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Untapped Mineral Potential of Somaliland: A review

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Abstract:- This comprehensive study explores the untapped mineral potential of Somaliland, a region rich in geological diversity and significant mineral deposits. By examining the intricate geology of Somaliland, including its ancient Precambrian basement and younger sedimentary sequences, the research uncovers valuable insights into the region's mineral wealth. Extensive exploration activities reveal substantial reserves of base metals, precious metals, industrial minerals, and gemstones, highlighting the region's promise for future mining endeavors. The findings underscore the strategic importance of Somaliland's mineral resources, offering a roadmap for sustainable development and economic growth through enhanced geological surveys, infrastructure investment, and robust regulatory frameworks. This article serves as a vital resource for geologists, investors, and policymakers interested in unlocking the mineral wealth of Somaliland and fostering regional development.

Keywords:- *Mineral, Potential, Base Metals, Somaliland.*

I. INTRODUCTION

Somaliland is located on the northern side of the Horn of Africa, bordering the Gulf of Aden to the north, Somalia to the east, Ethiopia to the south and west, and Djibouti to the northwest. The country's morphology is characteristic of extensional zones, with basins and mountains reaching elevations of up to 2000 meters [1].

A. Geology of Somaliland

BRITIS Somaliland is made up of a high plateau, with the northern scarp separated from the Gulf of Aden by a belt of low hills and plains known as the Guban. The southern plateau is made up of a massive block of Archean rocks, mostly gneiss and amphibolites, with intrusive pegmatite dykes, purple grits, red sandstones, and conglomerates. The coastal strip's rugged peaks are outliers of the Arehman plateau; nonetheless, the fundamental geological interest of this location stems from the existence of a limestone series. The limestones were clearly associated with more than one period from the beginning of records. [2].

The country's morphology is typical of extended expanses, with basins and mountains reaching elevations of up to 2000 meters. There is little folding, but a lot of regular faulting, some with quite long throws. Since the Lower Jurassic, these powerful vertical movements have dominated the available accommodation area for sediment deposition [3].

The Northern Somali Mountainous area (Fig. 1) occupies the southern wing of the Yemen-Aden Arch and is the eastern branch of the East African Orogen (Kröner 1984; Stern 1994; Meert 2003).

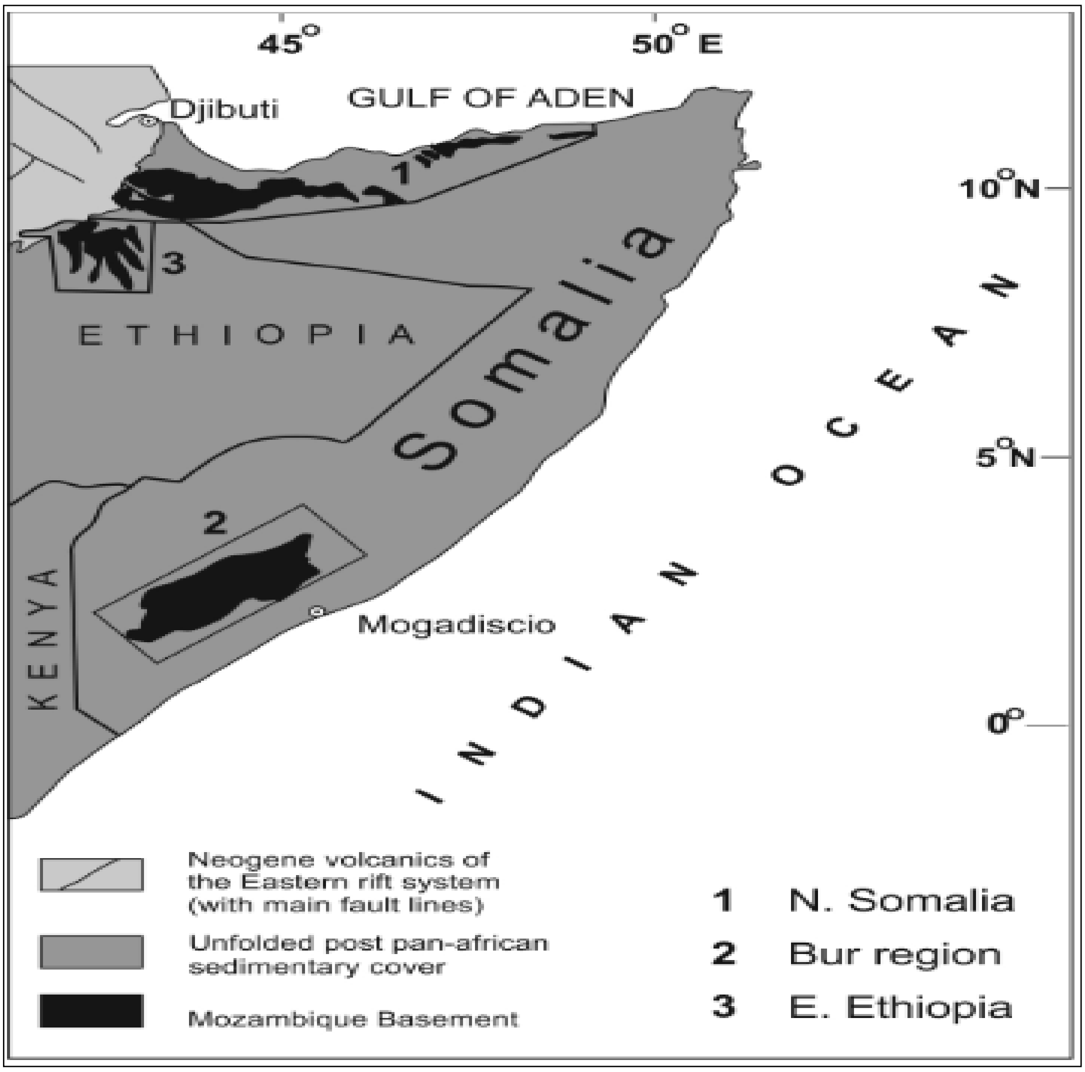

Fig 1. Geological Locality Sketch of Somaliland Main Basement Exposures (Kröner 1984; Stern)

Mesozoic and Tertiary continental-margin and marine sedimentary rocks, which were deposited unconformably over Precambrian metamorphic and igneous rocks, form the majority of the country's subsurface.

It is a massive swelling of the Earth's crust that reveals the results of Precambrian sedimentation, metamorphism, and extended magmatism.

This region is home to the majority of metallic mineralisation occurrences, as well as the majority of reconnaissance and prospecting operations (British Geological Survey reports and maps in 1:125 000 scale, 1952-1962; UNDP projects, 1962-1974).

The Precambrian Basement (Daniels 1965; Warden & Daniels 1972; Merla et al. 1973; D'Amico et al. 1981; Warden & Hörkel 1984; Dal Piaz & Sassi 1986; Kröner et al. 1989; Sassi et al. 1993; Kröner & Sassi, 1996; Kuski et al. 2003) was brought to the current erosion surface by uplifting, which was complicated by various tectonic movements [4].

The northern mountains' Precambrian rocks are classified into four units: (1) gneissic complex, (2) the Inda ad series, (3) mafic intrusive rocks, and (4) granite to tonalite.5].

B. *Gneissic Complex*

According to Osman and others (1976), the gneissic complex consists of a thick basal series of gneiss and schist, an overlying sequence of amphibolite and subordinate marble and quartzite, and an upper sequence of greenschist-facies greywacke, shale, and volcanic rocks.

C. *Inda Ad Series*

The Inda Ad Series appears in a small east-northeast trending anticline north and northeast of Erigavo. Greywacke, siltstone, and variegated shale are interbedded within the unit, while subordinate quartzite and marble strata extend down to a depth of 170 meters. Though it appears to advance from lowermost pebble greywacke to a graded graywacke-shale unit, then to siltstone and shale, and finally back to pebble greywacke, this unit is characterised by rapid lateral and vertical facies changes (Greenwood, 1960; Mason and Warden, 1956).

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D. Mafic Igneous Rocks

Mafic igneous rocks include gabbro, metagabbro, and diorite with small amounts of supplementary minerals. Dark grey, medium- to coarse-grained gabbro and metagrabbro rocks form as spherical boulders in grus. Some mapped plutons are layered. In Moro Tug (lat 10"10' N.; long 44"44' E. rhythmically layered gabbro is described by Mason (1962).

E. Granite

The granite unit consists of lower Paleozoic and Precambrian granites and quartz diorites from Merla and others (1973), as well as massive to foliated granitoid rocks as shown on easily accessible geologic maps at a 1:125,000 scale.

Monzogranite and medium- to coarse-grained granodiorite make up the majority of the unit. When compared to hornblende, biotite often performs better or is the only mafic mineral.The history of geology is extraordinarily lengthy, even by geological standards. While basaltic flows erupted within the last 30 million years with the entrance of the Gulf of Aden, the oldest rocks date back more than 1800 million years (Kroner et al., 1989). The opals mined in northwest Somalia may have originated from unusual rhyolite layers included within these basalts.

Gem minerals are absent from the vast sedimentary sequence accumulated over the previous 200 million years in the Mesozoic and Cenozoic eras [6].

Parallel to the Gulf of Aden and encompassing an area of roughly 30,000 km2, Somaliland's crystalline basement rises to the surface as an irregular ribbon that is about 600 km long and 30 km wide (Figure 1). In the west, it is composed of an older Precambrian crust that has undergone several geological processes, as well as a less complex Pan-African landscape that originated between 700 and 500 Ma in a single geological epoch in the east. For these rocks, the entire area provides extremely accurate dates (Kroner and Sassi, 1996).

Two distinct episodes of igneous activity disrupt five metasedimentary sequences that make up the basement. Age ages for individual zircons on samples from the Hargeisa-Sheik-Burao

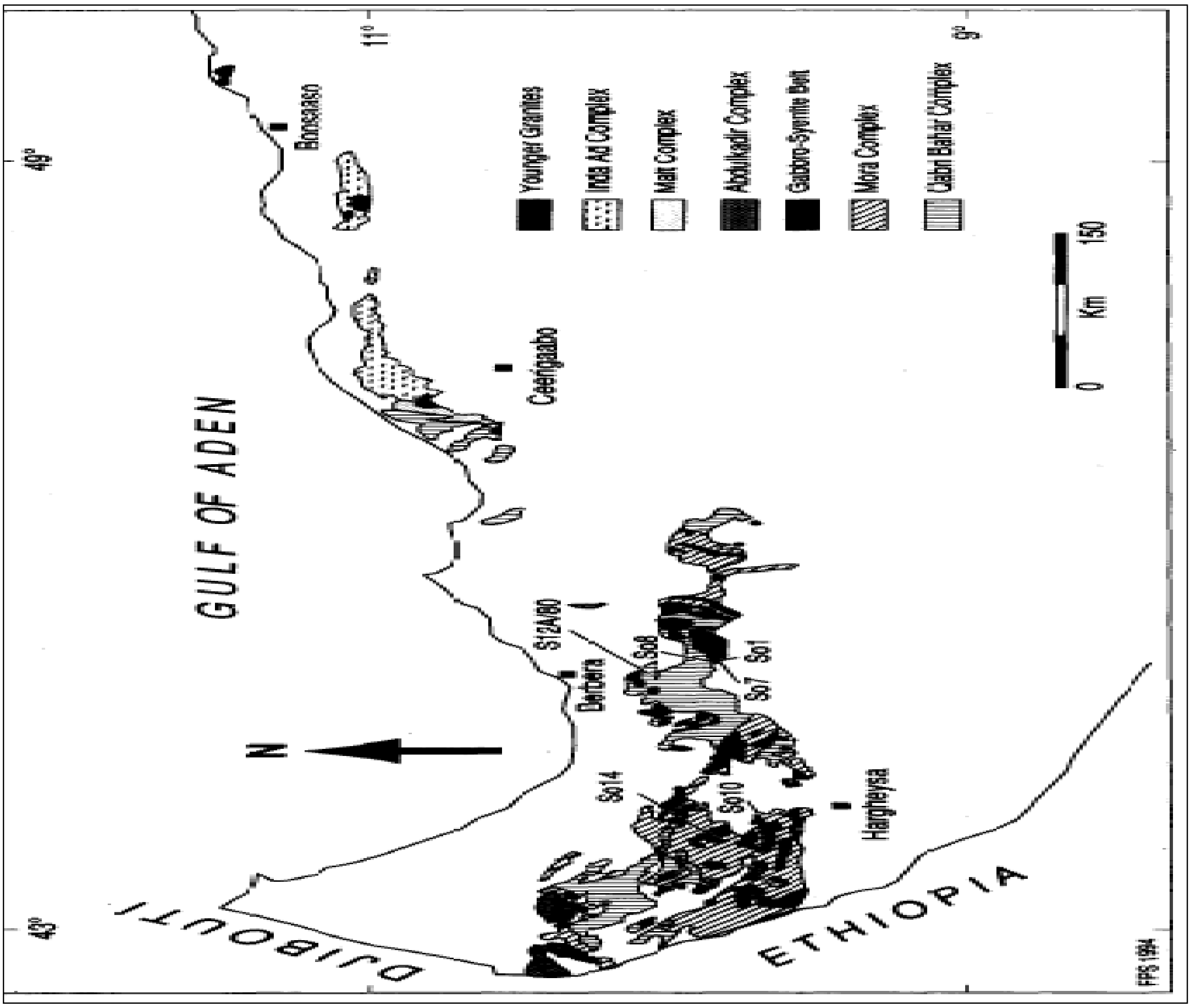

Fig 2. Geological Sketch Map of the Northern Somali Crystalline Basement (Based on the Geological Map of Somalia [8].

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The 600 kilometres of Proterozoic metamorphic and magmatic rocks that make up the crystalline basement of northern Somalia extend from the Ethiopian border to Heis (D'Amico et al., 1981; Warden and Daniels, 1984; Abbate et al., 1985; Ferrara et al., 1987; Dal Piaz and Sassi, 1988). This region is regarded as the northern branch of the Mozambique belt (Warden and Horkel, 1984). The crystalline basement is covered by Quaternary and Mesozoic sedimentary and volcanic stages.

Polymetamorphic paragneisses with amphibolite lenses, orthogneisses, and migmatites make up the basement. Polyphase folding and shear zones, which are most likely connected to the continental collision that the Adola suture zone in Ethiopia revealed, characterise the structural environment of the basement (Warden and Horkel, 1984). With a Rb-Sr isochron age of 828 Ma, the oldest rock in the basement is a sillimanite kyanite containing paragneiss (Dal Piaz et al. 1985).

Large magmatic bodies of homogeneous to layered gabbros (one of which is the Sheikh gabbro) in- truded the polymetamorphic basement at about 700 Ma (Ferrara et al., 1987), along with minor intrusions of monzonite, Ferich diorite and syenite. Subsequently, the basement underwent further deformation and metamorphism of greens&i&-amphibolite facies, which locally affected the gabbros. Between 550 and 470 Ma (the Pan-African event), numerous bodies of granite and pegmatite were emplaced in the basement [7].

According to Sassi et al. (1989), the NSB is made up of seven major complexes, the approximate position and exposed extent of which are depicted in Figure 1. Five of these complexes are primarily metasedimentary phases, with two consisting of igneous intrusive suites. The metasedimentary complexes are: i) the Qabri Bahar complex; ii) the Mora complex; iii) the Abdulkadir complex; iv) the Mait complex; and v) the Inda Ad complex. The first four also contain igneous protoliths..

The first two complexes form northern Somalia's medium to high grade polymetamolrphic basement. Greenschist-facies and volcano-sedimentary phases make up the Abdulkadir and Mait complexes, which are exposed in the western and central parts of the NSB, respectively. The Inda Ad complex is a low- to extremely low-grade metasedimentary series found in the easternmost portion of the NSB [8].

There have been many rifting events in northern Somalia that date back to the Late Jurassic Period. During the Calovian and Early Oxfordian periods, seafloor spreading between Madagascar, the Seychelles, and India started in the Jurassic Magnetic Zone (Bosellini, 1986, 1989; Coffin & Rabinowitz, 1987). As a result, several rift basins with a NW–SE trend emerged in the Late Jurassic. The earliest magnetic anomaly found in the Somali basin, M0-M10, suggests that seafloor expansion ceased in the Early Cretaceous [9].

II. MATERIAL AND METHODS

Search engines used for this study included Worldwide Science, Microsoft Academic, ASCI, SCOPUS, Google Books, BASE, CORE, ScienceDirect, Science.gov, Elsevier/ScienceDirect, BIOBASE, Google Scholar, GEOBASE, Semantic Scholar, SAGE, and the Google browser. Of these, 21 articles were chosen for this study based on their title and abstract. Ten articles were retrieved from the search, which followed a well-defined strategy. For the Google search engine, the keywords were "mineral potential" and "Somaliland."

The literature was carefully chosen and examined for this investigation. As much as possible, papers that appeared in predatory journals were rejected. To make sure they were pertinent to the purpose of the study, the abstracts and titles of the chosen items were carefully examined. After then, the chosen materials' content was assessed to make sure the sources used in this investigation were accurate, pertinent, and contributed to the body of knowledge.

III. RESULTS AND DISCUSIONS

F. Mineral Potentials

Mineral exploration was done by the British. The former British Protectorate of Somaliland is governed by the Compagnia Mlneraria Etispica (COMINA). Precambrian rocks of most of the northern ranges have been mapped at a 1:125,000 scale. They offer concise overviews of a wide range of mineral prospects and occurrences in their reports. A U.S. Technical Assistance Mission assessed the region's mineral potential in the former Italian Somaliland after World War II (Holmes, 1954). Following independence, the U.N.D.P. assessed the nation's mineral resources nationwide (U.N.D.P., 1970).

G. Base Metals

A wide range of mineral resources are available in Somaliland, including as precious stones (emerald and agate), industrial minerals (gypsum and celestite), basic metals, chromium, and cobalt. It is anticipated that Somaliland has enormous hydrocarbon resources, and enormous coal resources—estimated to be 6 billion tons—occur close to Berbera (Ali, 2009).

The ministry conducted mineral exploration for 2373 sq. km of total prospective regions between 2020 and 2022, which is equal to 6% of the 30,000 sq. km total basement areas. Information about mineral exploration projects completed in the Marodijeex, Awdal, Sanaag, and Sahil regions between 2020 and 2022 [1].

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Table 1. The Total Potential (Basement Areas) for Minerals is 30,000 sq. km(MoEm, 2022)

Zone	Region	Area (km2)	Target Minerals
Abdiqadir	Salal	896	Base-Metals and Gold
Dhagah-kurreh	Gabiley	160	Base-Metals and Gold
Damaan	Sahil	120	Gypsum and Limestone
Laalays	Sahil	309	Heavy Mineral Sand and Gold
Laasa-Surad	Sanaag	288	Base-Metals and Gold
Total Area Explored		**1773/2373**	**6% of Total Potential**

Table 2. The Table below shows Categories of Main Potential Minerals in Somaliland.

Metallic	Gemstone
Iron ore, Manganese, Copper, Lead, Nickel, Zinc and Gold- bearing veins, Tantalite-Columbite and huge deposits of HMS; containing ilmenite, rutile, zircon titanite, and titaniferous magnetite	Amethyst, Tourmaline, Aquamarine, Emerald, Garnet, Jade-Nephrite, Ruby, and Sapphire

In 1975, the Somali Mineral and Groundwater Survey conducted a reconnaissance geochemical survey of areas of northern Somalia with the assistance of a United Nations Development Programme mission. The reconnaissance study included stream-sediment sampling over an area of approximately 20,000 km, with an average sample density of around one sample per 2 km. Atomic absorption methods were used to analyse the samples for Pb, Zn, Cu, Ni, Cr, Mn, and Li [5].

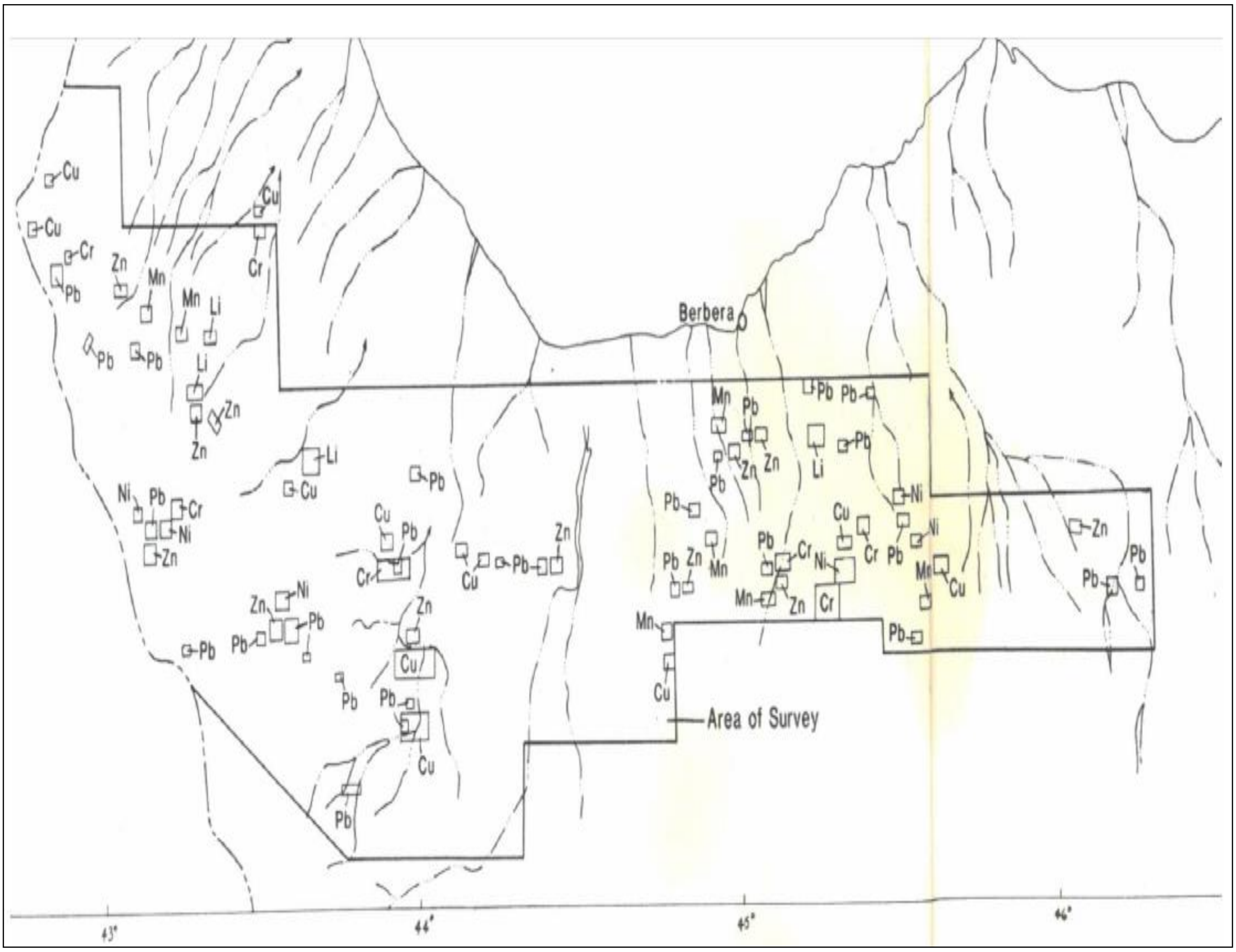

Fig 3. Geochemistry Map of Mineral Occurrences Somaliland

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Table 3. Summarized the Main Anomalies of the Geochemical Prospecting on Stream Sediments Carried Out in Northern Somalia (UNDP 1975) Resulted of Establishment of Many Positive Geochemical Anomalies for Lead, Zinc, Copper, and Nickel

Area Name	Main Anomaly
Dhagah Gure	Precambrian porphyritic granite is connected with veins of quartz and carbonate. Chalcopyrite, bornite, sphalerite, galena, arsenopyrite, and pyrite are examples of sulphide minerals. The gangue minerals are quartz, calcite, cale-silicates, dolomite, and barite.
Arabsiyo	Precambrian mafic and ultramafic rock outcrops in the area contain Ni, Cr, and Zn. galena, sphalerite, and chalcopyrite
Bawn	Anomalous Cu, Zn, and Cr in Jurassic limestone and anomalous Ni, Cr, and Cu in a range of Precambrian rocks.
Qolujeit	Pb, Zn, and Cu in Qolujeit region Jurassic limestone. Sphalerite and galena are found
Sheikh	Cr and Cu anomalies: A substantial, stratified gabbro complex underlies the anomalous region.

According to Ali et al. (2018), the study investigates the possibility of mineral sand deposits off the coast of Somaliland. The study focusses on discovering and quantifying numerous minerals in these sands that have commercial relevance. The article describes the geological background, the process for sampling and analyzing mineral sands, and the outcomes of these analyses.

The findings suggest that Somaliland has significant deposits of heavy minerals that could be exploited for economic development.

Table 4. Summarizes Important Minerals and their Locations (Ali et al. 2018).

Mineral	Location	significance
Ilmenite	Along the coast of Somaliland, particularly in the eastern regions	Ilmenite is a major source of titanium dioxide, which is used in the production of paint, paper, and plastics.
Rutile	Found in association with ilmenite in coastal sand deposits.	Rutile is another important source of titanium dioxide, used similarly to ilmenite in various industrial applications.
Zircon	Coastal sands, often found with ilmenite and rutile.	Zircon is used in the ceramics industry and as a refractory material. It is also used in the production of zirconium metal
Monazite	Present in heavy mineral sand deposits along the coast	Monazite contains rare earth elements, which are critical in the manufacture of high-tech electronics and renewable energy technologies.

These minerals are particularly abundant along Somaliland's coastal regions, with higher concentrations in the eastern coastal areas. These regions include:

- Berbera Area is notable for its high amounts of ilmenite and rutile. The eastern coast is rich in heavy minerals such as zircon and monazite. The findings show that these mineral sands have significant economic potential, and further extensive exploration and feasibility studies are needed to determine the viability of commercial extraction.

- Jama Aden, A., & Frizzo, P. (1996), provides detailed geological and geochemical information on the Barkasan and Sheikh gabbro complexes in Somaliland. The study analyzes their mineral compositions, geochemical characteristics, and magmatic evolution. Key findings include differences in trace element ratios, which suggest variations in magma source and fractional crystallization processes.

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Table 5. The Most Important Minerals Identified in the Barkasan and Sheikh Complexes and their Respective Locations are Summarized in the Table Below J(ama Aden, A., & Frizzo, P. 1996),

Mineral	**Location**	**Description**
Olivine	Sheikh Gabbro	Subrounded grains, never in contact with plagioclase.
Plagioclase	Sheikh Gabbro	Forms euhedral to subhedral crystals ophitically enclosed by clinopyroxene.
Clinopyroxene	Sheikh Gabbro	Coarse subhedral grains, two modes with vermicular intergrowths.
Orthopyroxene	Sheikh Gabbro	Coarse subhedral grains, associated with clinopyroxene.
Amphibole	Sheikh Gabbro	Forms coronas on pyroxene, Ti-rich, varies from Fe-pargasite to pargasite.
Biotite	Sheikh Gabbro	Interstitial lamellae with yellow to brown pleochroism.
Magnetite	Sheikh Gabbro	Occurs in large grains or as inclusions in orthopyroxene.
Ilmenite	Sheikh Gabbro	Found at magnetite-ilmenite interfaces or in orthopyroxene.
Green Spinel	Sheikh Gabbro	Associated with Fe-Ti oxides, exsolved in magnetite.
Gabbro	Barkasan Complex	Fragmented, composite nature, metagabbroic bodies.
Leucogabbro	Barkasan Complex	Less metamorphosed, considered part of the Sheikh-type gabbros.
Monzonite	Barkasan Complex	Contains rocks with both low and high TiO2 and FeOt.
Syenitic Dykes	Sheikh Gabbro	Cut the gabbro, indicating later magmatic events.
Alkaline Granite	Sheikh Gabbro	Occurs within the gabbro, indicating later stages of intrusion.

These minerals are critical to understanding the region's magmatic processes and tectonic history. The Barkasan complex comprises the Ago Marodi, Wahmadhigate, and Barkasan outcrop intrusions. The Sheikh complex is distinguished by its poorly stratified gabbroic pluton that contains considerable amounts of olivine, plagioclase, and pyroxene. Geochemical variances reveal distinct stages of magma formation and source compositions between the two complexes.

According to Kamenov, B. K., & Petrov, P. (2012, focuses on the hydrothermal metallic mineralizations in Northern Somalia. The study emphasizes the potential of these mineralizations, despite the lack of detailed prospecting and understanding due to political instability and insufficient funding over the past 30 years. The research categorizes these occurrences into several genetic groups and typical ore formations. Fluid inclusions in quartz crystals were analyzed to determine the temperature stages of crystallization. The findings suggest three temperature stages: high-temperature (350-400°C), medium-temperature (270-340°C), and low-temperature (100-220°C). The study provides preliminary conclusions that could aid further prospecting and metallogenetic generalizations for Northern Somalia.

The majority of the country's metallic mineralisation occurs in the Northern Somali region. In addition to regional mapping, the area was the focus of primary reconnaissance and prospecting activity, resulting in the discovery of several base-metal, auriferous, copper, and molybdenum manifestations, many of which were hydrothermal. There is no published information on this genetic type of mineralisation [4].

Table 6. Summarizes Important Minerals and Their Locations (Kamenov & Petrov, 2012

Mineral Formation	**Key Locations**
Quartz-Molybdenite-Chalcopyrite	Daaremo, Galo Ado, Bur Mado
Quartz-Sulfide	Dalan Central, Biyo Asse
Quartz-Molybdenite-Galena-Chalcopyrite-Pyrite-Arsenopyrite-Fluorite with Bismuthinite	Hed Valley, Bur Mado, Galo Ado
Quartz-Barite-Galena-Limonite-Carbonate	Dalan North, Biyo Ase, Sigib Ridge
Galena-Barite	Hidiq, Debis
Quartz-Cassiterite	Dalan Central
Quartz-Auriferous with Pyrite and Arsenopyrite	Biyo Asse, Debis, Daaremo
Quartz-Pyrite	Arapsiyo, Hed Valley
Quartz-Pyrite-Sphalerite-Chalcopyrite	Arapsiyo
Quartz-Pyrite-Chalcopyrite-Molybdenite-Galena-Hematite	Daaremo

This Categorization and the Detailed Analysis of Fluid Inclusions in Quartz Crystals Provide a Comprehensive Understanding of the Mineral Potential in Northern Somalia, which can Guide Future Exploration and Prospecting Efforts.

H. Previous Minerals (Gemstones)

Kinnaird, J. A., & Jackson, B. (2000), Discussed that the geological and mineral resources of the Mozambique belt in Kenya and Tanzania, highlighting the potential gem-producing capabilities of Somaliland as part of this geological formation.

It emphasizes the economic significance of these gem deposits for Somaliland, pointing out the need for external assistance to maximize the country's potential in gemstone production. This includes recognizing geological controls on emerald formation, identifying minerals through simple physical tests, and understanding the value of different gem minerals. Additionally, the article underscores the importance of marketing gemstones to secure funds for equipment and development.

Fig 4. Working In An Aquamarine-Bearing Pegmatite Near Heinwena With An Iron Bar, The Only Tool Available At The Site Apart From A Pick-A

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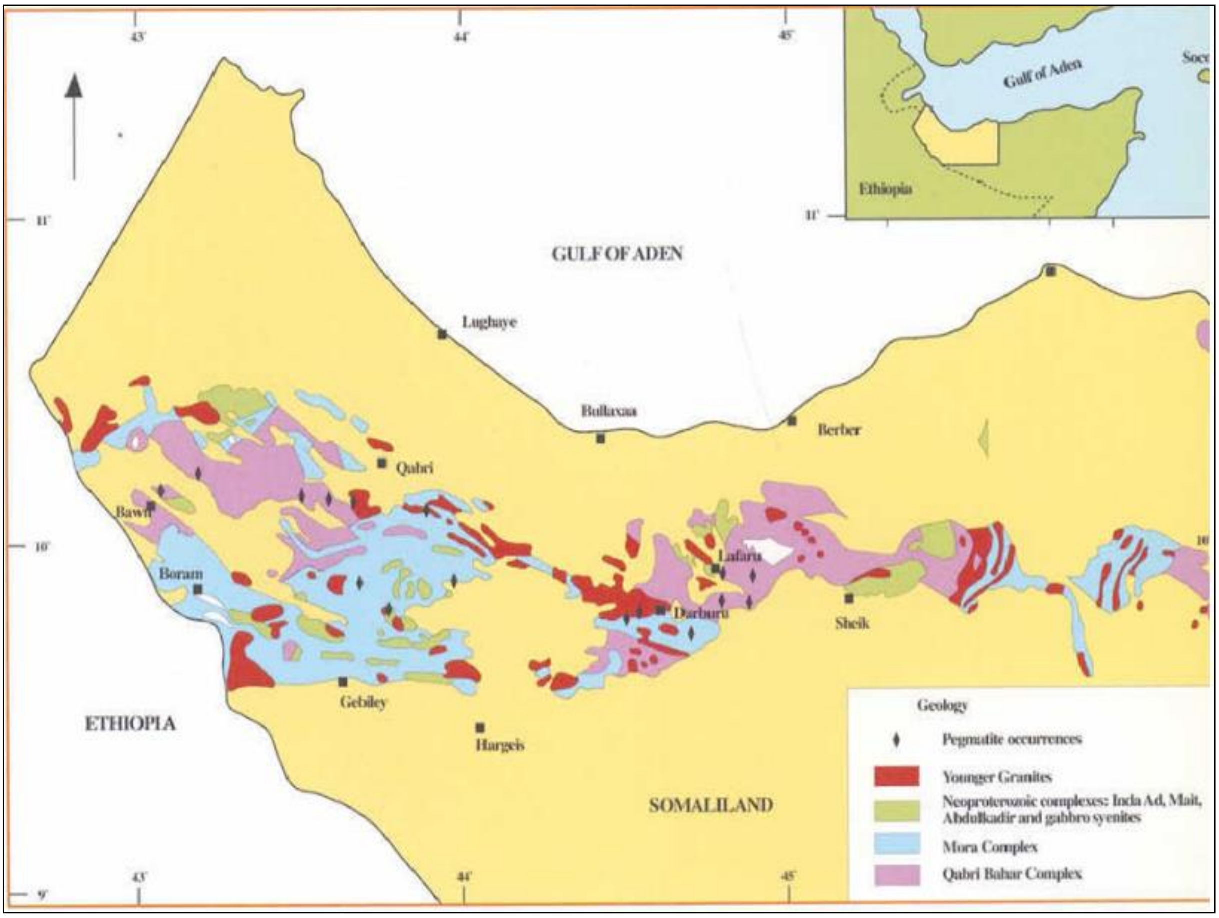

Fig 5. Geological Map Of Part Of The Northwestern Somaliland, Showing The Older Rocks Of The Qabri Bahar And Mora Complexes, And The Neoproterozoic Rocks Of The Mozambique Orogenic Belt, With Important Pegmatite Localities. The Younger Rocks Shown In Yellow Are Jurassic, Cretaceous And Tertiary Sandstones, Siltstones, Limestones, Evaporites And Tertiary To Quaternary Basalts.[6]

Table 7. This Table Details the Gemstones that can be Found in Somaliland and its Surrounding Areas, as Reported by Judith in 2002.

Mineral	Regions
Emeralds	Emeralds have been encountered in pegmatites in both the western pegmatite sector, and in the eastern Lafarug sector. However, emeralds are much more abundant in the west where pegmatites cut biotite and amphibole schists of the Mora Complex than in eastern Daarburug-Lafarug pegmatite belt, where the pegmatites cross-cut the Qabri Bahar complex.
Aquamarine	Heinweina Area to the East of Lafarug: Aquamarine occurs as perfectly-shaped hexagonal crystals in the milky quartz core of pegmatite, with crystals in excess of 8 cm having been recorded in this area.
Sapphires	West of Hargeisa on the Gebily Road: Bluish corundum (sapphires) has been observed in a quartz-poor, muscovite-rich pegmatite in this area.
Ruby	Rubies are found in Somaliland, although they are less abundant than emerald and aquamarine. They are typically color-banded with natural cracks and inclusions. The rubies are often surrounded by a rim of dark amphibole or a bright green rim, presumed to be zoisite. The geological characteristics of the ruby deposits in Somaliland are similar to those found in the Matabatu Mountains near Longido in Tanzania. The presence of serpentine, chromiferous zoisite amphibolites, and green chromium muscovite fuchsite may act as indicators for ruby deposits in Somaliland.
Garnets	Garnets are found abundantly in **Somaliland**. The range of crystal sizes, colors, and clarities varies widely, with crystals often exhibiting a perfect dodecahedral form. Garnets come in various colors, including light orange, pink, cherry red, dark red, purple, and almost black.

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Opal	**Between Borama and the Coast**: Opals are known to originate from a locality between Borama and the coast in Somaliland. Somali opals bear a remarkable similarity to opal from Shewa Province in Ethiopia, suggesting a related paragenesis. The Ethiopian opals occur as nodules in acid volcanic rocks in a layer of welded tuff, and similar Miocene volcanic rocks occur in Somaliland west of Cabdulqaadir near the border with Djibouti.

According to Yousuf, A. M. (2020), discusses the discovery and mining of hessonite garnets in Somaliland, an autonomous region in East Africa. It highlights that Somaliland has produced various gem-quality minerals, including garnet, opal, emerald, and aquamarine. The specific focus is on the orange garnets found near the town of Daarbuduq, between Hargeisa and Berbera. These garnets have been mined since the 1990s using both artisanal and mechanized methods.

Artisanal mining involves small groups of people using rudimentary hand tools, whereas mechanised mining, which is mostly done along riverbanks, uses machines. The article describes the physical properties of mined garnets, stating that they range in colour from medium yellowish orange to deep orangey-red and vary in size and quality. The report also includes the results of tests on the garnets, which confirmed their identification as grossular hessonite using various methods such as Raman spectroscopy[10].

Table 8. Important Minerals and Their Locations (Yousuf, A. M. 2020.

Mineral	Location	Characteristics
Hessonite Garnet	Area 10 x 10 km south-west of Daarbuduq, between Hargeisa and Berbera, Somaliland	medium to dark orange fragments, up to 50 grams, good quality 40%, lower grade 60%

IV. RECOMMENDATIONS

- Enhanced Exploration Programs: It is recommended to intensify geological surveys and exploration programs in Somaliland, leveraging advanced technologies to uncover further mineral deposits.
- Investment in Infrastructure: Developing infrastructure, including transportation and processing facilities, is essential to support mining activities and attract foreign investments.
- Capacity Building: Training local geologists and mining engineers will ensure the sustainable development of the mineral sector, fostering local expertise and employment.
- Environmental and Social Considerations: Implementing stringent environmental regulations and engaging with local communities will ensure that mining activities are conducted responsibly, minimizing ecological impact and enhancing social benefits.
- Policy and Regulatory Framework: Establishing a robust legal framework will provide clear guidelines for mining operations, ensuring transparency and encouraging investment from international mining companies.

V. CONCLUSION

The study highlights the significant mineral potential of Somaliland, underscored by its diverse geological formations and rich mineral resources. Detailed exploration has identified valuable deposits of base metals, gold, and industrial minerals, which are crucial for the region's economic development. The historical and recent geological surveys indicate that Somaliland's basement complex holds considerable promise for future mining endeavors. The findings underscore the importance of continued and enhanced exploration activities to fully realize the mineral wealth of the region.

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