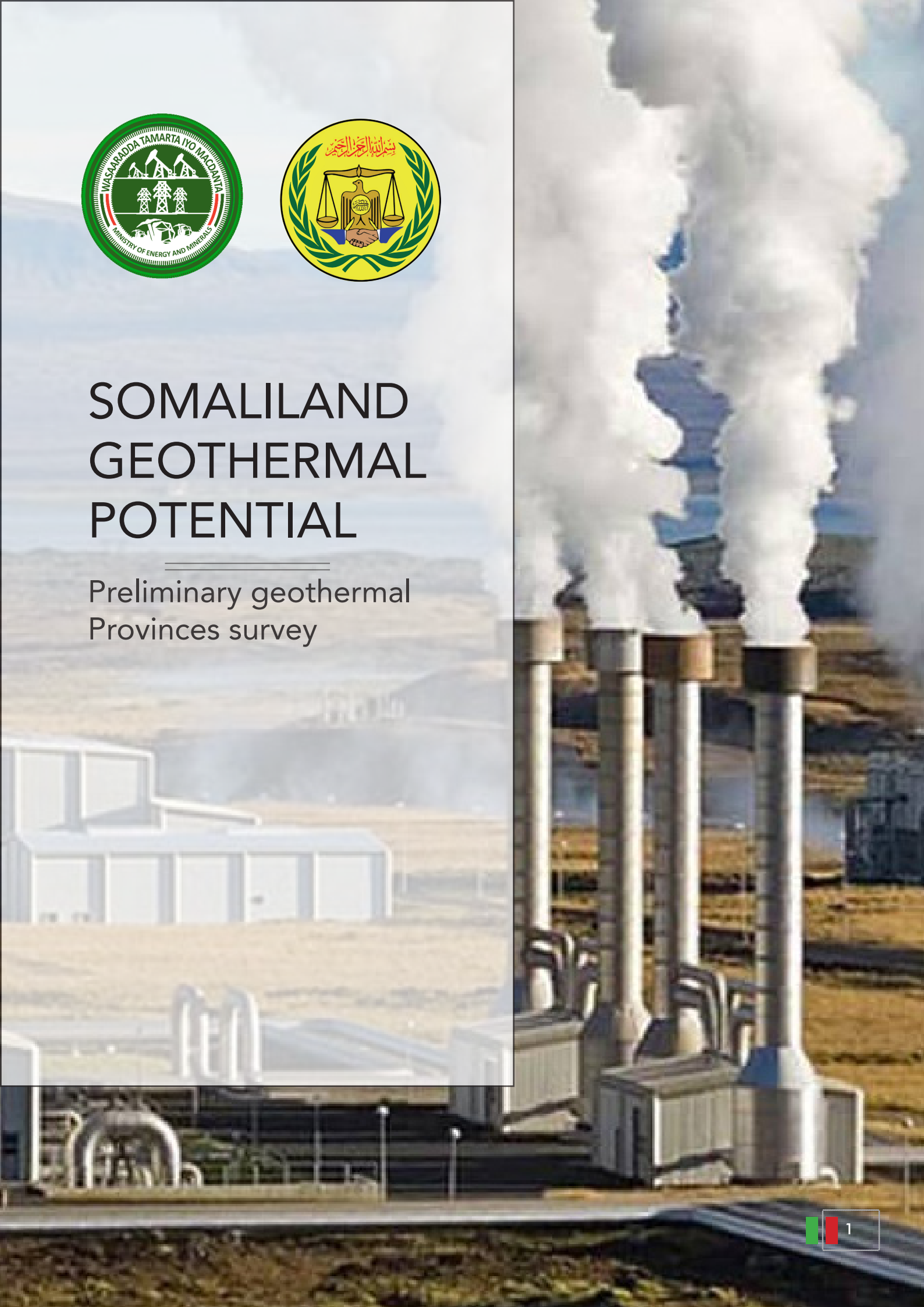
SOMALILAND

GEOTHERMAL POTENTIAL

Preliminary Geothermal Provinces Survey

2021



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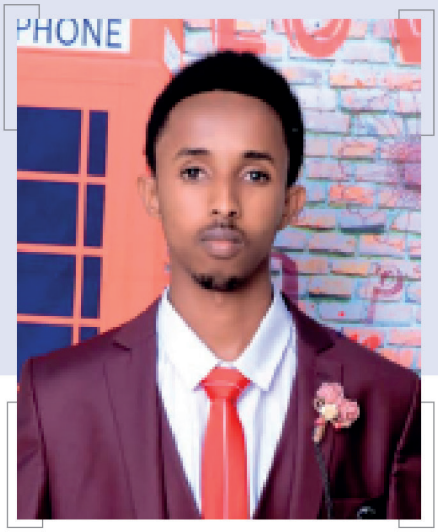
About the Authors



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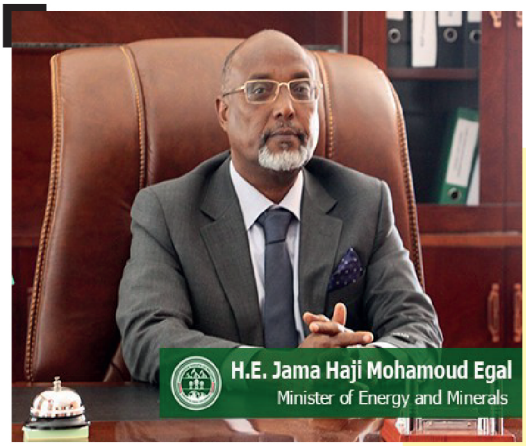
Our Vision for a Brighter Somaliland



Somaliland government priority is to transform the energy supply by investing indigenous geothermal energy resources to meet the growing demand of the electricity in Somaliland.

The Ministry of Energy and Minerals carried out a preliminary geothermal manifestations survey in the country to determine the promising places of the geothermal energy resource, and to make it available the information of the geothermal energy resources to the potential developers. The main geothermal appearances of the country radiated from the extensions of the east African rift valley. Therefore, policy and strategy of the ministry is to generate stable and reliable base-load power from domestic geothermal energy resources of the country. In addition, the ministry of energy and minerals is incentivizing the investment of the geothermal potential by making; supportive policies and regulatory legislations of the geothermal industry.

In closing, investment of the primordial geothermal energy in Somaliland becomes one of the long term solutions of the growing demand, and it improves the generation, transmission, and distribution systems of the power sector.

Jama Haji Mahmoud Egal

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Director General of the Ministry of Energy and Minerals (MOEM)

The ministry of energy and minerals is responsible for the energy security and prosperity of the country through investing geothermal energy resources to meet the growing demand for the energy in a safe and environmentally responsible manner.

Geothermal energy is one of the most important renewable energy resources that boost economic activities, and reduces our nation's dependence on imported energy; thereby reducing trade deficits. Domestic renewable energy resources development such as geothermal energy brings with it a multitude of economic and employment benefits. The benefits of the geothermal energy development are beyond dispute. Carbon dioxide emissions from geothermal power generation are lower than those produced by power generated from burning fossil fuels. Geothermal energy has the ability to provide stable and reliable base-load power at a relatively low cost. Once a geothermal power plant is operational; it will produce a steady output around the clock usually for several decades at costs competitive with other base-load power generation options.

The ministry of energy and minerals is ready to prepare an enabling environment of a successful geothermal development by making: available sufficient accurate geothermal resource data, effective and dedicated institutions, supportive policies and regulations, and access to suitable finance for the project developer.

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Director of the energy sector

Somaliland energy policy is to minimize energy from imported light diesel that is used as a base-load power for the electricity generation, and transform fossil based energy into indigenous renewable energy resources.

Somaliland receives some of the best solar irradiation in the world. Annually, it receives approximately 3,000 hours of reliably clear sunshine of a vast solar energy resource. Ministry of Energy and Minerals estimated to be as high as 5.8 to 6.0 KWh meter square per day. Similarly, Somaliland has the highest potential for onshore wind power in Africa. Along its 850 km coastline, offshore wind speed at 100m regularly exceed 10 – 11 meters per second. In addition to solar and wind, Somaliland has a great geothermal potential originated from branches of the triple junctions in the east African rift valley. Therefore, renewable energy resources of the country are reliable to produce green hydrogen which is new paradigm of energy transition toward zero or net-zero emissions.

In sum, Ministry of Energy and Minerals strategy is to enhance utilization of the renewable energy resources of the country to generate electricity, and to reduce dependence of the imported diesel for the power generation and to increase energy security and reliability.

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Introduction

Background

Somaliland, within an estimated population of **5.7 Million**, is one of the countries in the sub-Saharan region and it occupies the northeast Africa known as "Horn of Africa," sharing boundaries with the Gulf of Aden in the north, Somalia in the east, the Federal Republic of Ethiopia in the south-west, and the Republic of Djibouti in the north-west. It has a total surface area of about **177,000 square kilometres** and a coastline, which is **856 kilometres** long. Population density of the country is **28 persons per/ square kilometres,** the population of Somaliland is young and has become more urbanized over time. Furthermore, Somaliland has undergone a strong process of urbanization with its urban population is 53% while the other populations are nomadic population which is 34%, rural populations 11%, and internally displaced populations which are 2% [1].

The country's economy is driven by the private sector, communication technology, and the youth, these are the three (game changers) in Somaliland economy, unlike most other economies in the world, the government footprint is limited, amounting to under 10 per cent of the GDP. Reliable economic statistics on the Somaliland economy are limited. However, based on the Ministry of the Planning initiative, a **GDP estimate for 2017** was approximated to be **US$ 2.573 billion;** GDP per capita is **US$ 675** and is considered one of the lowest in the world. The economy of the country is dominated by low-productivity sectors with livestock and retail trade making up over 50% of the GDP. On the other hand, sectors those are the key to economic growth such as energy is contributing to 1% of the GDP, which is meagre participation. Food, energy and other material to support the population are imported [1].

Somaliland it has an estimated installed capacity of 77MW in 2010, out of which less than 7% is attributed to the public electricity agency. Furthermore, electricity demand on a per capita consumption is very low, which was estimated at between 27KWh to 30KWh at coverage about (125,370 customers) in 2010 [2]. Power losses have been estimated as an average of 25% with some suppliers recording more than 40%. This is a quite high compared to the 10-12% international target. Currently, the installed capacity of the country is double than that estimated in 2010, because of the urbanization of the rural and nomadic populations. Electricity service providers generate the electricity at high percentages of imported diesel oil and small percentages from renewable energy. However, Somaliland has a geothermal manifestations near Berbera district at Gaha, and Nogal and Daror basins that are unutilized. This energy source, if it will be explored and developed, would make Somaliland economy growing and politically stable [2].

Preliminary geothermal provinces survey in Somaliland

Geological and tectonic settings of Somaliland

The geology of Somaliland is characterised by several phases of metamorphism and igneous activities of various ages and types. The main tectonic regime of Somaliland was vertical movement – rifting and uplifting and was dominated by three trends of simple normal faulting, with minor fault-related folding and reverse faults.

The crystalline basement of Somaliland crops out at the surface in a discontinuous belt about 600 km long and 30 km wide, running parallel to the Gulf of Aden and covering an area of around 30,000 km3 [3]. It comprises an older Precambrian crust in the west, which has been through several geological events, and a simpler Pan-African terrain in the eastern sector which has evolved in one geological period from around -700 500 Ma. Altogether, the basement consists of five meta-sedimentary sequences interrupted by two different phases of igneous activity (Kroner and Sassi, 1996).

The Palaeoproterozoic Qabri Bahar Complex was originally dominantly sedimentary sandstones and mudstones. These were metamorphosed and deformed several times. In contrast, the overlying Mora Complex is dominated by carbonates with some sandstones and mudstones, which do not appear to have undergone the same multiphase deformation events. Field evidence suggests that the Mora Complex is in tectonic contact with the Quabri Bahar and the migmatites separating these two complexes are interpreted as a high strain zone [3]. The Mora and Qabri Bahar Complexes were intruded by gabbro-syenite bodies about (Daniels et al, 700(1965 Ma ago (Ferrara et al, 1987; Kroner and Sassi, 1996). A second phase of plutonism affected the whole Precambrian basement in the period 500-550 Ma with the intrusion of two granitic series: an older, sometimes foliated series affected by a

late orogenic deformation and a younger post-orogenic group which has associated aplitic and acid pegmatite intrusions. These pegmatite intrusions (very coarse-grained igneous rocks) are widespread.

The basement units were under considerable erosion and peneplanation throughout the Palaeozoic. Sedimentation started in the Mesozoic time (Middle Jurassic) with basal sandstone deposited in marginal marine environment (Adigrat sandstone).

This was followed by marine transgression and the depositions of limestones and shales of Bihin Group (in the west) and Ahl Medo Group (in the east).

Uplifting and resumption of erosion at the end of the Jurassic resulted the removal of significant thickness of Upper Jurassic sediments, before the sea spread in the Cretaceous which covered eastern part of the country and the deposition of fossiliferous limestone (Tisje formation). Whereas in the west, marginal marine sand deposition prevailed (Yesomma sandstone). New marine environment developed Palaeocene – Eocene. The deposition of limestone rocks (Aurado formation/Allahkajed and Karkar formation).

In between the deposition of Karkar and lower Eocene formation- during the Middle Eocene – regressive episode and the formation of gypsum/anhydrites (Talleh formation). After another break of deposition, sediments of marginal marine to local sabkha environment were deposited in Early Oligocene – lower Guban Group [4].

The rifting of the Gulf of Aden dominated the sediment deposition during the Oligocene – Miocene and restricted them to narrow isolated sub-basins. The units deposited include: upper Guban Group, Daban Group & Bandar Harshau Formation. In the north central a shallow, nearshore marine - Dubar formation, lacustrine and marginal marine deposit of Daban Group and alluvial fanglomerates (Boulder beds) developed Oligocene – Pleistocene.

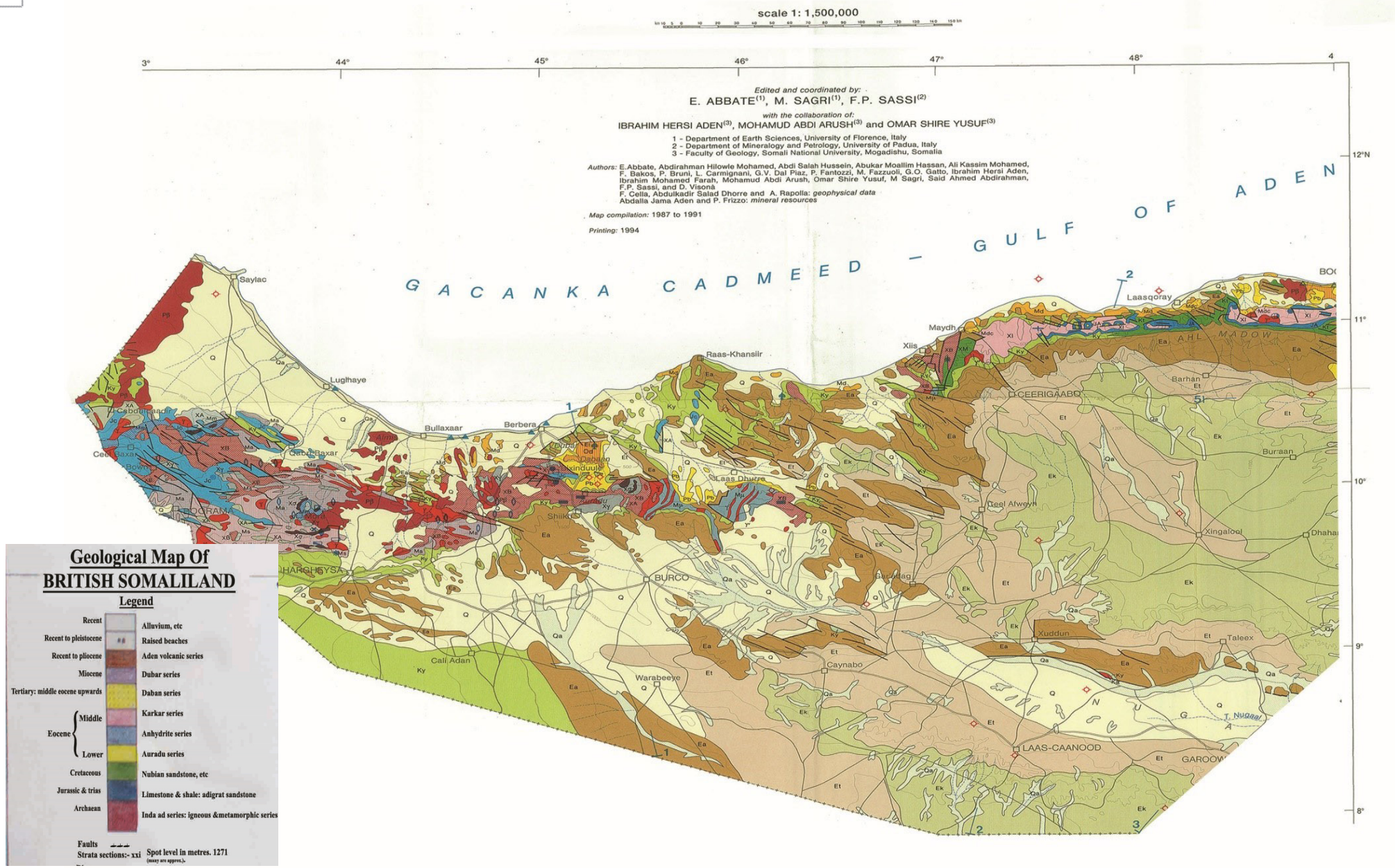
The main tectonic regime of Somaliland was vertical movement of regional extent and was dominated by three trends of extensional faulting, namely Gulf of Aden trend (E-W to ENE-WSW), Red Sea trend (NW-SE to WNW-ESE) and East Africa (N-S). These directions are not restricted to given geological time but at times there has been late stage reactivation of old-established trends. Important large-scale faulting movements appear to have taken place in the Mesozoic and, although it is usually impossible owing to rejuvenation to differentiate between fault movements of this early age and younger movements, they probably follow similar trends.

Red Sea trend faults are the most numerous faults, often forming parallel ranges. These Red Sea faults throw to either direction. In the west of the country the dominant down-throw is to the northeast so that the country is step-faulted towards the coast, but in the north-central and north-eastern regions the direction of throw alternates between southwest and northeast, forming a series of horst and graben structures. The vertical displacement of these fault movements is between few meters and 1000 metres. But at Suriamalableh, 15 kilometres south-southeast of Berbera there is a stratigraphic displacement of nearly 3,000 metres.

Gulf of Aden trend faults divides the country into its two main physiographic regions; the relatively uplifted North Somaliland Plateau and the sunk-land Guban area. All the main Gulf of Aden faults throw down to the north and the vertical displacements resulting from the movements are usually great. The single plateau-forming fault of the Sheikh area has a throw of from 800 to 900 metres.

East African trend faulting is only locally developed in this country. South of Ras Khanzir in north-central Somaliland a strong north-south fault forms the Jirba Range and throws the Allahkajid beds (upper part of the Lower Eocene) against Basement rocks. The stratigraphic throw of this near-vertical fault is at least 1500 metres to the east. Further north almost to Karin on the coast, this trend is continued by several faults which throw both east and west, but the main fault here has a throw of perhaps some 300 metres to the west [4].

GEOLOGICAL MAP OF SOMALILAND
WARQADDA CILMIGA DHULKA EE SOOMALILAND



Geological Map Of BRITISH SOMALILAND

Legend

Recent		Alluvium, etc
Recent to pleistocene		Raised beaches
Recent to pliocene		Aden volcanic series
Miocene		Dubar series
Tertiary: middle eocene upwards		Daban series
Eocene	Middle	Karkar series
		Anhydrite series
	Lower	Auradu series
Cretaceous		Nubian sandstone, etc
Jurassic & trias		Limestone & shale: adigrat sandstone
Archaean		Inda ad series: igneous &metamorphic series

Faults
Strata sections:- xxi
Spot level in metres. 1271
(many are approx.).

Somaliland Geothermal Manifestations

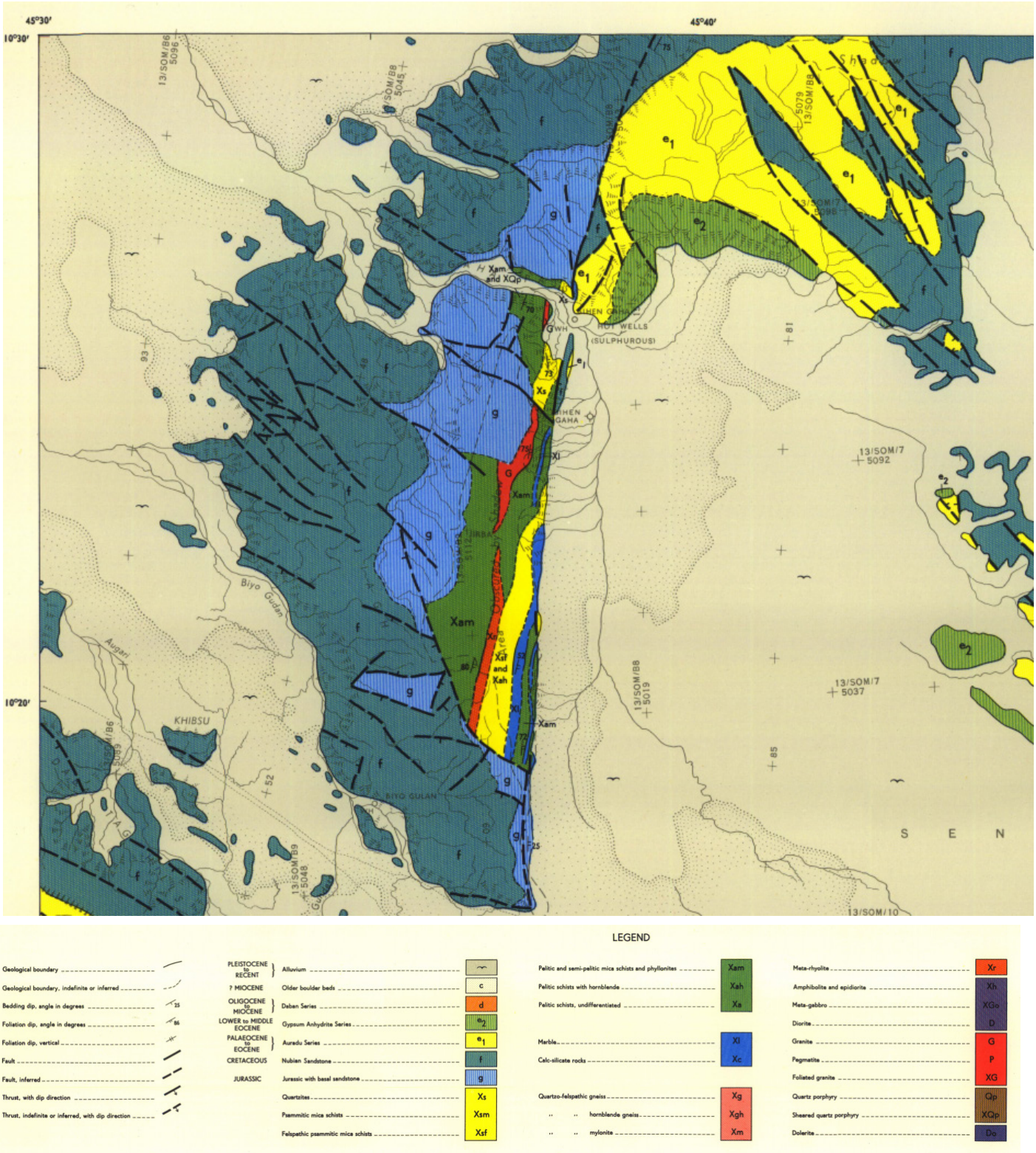
Somaliland is one of the east African countries where the East African rift valley system extends, and it forms one of the three branches radiated from the "triple junctions" illustrated in the Afar regions of Ethiopia and Djibouti. Somaliland shares boundaries with the Gulf of Aden in the north, the Federal Republic of Ethiopia in the south-west, and the Republic of Djibouti in the north-west. The complete rift system extends 1000's of kilometres in Africa alone and several 1000 more if we include the Red Sea and the Gulf of Aden as extensions.
Geothermal provinces in Somaliland originated from three major trends of faulting that have been demonstrated in Somaliland (Som. Oil Ex. Co. 1954).

Biyo-Kulule geothermal manifestations

Biyo-kulule is located near Berbera district 16 km to the East, geothermal appearances in Biyo-kulule distributed along two kilometres into the valley. These provinces characterized by warm springs with a temperature of 42 °C, hot springs with a temperature of 55 °C, steaming ground, and hot dry rocks (HDR).
Geothermal provinces at Biyo-kulule originated from the Red Sea trend faults that are dated stratigraphic disruptions to be upper Eocene and Oligocene.

Gaha geothermal manifestations

Gaha is one of the promising geothermal places in Somaliland, and it is located near Berbera city at 67 kilometres to the East. Gaha hot springs are located along a major, north-south fault of East African trend
Faulting as showing in (figure 1) . The fault is down throwing to the east and throws the Eocene units against Basement rocks, forming the north-east trending Jibra Range.
Attributes of the geothermal provinces in Gaha area are, hot springs, steaming surfaces, fumaroles, and warm springs. Thermal data collected around Gaha area are shown in table below



LEGEND

Geological boundary	PLEISTOCENE to RECENT	Alluvium —
Geological boundary, indefinite or inferred	? MIOCENE	Older boulder beds — c
Bedding dip, angle in degrees	OLIGOCENE to MIOCENE	Deban Series — d
Foliation dip, angle in degrees	LOWER to MIDDLE EOCENE	Gypsum Anhydrite Series — e_2
Foliation dip, vertical	PALAEOCENE to EOCENE	Auradu Series — e_1
Fault	CRETACEOUS	Nubian Sandstone — f
Fault, inferred	JURASSIC	Jurassic with basal sandstone — g
Thrust, with dip direction		Quartzites — Xs
Thrust, indefinite or inferred, with dip direction		Psammitic mica schists — Xsm
		Felspathic psammitic mica schists — Xsf

Pelitic and semi-pelitic mica schists and phyllonites	Xam
Pelitic schists with hornblende	Xah
Pelitic schists, undifferentiated	Xs
Marble	Xl
Calc-silicate rocks	Xc
Quartzo-felspathic gneiss	Xg
" " hornblende gneiss	Xgh
" " mylonite	Xm

Meta-rhyolite	Xr
Amphibolite and epidiorite	Xh
Meta-gabbro	XGo
Diorite	D
Granite	G
Pegmatite	P
Foliated granite	XG
Quartz porphyry	Qp
Sheared quartz porphyry	XQp
Dolerite	Do

Figure 1: GEOLOGY OF GAHA AREA (Somaliland geological survey by D.C. Gellatly 19591960- and Stewart 19531954-/ sheet 25 Las Dureh)

Figure 2: ***Steeply dipping Cretaceous unit as part of rotated fault block adjacent to the major fault at Gaha springs***

Figure 3: ***Hydrothermal manifestations at the Gaha springs (photo by Meom)***

S/N	Locations	GPS coordinates	Elevation (m)	Water temperature (oC)	Water salinity - WEC (µS/cm)
1	Site/spring 1	10.420420° 45.632010°	307	43	Over 10,000
2	Site/spring 2	10.424840° 45.631690°	306	51	4100
3	Site/spring 3	10.429120° 45.631860°	298	60	3960
4	Site/spring 4	10.43016° 45.63369°	301	55.7	4066

Table 1: Measurements taken from the Gaha springs

Somaliland policies and strategies for the geothermal industry

Development of the geothermal industry in Somaliland is necessity, and there is no other proven sources of energy that can be used to generate base-load power. Therefore, Somaliland government efforts to get the geothermal industry off-the ground.

Somaliland government is ready to make geothermal resource information available to potential developers and investors without any bias; and also, to support and fund geothermal resource assessment and development. The strength of the institutions and their structural organizations with respect to geothermal energy development is the key element in successful geothermal energy development. For that reason, Somaliland Ministry of Energy and Minerals is starting to establish and strengthen a clear legal and regulatory framework, well defined institutional responsibility, and transparent procedures for granting geothermal rights. Besides, the Ministry is preparing to create supportive policies required for successful geothermal development to attract and incentivize private investors of the geothermal industry, these policies are FIT policy, quantitative target (quotas), and dispatch priority.

Ministry of Energy and Minerals (MOEM) vision, is to contribute to Somaliland's social and economic development through the sustainable utilization of the country's geothermal energy resource for the benefit of all Somaliland people by 2030.

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[2] Somaliland energy policy November 2010 p .13
[3] Judith A. Kinnaird, and Brian Jackson, July 2000. Somaliland - a potential gem producer in the Mozambique Belt: the journal of geology volume 27 No.3, p. 139-154
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