore, the present work was mainly focused on collecting geological data on the area covered by the subsheet Metima, to supplement information for the compilation of the map sheet (NB37-14)

1.2. Geography

1.2.1. Location and Access

Metima area is located in southern low lands of Ethiopia, Oromiya Regional state, Borena Zone, Mega Wereda, at the central north part of Yabello map sheet (NB37-14). It is bounded by geographical coordinates of 4^0 30' - 4^0 45' N latitude & 38^0 15' - 38^0 30' 00"E longitude (Fig.1). The Addis Ababa - Awassa - Moyale asphalt national highway traverses near-by the Western Margin of the map area. Dry weather road, which links the two towns, Yabello and Arero, passes through the northeastern quarter of the sub-sheet K. Few trails of short distance which branch out from the main high way provides short access to the area. They can be used by four-wheel drive vehicle through difficulty even on dry seasons (Fig.2). The remaining part of the area is inaccessible by vehicle and only reached on foot. Footpaths connecting villages are common in the mapping area, which are very important in facilitating to get back to the campsite from the field traverses.

1.2.2. Physiography and Drainage

The map area has a topographic expression of elongated ridges trending northwest direction on its western part and low land plain with sporadic small ridges at the central portion on the eastern part. At present the area is sub divided in to four small physiographic parts. These are the area <1400m above mean sea level (the southeastern part), 1400-1600m above mean sea level (the eastern and some western parts of the area), 1600-1800m above mean sea level (the central part of the area), and> 1800m above mean sea level (small are at the north central part of the area). There is a remarkable elevation difference, the highest point being 1918m above mean sea level (on the top of Komora Har Digelu ridge), and the lowest is less than 1380m above mean sea level at Boji plain (southeastern corner of the area)(Fig. 2). Some of the ridges show abrupt topographic change forming vertical cliffs (e.g. Metima Guda ridge).

Several small creek and valleys (all dry) probably following the structural weak zones (faults and fractures) are common in the area. They drain the elevated western side of the area and flooded the eastern low land plain during heavy precipitation. They collectively flow to the south east of the area. There is no perennial stream in the area, however, the creeks and valleys form trellis drainage pattern.

1.2.3. Climate and Vegetation

Like most low lands of Ethiopia, this region is known to have hot and arid- semi arid climatic condition. The mean annual rainfall is relatively low. The region received low & moderate perception for two short periods with in a year. These rainy seasons are from February – April and mid September- mid November with low & moderate perception respectively.

The vegetation cover of the region at large is grassland over shaded by shrubs and thorny bushes, which sometimes hamper the field traverses. Burning of these bushes and sharps is practiced by nomadic people at some places for the purpose of free growing of the grass for their livestock grazing.

Land cultivation is relatively uncommon in the region, however small and limited farming is practiced to grow maize & sorghum at some localities where settlements are existing.

Draught and shortage of water extremely threaten the life of the people &n livestock population in the region. Drought is the major problem, which had been occurred at certain intervals of time for the last some decades. During the fieldwork, it has been observed that it has largely affected the region in a bad situation. It has been the cause for the death of more than 80% livestock population in the region due to the shortage of water and grazing grasses.

1.2.4. Population and Fauna

As compared to the high lands of Ethiopia, this region is sparsely populated by Borena and Gujji Oromo & Somali people; speaking their respective languages of Oromigna and Somaligna. Other ethnic minorities are also living in the region, particularly in the towns. The life of these people depends largely on the livestock breeding. Large number of cattle, camels & goats are known to exist in the region, under normal circumstances (good weather conditions).

In addition, diverse wild life such as birds wild goats, hyenas, leopard and other mammals are known to live in the region. At present their number seems considerably decreasing due to their migration to other places in search of food, water and shelter.

1.3. Previous work

Various professionals had carried out several geological studies in different parts of southern Ethiopia, in the past few decades. Detail geological studies have been carried out for about half a century in different parts of the region (Adola, Moyale,Hagere Mariam, Kenticha, Dawa Digati and other localities) for the purpose of gold and base metals exploration. Adola zone in particular has been extensively studied since the early fifties (Astrup 1948; Bixell 1948; Jelenc 1966 in Hussien 1999). More detailed integrated geological studies were conducted in the seventies by Gilboy (1970), Chater (1971), Kazmin (1971,1972a) and United Nation Development Program (UNDP 1972).

Based on field evidences and correlation with other belts in north and northeast Africa, Kazmin et al. (1978), de Wit and Chewaka (1981) and Warden and Horkel (1984) (all in Hussien 1999), suggested plate tectonic model for Precambrian of Ethiopia. Later, it is complemented with more advanced modifications on the basis of geochemical studies by recent works of Berhe (1988, 1990),Wodehaimanot (1995), Woldehaimanot and Behrmann (1995), Worku (1996), Worku and Schandlemeier (1996) (in Hussien 1999).

Several geologists of the Geological Surveys of Ethiopian (GSE) and others in the region have done geological studies and mapping also; particularly in Sololo, Hagere Mariam, Negele and Moyale map sheets.

Similarly, regional mapping is going on for the map sheet of Yabello (NB 37-14) since 1998 to present by Regional Geology and Geochemistry Department of the GSE for final compilation the entire map sheet. Therefore, geological mapping at a scale of 1:50,000 already covered more than 20 sub sheets and the accompanied reports are almost completed.

1.4. Methodology

Before deployment to the field, office preparation has been undertaken. This includes: aerial photographs interpretation, review of previous works in the region, requesting field equipment and materials from store & other preparatory works has been accomplished.

Using the topographic map of 1:50,000 scale and aerial photographs of approximately the same scale were used as base map to plot geological data during mapping. Photo geological interpretation was also done in the camp before taking the field traverses. The traverses were designed across the structures or regional foliations and the denser traverse lines and observation points were taken where the exposures of bedrocks are abundant (Fig.3). Representative rock samples were systematically collected for petrographic studies.

Thin sections study, data compilation and report writing have been done in the office.

2. Geology

2.1. Regional geology

Many researchers have done several studies at different times on the geology of East Africa and in particular southern Ethiopia, and tried to explain the geology of the region. The Precambrian in southern Ethiopia and northern Kenya occupy the central-eastern region of the East African Orogen (Hussien1999). The region corresponds to the area where the northern branch of the Mozambique Belt (MB) supposedly merges with Arabian-Nubian Shield (ANS). As explained by the same author, these Precambrian rocks in the region are bounded by Quaternary rift volcanics in the west and Mesozoic sediments in the east. These rocks consist of a wide variety of metasedimentary, metavolcanic and associated massive to foliated, felsic and mafic intrusives (Kazmin 1972; Hussien 1999).

Similarly, (Abreham 1996) explained that the Precambrian of southern Ethiopia consist mostly of high-grade gneisses, pelitic to Psamitic as well as mafic to felsic, and partly migmatized rocks. The metamorphic grade is mostly middle to upper amphibolite facies. Granulite facies rocks are restricted to an area of about 5000 sq. km southeast of Jinka. Various plutons intrude the gneisses (Abreham 1996).

The spatial distributions of rock types of the crystalline basement unit are controlled by structural framework of the region. Most of the structures had evolved from continental collision of the East African Orogen. However, there is no yet an exclusive tectonic model that accommodates the interpretation of various structural and geological relationships in different parts of the orogen (Hussien 1999). The convergence of continental blocks gave rise to crustal shortening that is accommodated along localized north-south trending strike-slip fault zones and resulted northward extrusion of the juvenile terranes (Bure and Sengor 1986; Bonavia and Chorovwicz 1992 in Hussien 1999). The associated uplift was accompanied by late- to post- collision magmatism, that is characterized high felsic intrusions consisting of biotite granite, hornblende biotite granite, and basic to intermediate enclaves and dykes (Kuster and Harms 1998 in Hussien 1999). The orogenic activity culminated with the formation of northwest trending strike-slip fault systems (Berhe 1990).

The Precambrian rocks in Ethiopia generally classified in to Lower, Middle and Upper Complexes (Kazmin 1972, 1972a, 1973), which were assigned to Archean, Middle and Upper Proterozoic ages respectively; mainly on the basis of correlation with other similar rocks in east and northeast Africa. However due to the discrepancies in the age of this previous stratigraphic nomenclature and the geological knowledge gained within the past two decades of mapping necessitates the revision of the geological map of Ethiopia (Tefera et al. 1996,1997 in Hussien 1999). In the recent map the use of the three complexes is abandoned.

The lower Precambrian litho tectonic unit in southern Ethiopia comprises a variety of high-grade gneisses that are represented by Yabello, Alghe and Awata groups (Tefera et al. 1997 in Hussien 1999), whose contact relationship was not certainly known (Kazmin 1975a,b).

The Yabello group is comprised of discontinuous layers of pale pink to light gray, massive quartz feldspar rocks, which locally merge into granitc gneiss (Kazmin 1972). In some places a well layered leucocratic orthogneisses with granulitic mineralogy (Tefera et al. 1997) and less deformed arkosic metasediments (Warden and Horkel 1994 in Hussien 1999) are found. The middle litho- tectonic units constitutes the Mormora and Wadera groups and mainly occur in the middle of the Adola area enveloping the narrow mafic-ultramafic belts of the Megado and Kenticha zones in the west and east, respectively (Hussien 1999).

The upper part of the Precambrian succession in southern Ethiopia consists of a lower unit comprising an association of metamorphosed mafic-ultramafic rocks metasediments and concordant felsic intrusives (Adola group) that are thought to represent a suite of opholitic rocks (Kazmin 1976; Kazmin et al. 1978; de Wit and Chewaka 1981 in Hussien 1999). In the Adola area the ophiolitic suites at places is unconformably succeeded by a sequence of metagraywacke and polymictic metaconglomerate (Kajmiti beds) (Kazmin 1972a, 1973; Kozyrev et al. 1985) representing the youngest Precambrian unit in the region.

Granitoids ranging in composition from intermediate to felsic are wide spread in the Precambrian of southern Ethiopia (Hussien 1999).

In summary, the southern Ethiopian region is known mainly underlain by crystalline basement rocks of different deformational styles and metamorphic grades, and locally covered by younger volcanic rocks & clastic sediments. Several intrusive bodies are also very common in the region. The outcrops of the bedrock are scarce at low lands and where the younger formations are widely covered. Most of the ridges and outcrop patterns are seen mainly following the trends of regional structures.

2.2. Local geology

Since Matima area (sub sheet K) is situated at the central portion of the Yabello map sheet area (NB37-14) the geology is much similarity to the regional geology. It comprises deformed crystalline basement rocks and Quaternary alluvium and elluvium soil or recent clastic sediments. These crystalline basement rocks vary in lithological characteristics, degree of deformation, geographical position and area coverage from one another. The field relation, degree of deformation and mineralogical composition of each map unit in the area will explain in the successive sections.

3. Lithology

3.1. Introduction

The lithologies of the study area are subdivided into three crystalline basement map units and two Quaternary soil types (Fig.4). According to lithostratigraphic order from older to younger they are:

1. Sillimanite Bearing Quartz-Feldspar Gneiss (Pqfgn)
2. Banded Magnetite bearing Hornblende- Biotite Gneiss (Phbgn)
3. Foliated Granite (Pgt)
4. Alluvial soil (Qa)
5. Elluvial soil (Qe)

Except at few localities (where the foliation of the rocks is weak and the degree of weathering is high), the outcrop patterns follow the structural trends of the area. These structural trends are mainly oriented northwest- southeast and northeast- southwest directions. The ridges are seen following similar direction too. However, foliations with different trends were recorded at some localities. Most of the ridges are elongated and oriented northwest-southeast direction.

3.2. Sillimanite bearing quartz- feldspar gneiss (Pqfgn)

The unit Pqfgn is located at the northwestern corner of the study area. It covers about 9% of the total mapped area. The quartz - feldspar gneiss forms ridges with a trend of NW-SE. This unit consists of Quartz-feldspar gneiss (60%), Quartzite (25%) and Biotite gneiss (25%). Generally the rocks of this unit are medium grained, well foliated and occur intercalated with each other.

The quartz- feldspar gneiss is mainly exposed at the eastern part of the unit Pqfgn and become coarser in texture near Pgt. It is pinkish gray, medium grained and well foliated. Due to its resistance to weathering, this rock is ridge forming as compared to biotite gneiss. The quartz-feldspar gneiss is composed of 50% quartz, 45% alkali feldspars (mainly microcline), 3% opaque minerals, 1%plagioclase, 1% biotite in average and traces of pyroxene and calcite. The composition of the rock is highly changed by granitization and silicification. The silicification is high at the top part of the rock. It is composed of 5% sillimanite minerals on its weathered part.

The quartzite is exposed at the western part of the unit Pqfgn. It is light yellowish gray, medium grained and foliated. This rock is composed of 65% quartz, 22% sillimanite, 10% feldspar 3% muscovite in average. Traces of Biotite are also seen as laminar fracture filling. Several fibrolitic crystals of sillimanite show undulating preferred orientation is the typical nature of sillimanite rich part. This is also clearly observed on the hand specimens of the rock.

At places the sillimanite comprises more than 50% of the total volume of the rock and becomes very coarser. At Meleko ridge the average size of sillimanite is 10 by 15 centimeters. Sillimanite to mica alteration is common.

The biotite gneiss occurs intercalating with quartz feldspar gneiss and the abundance increases at the west. The thickness of the biotite rich layer varies from 0.5 meter to 30 meters. The mineralogical composition of the rock cannot be determined due to the scarcity of the fresh samples.

Concordant and discordant pegmatite and quartz veins are observed intruded the unit Pqfgn. The proportions of the pegmatite veins are more than the quartz veins and the former has a width of 5centimeters to 1 meter. Some of these veins are strongly deformed forming small-scale asymmetric S & Z- folds (southern tip of Hochu ridge). Similarly in the sillimanite bearing part, thin quartz veins were deformed showing a series of elongated m-folds.

The trend of the foliation of the unit Pqfgn changes at some localities from NW to NE dipping to the SW, W and NW directions.

3.3. Banded magnetite bearing hornblende- biotite gneiss (Phbgn)

The unit Phbgn is mainly exposed at the central western part of the study area with the outcrop pattern trending NW-SE direction, forming ridges. It covers about 20% of the total area. The unit Phbgn consists of magnetite bearing biotite granitic gneiss, which estimated up to (85%), and hornblende- biotite gneiss of about (15%). The later form layers of different thickness and intercalate the former at different positions and places. The difference between the two is not only mineralogical composition, but also they differ in degree of weathering.

The magnetite bearing biotite granitic gneiss has gray to pinkish gray color in fresh and dull white to light gray and sometimes reddish brown weathered color. It is medium to course grained, banded, well foliated and locally silicified (ridges top). Several deformed and undeformed pegmatite and quartz veins ranging in thickness from fee centimeters to more than a meter were intruded concordant and discordant to the foliation. Banding rich in dark minerals are observed bounding some of the pegmatite veins.

The rock of this sub unit is moderately weathered and the biotite rich part is more affected by weathering. Therefore samples were not at this part of the rock. As the samples taken relatively from fresh part indicate that the rock is composed of alkali feldspars, quartz, plagioclase, biotite (most of it altered) and opaque minerals in different proportion as major constituents. Minor amount of epidote and garnet are also present in some of the samples. Hence, the mineralogical composition of the rock is alkali feldspars (mainly microcline) 48%, quartz 31%, plagioclase 12%, altered mafic minerals 5% and opaque minerals 2% in average. Minor and trace amount of epidote and garnet are existing in some of the samples.

Sericitization is the major alteration observed in most of the thin sections. Rounded and spherical shape small crystals of quartz re-crystallizing in feldspars and plagioclase minerals also are common.

Hornblende- biotite gneiss occurs in the unit Phbgn as intercalation ranging in thickness from less than a meter to several meters. It is more observed at the central part of the unit. The hornblende biotite gneiss is coarse grained, dark gray tone, having pegmatoidal nature, banded and well foliated. The texture of this rock changed to fine and medium grained at the central part of the unit (Kete ridge). It also locally silicified. It is observed more affected by weathering than the hosing rock (magnetite bearing biotite granitic

gneiss), and greenish thin layer at the contact between the two (Kompo ridge). Biotite is also observed altered to epidote at the top of the same ridge.
The medium grained part of the hornblende-biotite gneiss, (at the central part of Kete ridge) is composed of quartz 55%, plagioclase 18%, alkali feldspars 15%, hornblende 6%, biotite 2% and opaque minerals about 2%. It has granular microscopic texture. Some plagioclase crystals are observed replaced by alkali feldspars. Recrystallized smaller crystals of quartz with rounded and spherical shape are common in the plagioclase and feldspars.
The foliation of the unit Phbgn mainly trends NE-SE with the dip angles mostly less than 45°. The foliations are also having sinusoidal nature (swing to the NE-SE), with out changing the major trend. The strong gneissocity of the unit however, is not well defined in the thin sections.
Pinch and swell structure is observed at places with the foliation.
The deformed quartz and pegmatite veins show folds of S-type and Z-type at different localities. Disharmonic types of folds of the pegmatite veins are more common in medium grained part of the unit at the central part of the area (Kete Ridge).

3.4. Foliated granite (Pgt)

The deformed granite of pinkish and light pinkish color and very coarse grained occupies most part of the area. About 20 percent of the study area is covered by the unit Pgt. Most of the contacts are inferred due to the soil cover. It forms discontinuous or scattered outcrops which are encircled by sandy elluvial soils with no specific outcrop patterns (trends) like the other units, however, it shows foliations trending to different directions with some of them oriented parallel to the foliation of the other rock units. The dip angles of the foliation of this unit are variable and commonly more than 45°. The weakly foliated part of the Pgt is vertically dipping at places and the direction of the dip is obscure. The outcrops this part is massive and forms jointed blocks standing vertically. Concordant and discordant pegmatite & quartz veins of different magnitudes are observed intruding the granite through out the outcrops.

Minerals such as feldspars & quartz are the major constituents as observed in hand specimens, which are more or less having similar proportion. Magnetite & biotite are also present as minor components. Most of these minerals are coarse-very coarse grained.

The high weathering degree disintegrated the Pgt to very coarse sandy soil in many parts of the study area and the cause for its alteration to limonitized massive weak rock type at the north central & south parts (Komora Har Digelu & south of Kompo ridge) Petrographic studies of the thin sections indicate that the foliated granite is composed of Alkali Feldspars (mainly microcline) 45%; Quartz 40%; Plagioclase 10%; Opaque minerals 3%; Biotite, (most of it confusing due to alteration) 2%; and Garnet and Sphene as accessory minerals in some thin sections. The inter- growth of feldspars and Quartzes are observed in most of the thin sections forming graphic texture. Similarly, Feldspars and Plagioclase are seen inter growing in some thin sections. Sericitization is the common alteration of the foliated granite observed in the thin sections.

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3.5. Alluvial soil (Qa)

The alluvial soil exposed at the lower topographies, along the courses of creaks & flood plains of the area. Most parts of the northeast & some parts of the south east of the studied area are covered by alluvium. It covers about 15-17 percent of the total area. The outcrop pattern is irregular following the courses of creeks & morphology of the low land. It has more or less defined boundaries (contacts) with sandy soil in most parts. However, the boundaries are clearly differentiated by observation of the aerial photos, which show black & smooth photographic tone & texture. The alluvial soil of the area has gray-dark gray color and it is composed of the grains ranging form clay size-medium sand.

3.6. Elluvial soil (Qe)

Most part of the study area (the majority of eastern half & south western portion of the sub sheet (Metima) is covered by elluvial soil. By area, the sandy soil is estimated to cover about 35 percent of the total. It occupies the lower topographies next to the alluvium. It is observed also follow more or less similar patterns like alluvium, (the low lying topographies of the area). The elluvial soil consists of grains ranging from fine sand to very coarse sand. Locally it is concentrated by magnetite mineral which disintegrated from the near by bedrock. At the southern part and north central parts of the area, the elluvial soil is observed exposing in close associated with calcrite and silcrite formations and also mapped together. Most part of elluvial soil has light pinkish or light brownish color but, the calcrite or silcrite have dull white (buff) color. The calcrite or silcrite partly form loosely consolidated irregular fragments scattered on the surface as floats and expected to continue to the depth. Local people are seen to dig shallow depth water wells where this formation is well exposed.

4. Structure

The crystalline basement rocks of the southern Ethiopia display different structural styles in different parts of the region. The regional structural trends of the gneissic rocks are NNW, NNE and N-S. The foliation usually dips rather gently to the west (25-30 °), Kazmin (1970). On the other hand, it has been mentioned by Hussien (1999) about the existence of different structural styles across the Precambrian rocks in the region, however, the most prominent one is NW-SE oriented.

Concerning the local condition, the structural trend of the Metima area is observed showing similar orientation with the regional one. Hence, structures (possibly faults, which are traced from the aerial photographs) and the foliations are seen mainly oriented to the NW-SE direction (Fig. 5). Most of the ridges are also seen following similar trend. Locally it has been observed the orientation of the foliation changes its direction to the NE- SE, at the southeast and northwest parts of the area. In addition the foliations are observed swinging locally with out changing the major orientation direction. However, the dip angles of the foliations vary 25°- 55° towards southwest and west directions. Other structures such as small-scale asymmetric folds of S, Z and M shapes, swell and pinch of the quartz and pegmatite veins, oscillatory gneissic bandings are encountered in different parts the area. Fractures oriented parallel and discordant to the foliation and joints of different magnitudes are also observed in the area.

4.1 Phases of deformation

For high-grade metamorphic rocks it is virtually difficult to distinguish and put the sequences of deformation and steps of metamorphism the rocks have experienced. Therefore, in the study area (Metima), the phases of deformation are explained based on the previous regional geological history and the limited observation of structural features in the field. From regional geological studies made so far several authors agree that the basement rocks of southern Ethiopia had undergone poly phases of deformations and metamorphism. From present field study, three phases of deformations are explained from the observation of small and large-scale structures and their spatial outcrop patterns.

4.1.1. The first phase of deformation (D1*)*

The early phases of deformations are usually poorly recognized due to the superimposition of successive later deformations. The first phase of deformation is probably recognized from some relicts of the layers of Sillimanite bearing Quartzo-Feldspathic Gneiss (Pqfgn), which forms small-scale asymmetric series of M-shape folds remain on blocks of this rock (Hochu Guda ridge). The folding of these early layers might have occurred in the later stage of deformation. Other possible evidence of this event is the horizontal lying of pebble size crystals of sillimanite mineral (reaching 7 centimeters long and 2 centimeters width), which is observed at the northwest part of the area (Meleko ridge). Other evidences which possibly representing this deformational event are unlike to be easily identified.

4.1.2. The second phase of deformation (D2)

The second phase of deformation may be represented by the presence of small-scale asymmetric folds of M, S and Z- shapes, observed at the west side of the area (southern part of Hochu and northern part of Kete ridges). Regional foliation of most of the rocks with the major trends of NNW-SSE and dipping to the SSW, W and NNW directions is assumed to have been occurred during the second phase of deformation (Fig.5). It is also thought that the deformation of pegmatite and quartz veins in the unit Pqfgn and Phbgn and the pinch and swell structure are the result of the second phase of deformation. However the emplacement time of these veins is not clear whether they were pre or syn this event.

4.1.3. The third phase of deformation (D3)

The third phase of deformation is probably understood by presence of both ductile and brittle deformations. The emplacement of large intrusive body (granite) and its foliation with other units of the area to major trends of NE and N, and dipping to different directions as well as sinusoidal nature of the early formed foliations are thought to be the results of ductile deformational events of this stage. Lineaments (faults and fractures) and joints represent brittle deformational event of this stage.

The spatial distribution of the crystalline basement rock units in the area is probably took place during this event. However, the emplacement of undeformed concordant and discordant pegmatite and quartz veins might be occurred syn to post third phase of deformation.

5. Metamorphisim

The metamorphic condition of the rocks in the study area may relate to the regional metamorphic history. Since the present work is lacking the detail studies on the successive stages of metamorphic evolution on the rocks of the area, it is only attempted to roughly estimate the metamorphic grade based on the review of previous works in the region and comparing the mineralogical assemblage of the rocks. The mineral paragenesis together with the structural grains of the rocks of gneissic terran indicates a prevalent dynamothermal metamorphism (Yihune and Tesfaye 1998), in the region. Similarly, Abreham (1996) mentioned that the Precambrian rocks of southern Ethiopia consist mainly high-grade gneiss, pelitic-psammitic as well as mafic to felsic and partly migmatized, with metamorphic grade of middle to upper amphibolite facies. It is also mentioned by various authors that the presence of low-grade belts (at Adola, south of Negele, and Moyale areas) in the region.

In the Metima area the rocks have the following mineralogical assemblages:

Quartz + K-Feldspars + Plagioclase + Hornblende + Biotite + Opaque minerals + Sillimanite ± Muscovite ± Epidote

Quartz + K-Feldspars + Plagioclase + Hornblende + Biotite + Opaque minerals ± Garnet ± Sphene

These mineralogical assemblages indicate that the rocks of the area fall in the range of lower - upper amphibolite's field of metamorphism. In another case, the presence of low pressure and temperature minerals; and the frequent alteration of the rocks in the area may also reveal the imprints of retrograde metamorphism.

6. Discussion and conclusion

The geological history of the crystalline basement rocks of the southern Ethiopia can be attempted in the framework of the geodynamic evolution of the northeast African crust. The Horn of Africa represents a zone of intersection of two orogenic Belts namely, the Mozambique; which had suffered poly deformation and metamorphic events and the juvenile Arabian-Nubian Shield (Kazmin 1975; Veil et al. 1986 in Alene and Barker 1992; Abdul Salam and Stern 1996; Worku 1996 in Hussien 1996). These two Belts together form Neoproterozoic east African Orogen (Hussien 1999). Many researchers who have done researches in different parts of southern Ethiopia agreed that poly deformational events and metamorphism had resulted in the structural complexity of the region, which makes stratigraphic sequences among map units less definite (Yihune and Tesfaye 1998). However, working classification scheme have been proposed by different researchers (Gilboy 1970; Chater 1971, Kazmin 1972; Kozyreve et al. 1985; Mengesha et al. 1996 in Yihune and Tesfaye 1998) to classify the rocks in the region in their plausible stratigraphic order.

Metima area of the Yabello map sheet (NB37-14) comprises deformed and metamorposed Quartzo- feldspathic gneiss (Pqfgn), Banded Magnetite bearing Hornblende- Biotite gneiss (Phbgn) and Foliated Granite (Pgt). Based on the field geological evidences, the Sillimanite bearing Quartzo- feldspathic gneiss is assumed to be the oldest rock unit in the study area. From its lithological characteristics, the protolith of this unit seems sedimentary in origin. It might be the result of metamorphism and deformation of continental clastic sediments (sandstone).

The second older rocks of the area assumed to be the Banded magnetite bearing hornblende- biotite gneiss. The original parent rocks of these units were thought to be igneous in origin. The assumption is based on the observation of the intensity of deformation the rocks in the unit, their field relation and their textural nature. However, to be sure, further study and correlation to other similar unit in the region will strengthen the assumption.

From the entire crystalline basement rock units of the area, the younger one is assumed to be the foliated granite. Although it is deformed and foliated, its lithological characteristics, intensity of deformation and its field relationship with the other rocks in the area draw the conclusion that the rock is relatively younger in age. Its deformation and foliation is thought to be the result of later tectonic events in the region.
There is no age dating data exactly on the rocks of the study area. However, according to the age dating done on Yabello Gneiss (Tekly M. et al 1998) a mean age of 716± 1.2 Ma is recorded. Since the rock unit of the study area particularly the units Pqfgn and Phbgn have some similarities in lithological characteristics with the Yabello Gneissic unit (Kazmin 1970), they may have also comparable age range.
The detail geological history of the rocks in the area (phases of deformation, metamorphic history and their paragenesis), is expected to be more clarified during the compilation of the whole map sheet in the future, with the interpretation of the geological data of the adjoining areas.

7. Economic geology

Due the course of mapping it has been focused in looking for economically important metallic and industrial mineral occurrences as well as construction materials within the study area. So far, there is no encouraging finding of useful mineral occurrence in the study area. With the present field investigation, it has been encountered only magnetite minerals disseminated within banded biotite hornblende gneiss. The concentration of this magnetite within the host rock varies locally. The sandy soil lying in the valleys, near by this bedrock also some magnetite. The percentage or concentration of this mineral is yet not determined by analysis, however in the hand specimens and thin-sections it estimated to be 5--10%. From field observation it seems that the concentration is increasing at the central part of the hosting rock outcrops. The crystals size of the magnetite ranges from a millimeter to 5 centimeters and sometimes more.

Concerning non-metallic or industrial minerals, the presence of large blocks and fragments of feldspar crystals within granite (the one which is very coarse grained or pegmatoidal granite) draw attention in the field. However, since they are very localized and scattered, it may not be economically worthy.

On the other hand, construction materials are widely available in the area. The fresh rocks with more granitic composition and the sand may consider as good example of the construction materials.

In general due to the scarcity of valuable minerals, no mining activities have been practiced in the study area except very that the existence small local quarry of the foliated granitic rock for the purpose of using as foundation filling of school building.

7.1. Alteration

All the rock types identified in the Metima area have shown different degrees of alteration. The intensity of alteration of each rock considerably varies from place to place and ranging from slight to high degree of alteration. Beside the physical disintegration, limonitization,

Silicification and sericitization are the most common types of alteration distinguished in the field and petrographic study of the thin sections.

Limonitization in particular, totally changed the bedrock to unknown depth to yellowish brown masses of weak rock, which is confusing with mud supported conglomeratic sandstone. The outcrops of such type are observed at the central north and south parts of the area. It has been observed that the outcrop of this rock has close field relation with the calcrite or silcrite formation.

Silicification is seen more significant on the sillimanite bearing quartz- feldspar rock, on the outcrops lying at the top of the ridges.

Sericitization is also the common alteration observed in most thin sections of the rocks in the study area.

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