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Barriers of Geothermal Exploration in Cameroon

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ABSTRACT

The presence of an active volcanic line in Cameroon, coupled with thermal springs and frequent eruptions of Mount Cameroon are in favour of the development of a geothermal industry that can provide clean and renewable energy. However, no feasibility studies have been carried out to identify the full potential of geothermal in Cameroon since the reconnaissance work of Le Maréchal (1976) who recorded 130 thermal springs concentrated in the corridor of the Cameroon Volcanic Line.

This study primary aims at reviewing the issue of geothermal exploration in Cameroon with an emphasis on the existing barriers for its development and the level of awareness of academics about geothermal energy as a barrier to the development of geothermal energy.

A review of the literature regarding the energy sector in Cameroon was firstly conducted. Furthermore, a survey on 175 Postgraduate students in Geology of the University of Yaounde I was carried out in June 2018 using a self-developed questionnaire. The literature was analysed using thematic analysis and the questionnaire was analysed using the STATA software.

The literature revealed that poor policies, insufficient financial resources, untrained personnel, constrained environments, and unawareness of stakeholders, investors and academics are the main obstacles for geothermal exploration in Cameron. The insufficient and inadequate knowledge of academics about geothermal energy has been highlighted by the results of the survey.

Geothermal energy is still underexplored and underexploited in Cameroon. It is therefore recommended that an initial exploration in Cameroon has to be done through a surface exploration by combining geological, geochemical and geophysical methods. Through these,

it is expected that information on the location, area, extent, volume, geometry, boundary conditions of resource, permeability, density, heat capacity and conductivity of the potential geothermal resources should be obtained. Finally, awareness on geothermal exploration should be increased.

1. Introduction

Cameroon is a Central African country, located in the Gulf of Guinea between latitude 2° and 13° degrees north and longitude 9° and 16° degrees east. The country covers an area of 475,650 km^2. It has a triangular shape, which stretches south to Lake Chad nearly 1200 km, while the base is spread from west to east about 800 km. It has a south-west maritime border of 420 km along the Atlantic Ocean. It is bounded to the west by Nigeria, to the south by Congo, Gabon and Equatorial Guinea, on the east by the Central African Republic, and north-east by Chad (Annexure 1). Cameroon has a population of 24,994,885 inhabitants (CDP, 2018). Acording to the Central Intelligence Agency 2016, about 54.4% of the population lives in urban area and 45.6% lives in rural area. It is the most populated country in Central Africa with a population that is in constant growth. The population growth rate and economic (GDP) growth rate are 2.59% (2015) and 5.9% (2015), respectively. Over 60% of Cameroon's active population is employed in agriculture, representing 42% of GDP while mining and industry accounts for 22% (Muh et al., 2018).

Cameroon is endowed with a great potential of energy resources: oil, natural gas, bauxite (iron ores), forestry, hydropower, wind, solar, biomass and geothermal. However, these resources have not been adequately harnessed especially renewables (Ayompe and Duffy, 2014). Access to energy is among the key elements for the economic and social developments of a country. The level and intensity of commercial energy used in a country is one of the key indicators of socio-economic development. As incomes increase and urbanization intensifies, household demand for energy will also rise. Unfortunately, the energy sector in Cameroon has failed to align supply with demand for electricity in the country. Although Cameroon is endowed with a variety of energy resources, many of these resources have not yet been exploited. Currently about 73% of the electricity generation is from hydro and the remaining 26 % and 1% are from combustible fossil (oil and natural gas) and biomass respectively. Hence, there is a need to find new solutions to improve access to energy and to ensure that such access is sustainable.

In Cameroon, the presence of an active volcanic line emphasized by thermal springs and the frequent eruptions of Mount Cameroon (that last erupted in 1999 and 2000) can favour the development of a geothermal industry that can provide clean and renewable energy. However, Le Maréchal (1976), identified 130 thermal springs concentrated in the corridor of the Cameroon Volcanic Line (with temperature that reaches 74°C in Woulndé), but no feasibility studies have been carried out to identify their full potential.

This study addresses the issue of geothermal exploration in Cameroon with special attention on the existing barriers for the development of geothermal energy. Specifically, what is known about the energy sector and renewable energy and the level of awareness concerning geothermal energy in Cameroon have been identified.

2. Energy sector in Cameroon

2.1 Energy demand and consumption

The main sources of commercial energy in Cameroon are: hydropower, coal and petroleum, with 90% of the population using biomass (wood) for cooking, heating and lighting in remote areas (FUSS, 2013). Electricity access is estimated to between 65–88% urban and around 14% for rural populations (report from MINEPDEP, undated).

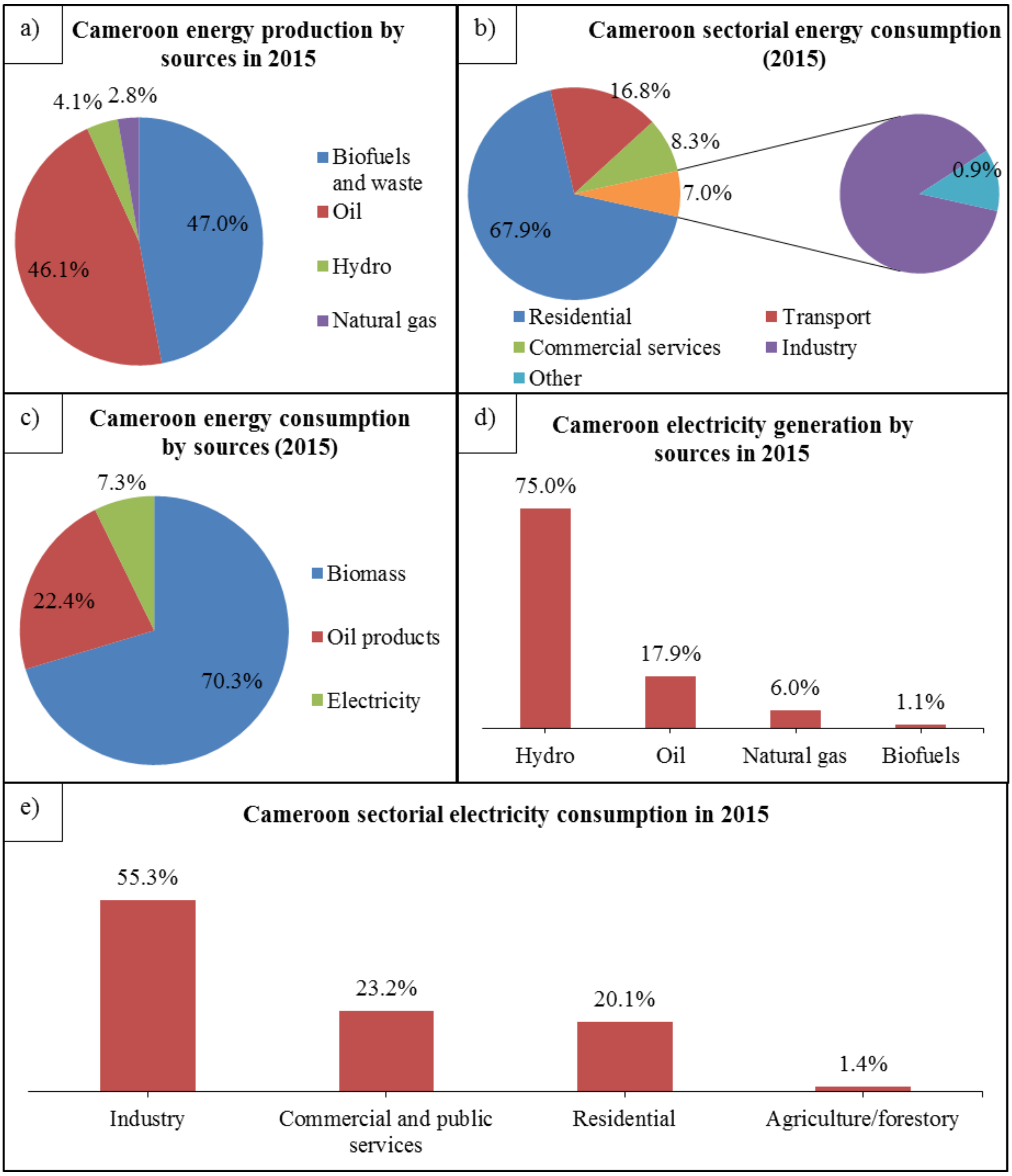

Figure 1: Energy and electricity production and consumption in Cameroon (IEA. Cameroon: Energy balances for 2015. International Energy Agency, 2018).

In 2015, according to the International Energy Agency (IEA, 2018, Energy balance of Cameroon), energy production was estimated at 10670 ktoe of which 47.0% came from biofuels and waste and 46.1% from oil (Fig. 1a). Energy consumption in 2015 was 6849 ktoe, with the residential sector on the lead with 67.9%, followed by the transport sector with 16.8% (Fig. 1b). With respect to sources of origin, 70.3% of energy consumption in 2015 came from biomass (Fig. 1c). Hydropower dominates electricity generation in Cameroon with 69%, followed by self-production 22%, with an installed capacity of 1558 MW in 2009. In 2015, total electricity generation (International Energy Agency, 2018, Electricity and heat for 2015) was 6758 GWh with 75.0% from hydro, 17.9% from oil, 12.8% from gas and 1.1% from biofuels (Fig. 1d); and in sectorial consumption (total 5784 GWh), industry is the highest electricity consumer with 55.3% (Fig. 1e). Apart from hydropower as the main installed capacity, 298 MW currently result from thermal power plants. The country potential to produce electricity from biomass residues is estimated at 1076 GWh (International Energy Agency (IEA, 2018, Electricity and heat for 2015).

2.2 Institutions and political energy actors

According to the Ministry of Environment Protection of Nature and Sustainable Development (MINEPED), there are many state agencies actively involved in the management of the energy sector in Cameroon:

- The Ministry of Energy and Water (MINEE), with a department of renewable energies, is in charge of design and implementation of the national energy policy as well as providing administrative and technical oversight of the establishments in the energy sector;
- The Ministry of Environment, Protection of Nature and Sustainable Development is responsible for the promotion of sustainable development in the renewable energy sector;
- The Rural Electrification Agency (AER) is responsible for promoting and implementing rural electrification programs in Cameroon. It also manages the Rural Energy Fund (FER);
- The Electricity Sector Regulatory Agency (ARSEL) is responsible for regulating the electricity sector as well as setting electricity rates and determining electrical standards;
- The Electricity Development Corporation (EDC) is in charge of construction and development of the main hydroelectric projects in Cameroon. It also plays a strategic role in the development of the electricity sector while ensuring conservation of the public heritage in the sector;
- The National Society of Electricity Transport (SONATREL) is responsible of the exploitation, maintenance of public electricity transmission throughout Cameroon;
- The Energy Of Cameroon (ENEO) is responsible for power generation, transmission and distribution.

2.3 Renewable energy resources in Cameroon

2.3.1 Hydropower

Hydropower is the major source of power generation in Cameroon (Mas'ud et al., 2015). Cameroon has the second largest hydropower potential in sub-Saharan Africa (294 TWh) (Nématchoua et al., 2015), after the Congo, with an estimated total theoretical potential of 23

GW and a production potential of 103 TWh/year (FUSS, 2013). Hydroelectric theoretical generation potential of Cameroon is estimated at 297 TWh with only 13,700 MW currently implemented due to numerous environmental obstacles (UNIDO, 2016a). Water variations induce regular and frequent power shortages throughout the country. The solution for that problem is the Lom Pangar retention damp recently constructed by EDC. The electricity production capacity of Cameroon as of 2015 was 817 MW with 88% from hydroelectricity and the rest from thermal sources (Mas'ud et al., 2015). The major hydropower stations in the country are: Edéa (263 MW), Song Loulou (388 MW) and Lagdo (72 MW); with Edéa and Song Loulou located along the 920 km Sanaga river producing 97% of hydropower supply (UNIDO, 2016a) and Lagdo in the north near Garoua. Cameroon also has a huge potential for small hydro power supply (estimated at 1.115 TWh), mainly in the western and eastern regions (Nématchoua et al., 2015). However, these small hydro potentials are poorly utilized, exceptions done for Mekin and Menve'ele power stations currently under construction in south Cameroon.

2.3.2 Solar energy

Cameroon has good potential for solar energy exploitation. In the most suitable parts, the average solar irradiance is estimated at 5.8 kWh/day/ m^2 (in the Northern parts of the country), while the rest of the country commonly sees 4.9 kWh/day/ m^2 (UNIDO, 2016b). This potential, however, is weakly valorised despite the availability of ideal conditions throughout the country. Solar power is currently used in distributed generation systems, particularly for powering the cellular telecommunications network. However, only approximately 50 PV (Photovoltaic) installations currently exist (Wirba et al. 2015). Other recent applications include: solar street lighting; solar security and surveillance cameras for both streets and public offices; solar phone charging for small businesses and remote applications; solar home systems for both remote and some city applications; solar powered deep freezers and air conditioning systems (Muh et al., 2018).

2.3.3 Wind energy

Most of the country has insufficient wind speed for power production with an average of 2-4 m/s at the height of 100 meter. However, the Northern and Littoral regions of Cameroon have substantial potential for wind energy with wind speeds averaging 5-7 m/s (Tchinda and Kaptouom, 2003). The wind energy potential of Cameroon is not as vast as solar and very low consideration has been devoted to it so far. The potential of wind energy for small scale applications (water pumping systems, water farms for livestock and small irrigation schemes) for rural households in the far north region of Cameroon has been assessed by Kaoga et al. (2016).

2.3.4 Biomass energy

Cameroon has the third largest biomass potential in sub-Saharan Africa, with 25 million hectares of forest covering three-quarters of its territory (Mas'ud et al. 2015). However, the unsustainable use of this resource has led to significant deforestation throughout the country, with an annual clearance rate of 200,000 ha/yr. and regeneration of only 3,000 ha/yr. Primary uses for biomass in the country include heating and light for the majority of the rural population (Tansi et al., 2011).

2.3.5 Geothermal energy

Potential for geothermal energy exists in Cameroon. However, the exact capacity is unknown since no investigation has been yet carried out to estimate this potential despite some recent academic/research works of Domra et al. (2015, 2017). Nevertheless, hot springs are found in extensive areas: Ngaoundéré area, Mt Cameroon area and Manengouba area with Lake Moundou (EUEI-PDF, 2013).

2.4 Renewable Energy Policy/ Existing Policies and legal framework

Cameroon has set the goal of being an emerging country within the next 30 years, and announced 'Cameroon Vision 2035', which proposes a strategy to accomplish this goal. 'VISION 2035' can be considered as a reference framework that guides policy, national strategy, and development plans and cooperation for entire sectors and regions in Cameroon (Domra et al., 2017). The energy sector is one of the important sectors that will assist the country to achieve 'VISION 2035'

In Cameroun, a renewable energy policy is being prepared, with policy goals to increase the share of renewables in power and heat generation, and to involve private capital in the delivery of energy (FUSS, 2013). In order to attract private investors into the energy and renewable energy sectors in Cameroon, special mechanisms have been introduced: equipment manufacturers benefit from import tax reduction and special fiscal measures, and the Rural Energy Fund subsidises investments (70%) and studies (80%) in rural energy projects (Muh et al. 2018).

The government's policy seeks to get the country out of under-development, through the implementation of the long-term Energy Sector Development Plan (PDSE 2035) and the Poverty Reduction Strategy Paper (PRSP). Development of the energy sector is seen as a factor for attracting investment and strengthening growth.

Moreover, Cameroon's development objectives under the Vision 2035 envisage significant investments in the energy sector, with the inclusion of renewable. The policy goals of the government are to ensure energy independence through increased production and delivery of electricity, of oil and gas (petroleum resources) and to ensure their contribution to economic development.

However, prior to that, there are some existing policies that highlight renewable energy in Cameroon. The renewable energy sector has been in consideration since 1996 as according to article 24 of law N° 96/12 of 5th August 1996, relating to Environmental management. According to this article, the competent ministry in collaboration with the ministry in charge of environment and the private sector are in charge of producing renewable energy so as to protect the atmosphere. The level of intervention of each party is not clearly stated in this legal document.

The Law N° 2011/022 of 14th December 2011 governing the electricity sector in Cameroon attempts to organises the renewable energy sector in Cameroon (EUEI-PDF, 2013) creates Department of Renewable energy. Article 59 (2) imposes the use of renewable energy in the implementation of the decentralized rural electrification program so as to encourage environmental protection. This law also imposes the obligations for the energy operator to buy all renewable energies produced but the price is not fixed in this document.

3. Status of Geothermal energy in Cameroon

3.1 Geological setting: The Cameroon Volcanic Line (CVL)

The Cameroon volcanic Line is a linear magmatic megastructure of 100 km wide oriented N30°E, that extends more than 1500 km from Pagalu Island in the Gulf of Guinea to Lake Chad (Fitton, 1987; Deruelle et al, 1983, 2007). In the ocean sector it consists of four volcanic islands (Pagalu, Sao Tome, Principe and Bioko) and two seamounts, all located in the Gulf of Guinea (Fig. 2).

The continental area consists of series of volcanoes in Cameroonian territory. Monogenic volcanoes are Noun Plain (Wandji, 1995), Tombel and Tikar. Polygenic or stratovolcanoes are Mt Cameroon (Deruelle et al., 1983), Mt Manengouba, Mts Bamboutos (Marzoli et al, 2000), Mt Bamenda and Mt Oku. In the continental area of CVL, more than sixty an-orogenic complexes have been studied, including Mount Kupe, Nkogam, the massif Mayo Darle, Nlonako and Nda Ali. Initial activity concerning these an-orogenic complexes is dated at 82 Ma (Jurassic to Cretaceous) for plutonism and 51 Ma for basaltic volcanism.

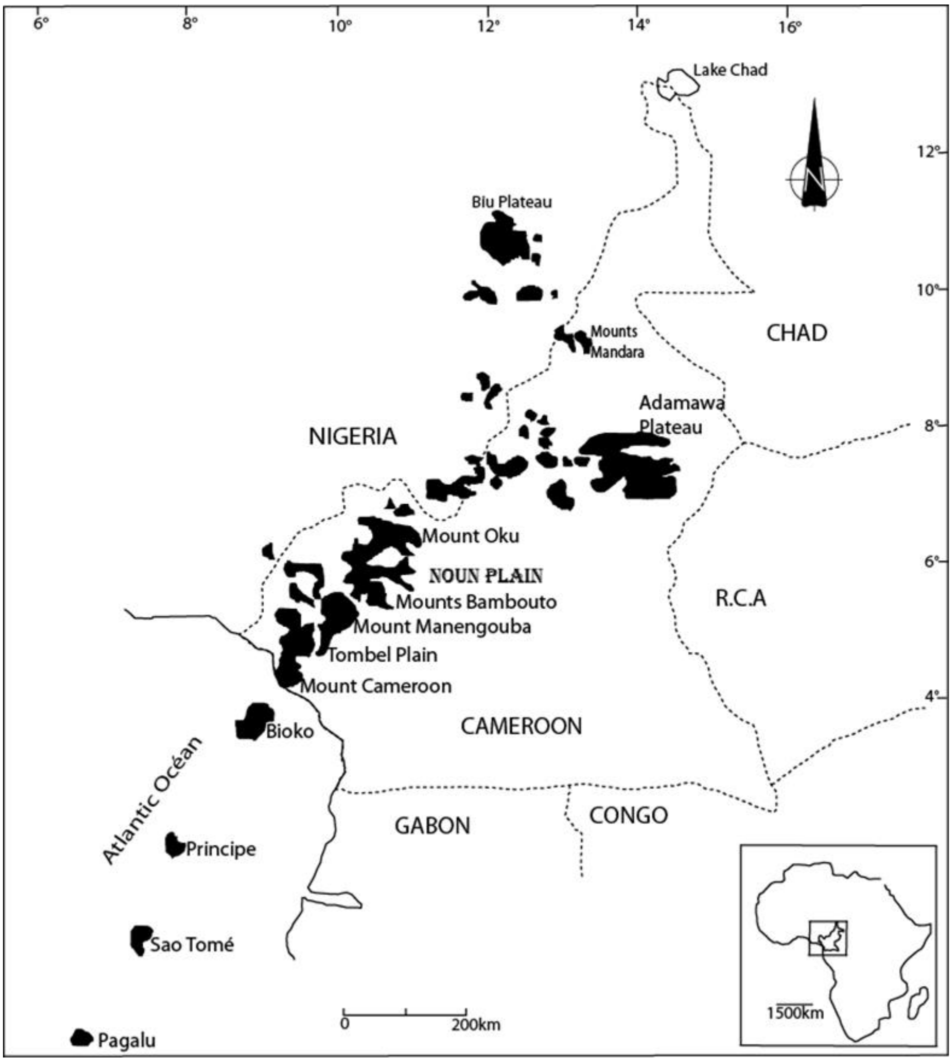

Figure 2: Cameroon Volcanic Line (simplified from Marzoli et al., 2000)

3.2 Geothermal hot springs

In Cameroon, a spring is characterized as thermal when its temperature is above the mean temperature of 23°C (Le Maréchal, 1976). One hundred and thirty thermal springs were recorded by Le Maréchal (1976). They are concentrated in the corridor of the CVL (Fig. 3)

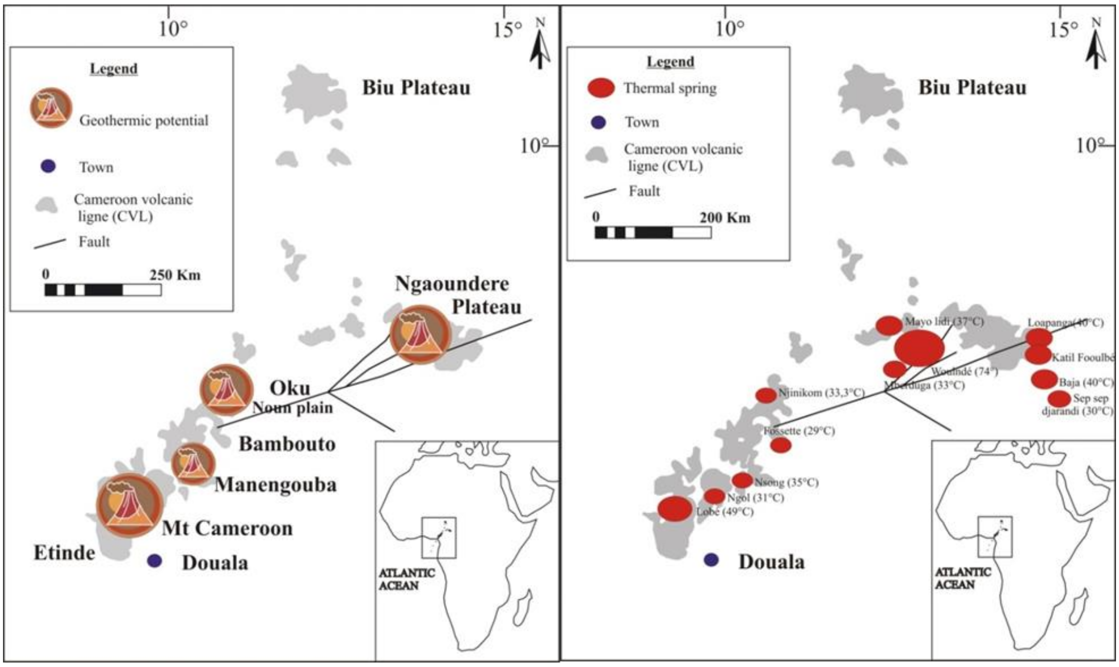

Figure 3: Presentation of some major thermal springs of the Cameroon Volcanic Line (Tetchou and Tchouankoue, 2014).

However, the current data available includes a detailed investigation of only 40% of the Cameroonian territory. The hottest spring (Woulndé, 74°C) is located in the Centre region of Cameroon, at the intersection between the CVL and the Adamawa shear zone, a transcontinental lineament that extends from Cameroon to the Red Sea. Just behind the Woulndé spring is the Lobe spring with a temperature of 49°C, located at the foot of Mount Cameroon. The location of these hot springs is distributed along the CVL. The largest number of springs is located in the region of Adamawa (see Annexure 2).

4. Methodology

This work is based on the analysis of literature that addresses the energy sector in Cameroon and geothermal energy in Cameroon. The data have been sourced from international organisations websites, government documents, peer-reviewed documents and other relevant reports relating to the study at stake.

In addition, in other to assess the level of awareness of academics on geothermal energy, a survey was conducted at the University of Yaounde I in Cameroon in June 2018. The setting was selected because it hosts a variety of students coming from other state universities to obtain their master degree there. The inclusion criteria included being a registered student in first or second year of master in Geology and being voluntary to participate to the study. A self-developed questionnaire (Annexure 3) was pretested and used to assess their level of awareness. Students were recruited in classroom after lectures and their consent was sought prior to the distribution of the questionnaires. A total of 200 questionnaires was distributed and 175 questionnaires were returned. The data was entered under the CS PRO software. A descriptive analysis of the results was conducted using the STATA software.

5. Data presentation, analysis and interpretation

From the study conducted on 175 Postgraduate students in Geology of the University of Yaoundé I to assess the level of knowledge of academics on geothermal energy in Cameroon, the results show that the majority of the students had already heard about geothermal energy at different levels (41% a little bit, 34% moderately, 13% enough and 4% deeply). Only 8% had never heard about geothermal energy (Fig. 4a). They mainly heard about it at the University, from mass media (Television and radio) and from internet respectively. Other ways they heard about geothermal energy were through friends and in high school (Fig. 4b). It is suggested that they might have heard about it in their lecture classes.

The results of this study show that hydroelectricity was mentioned as the main source of energy in Cameroon (93%), followed by solar energy (86%), hydrocarbons (61%), biomass (31%), and wind energy (22%). Only few (6%) mentioned nuclear energy in Cameroon whereas there is not (Fig. 4c). For the majority, the production of energy in Cameroon in relation to the demand is insufficient (55%) and unsatisfactory (36%). Only few of them judged it satisfactory (3%) or very satisfactory (3%). And another 3% had no idea about it (Fig. 4d).

In their opinion, among the obstacles to energy self-sufficiency in Cameroon, stand in good position the lack of appropriate technology, followed by financial resources, lack of qualified human resources, and lack of partnerships respectively (Fig. 4e). The other obstacles they mentioned are mainly poor energy policy, followed by poor policy and the non-use of all the available resources or of all the energy potential.

More than the half of the students (55%) thought that geothermal energy is a renewable source of energy, while 22% estimated that it is a non-renewable source of energy, and 23% did not know what kind of energy it is (Fig. 4f). This shows that despite the fact that the majority had already heard about geothermal energy mainly at the University, almost half of them did not have appropriate knowledge or understanding about it. Most of the students (72%) agreed that geothermal energy can be produced in Cameroon, while only 13% thought that it cannot be developed in Cameroon. However, a few of them (15%) did not know whether it can be developed in Cameroon or not (Fig. 4g). This result suggests that academics should be actors in any development of geothermal energy in Cameroon. And for conducting geothermal exploration in Cameroon, the participants of the study thought that geologists should be the main actors, followed by physicists, environmentalists, engineers and hydrologists respectively (Fig. 4h).

From the student’s perspective, the main stakeholders for the development of the energy sector in Cameroon are the Government, followed by academics, private enterprises, foreign Investors and industries (Fig. 4i). The majority (76%) agreed with the fact that by developing a new source of energy in Cameroon, it will benefit the population by enabling them to have access to energy at low prices. The students furthermore stated that the development of the energy sector in Cameroon will bring variety and sufficiency related to energy. On the other hand, only a few of them (15%) thought that developing a new source of energy will not reduce the price of energy because exploitation can be more expensive. For the rest (9%), they don’t have any idea of the impact this will have (Fig. 4j). These show that they are aware of the fact that academics have to play a major role in the development of any new source of energy and that there is a need of developing other sources of energy in Cameroon.

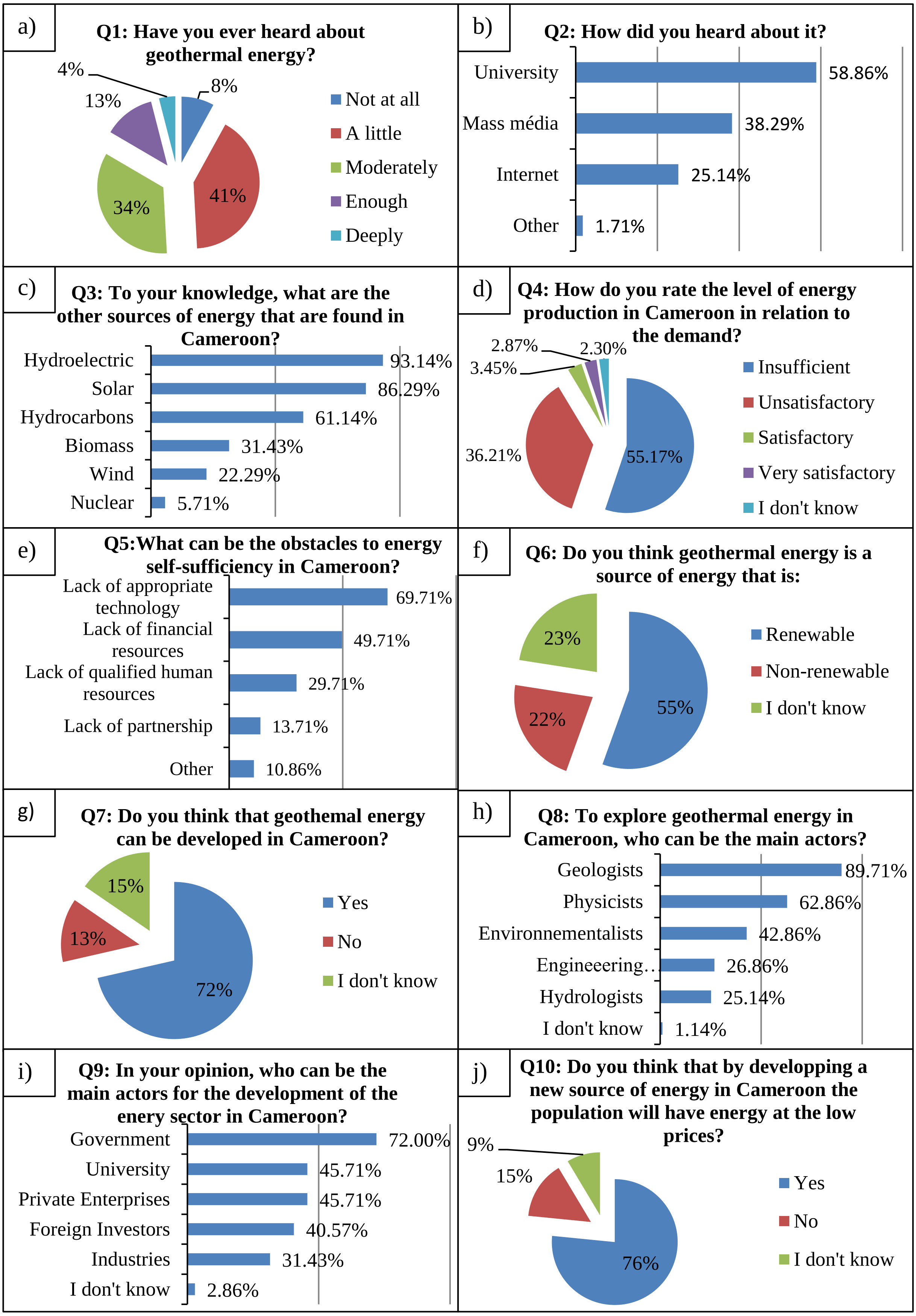

Figure 4: Results of the survey among 175 Postgraduate students of the University of Yaounde I in June 2018.

6. Discussion: Barriers to geothermal exploration

According to the literature review and the investigation, barriers to the exploration of geothermal energy are:

- Poor energetic policy: Cameroon unlike many other African countries such as Nigeria has no clear energy policy and hence no clear guidelines regarding renewables. However, most of the laws enacted in the Cameroonian parliament have aspects of renewables but mostly hydropower is usually addressed (Mas'ud et al., 2015). The regulatory framework of renewable energy is almost void despite some measures previewed by the 2011 law on electricity; the absence of application texts does not permit the active operation of renewable energy in Cameroon. Futhermore, the 2035 Energy Sector Development Plan gives future projections on renewable energies but do not consider other sources like geothermal, solar, wind and biogas (Muh et al., 2018);
- Incentives: There is an absence of fiscal incentives and subsidies for renewables, although the government of Cameroon has established a strategy to modernize the electricity sector with several measures to facilitate the deployment of renewables (Ngikam et al., 2009). The present prevailing framework in Cameroon does not encourage the widespread use of clean energy technologies given the high taxes and custom duties in the country (Muh et al., 2018). Also, renewable energy promoters are not exempted from taxes and this may have a political impact on both private and public sectors. There is lack of legislative texts that encourages the local manufacturing of renewable energy equipment;
- Institutional environment: there is a lack of strong, dedicated institutions, lack of clear responsibilities, complicated, slow or non-transparent permitting procedures. Inadequate investment regulations, standards and quality control mechanisms do not encourage investments. The legal framework of Cameroon is not clearly defined and also there are no existing texts on renewable energy sector in Cameroon. Meanwhile the Law No 2011/022 of 14 December 2011 governing the electricity sector of Cameroon gives a little attribution of renewable energy but with a lot of insufficiency;
- Techno-economic barriers: there is inadequate technological capacity and Cameroon being a developing country has a very low capital income thereby making it very difficult to afford for adequate technology to develop the renewable energy sector;
- Financial barriers: there have been inadequate funding opportunities in the sector of renewable energy in Cameroon;
- Infrastructure barriers: Absence of infrastructures such as an executing body to manage renewable energy government in order to integrate or absorb renewable energy;
- Inadequate knowledge about geothermal energy and unskilled personnel: Cameroon equally faces inadequate sensitization on the environmental benefits of renewable energy as well as the inadequate number of trained renewable energy experts in the country. In fact academics are among the main actors for the development of such a new domain and unfortunately their knowledge about geothermal seems insufficient;
- Low priority given to renewables development of geothermal energy: The Cameroonian government is the main actor for the development of the energy sector, but not much is done with regard to geothermal energy.

7. Conclusion and recommendations

Geothermal exploration in the aim of the identification and the characterisation of potential geothermal faces many challenges and obstacles in Cameroon despite the presence of a volcanic activity and geothermal manifestations. Among the main obstacles identified, there are inadequate policy, regulatory and institutional framework, funding constraints, technology constraints, inadequate skilled manpower and training institutions and unawareness of academics, government and investors.

Despite these obstacles, geological, geophysical and geochemical researches have to be nevertheless carried out; the main parameters for geothermal resource exploration being the identification of the heat source, reservoir rock, impervious cap rock and recharge of the system. In order to achieve a good geothermal exploration in Cameroon, the following geothermal activities have to be carried out: Geological survey, which consists mainly in geological mapping of potential geothermal areas to investigate the tectonic, volcanic and geology of the area. The aim of the structural geological mapping will be to expound on the structural setting of fields, to identify parameters that support the existence of a geothermal system namely; heat source, permeability and recharge mechanism; Geochemical surveys to predict subsurface temperatures, to obtain information on the origin of the geothermal fluid and to understand subsurface flow directions (Arnorsson, 2000). The results obtained after measurements of surface temperature, water and gas flow as well as water and gas analyses of the hot springs could also be used to assess the geothermal potential; And regional and semi-detailed geophysical studies carried out in geothermal prospect area with the aim of investigating the deep structures and to delineate possible geothermal reservoir and heat source. Many methods such as electrical, magneto telluric and gravimetric studies, using MT and TEM, DC resistivity methods, gravity and magnetics have to be conducted to study the subsurface structure.

Geothermal power is a reliable, low-cost, environmental friendly, alternative energy supply and an indigenous, renewable energy source, suitable for electricity generation. Economically, Cameroon depends a lot on agriculture, fishing and breeding, so the direct applications of geothermal resource could boost these sectors. Development of alternative energies from renewable sources such as geothermal will be a key part of Cameroonian's energy diversity.

We recommend therefore for the coming years:

- Detailed structural geology field mapping accompanied by geochemical and geophysics survey along the Cameroon Volcanic Line. If geophysical, geochemical and detailed structural mapping results prove positive the potential areas should be investigated further such as for the delineation of the reservoir to know its size and its volume;
- Introduction and application of new policies that will create a highly attractive climate for foreign investment, trade liberalization, financial sector reform, privatization, and special tax incentives;
- Creation of a national agency that handles the promotion of renewable energy;
- The Cameroon curricula should include studies in renewable energy at all levels;
- Massive sensitization in the area of renewable energy in Cameroon ;
- Training Cameroonian experts in acquiring, analysing and interpreting exploration data ;

- A fruitful collaborations with institutions specialized in geothermal energy around the world;
- Dissemination of information about possibilities of geothermal energy use in Cameroon among decision makers and search for funds.

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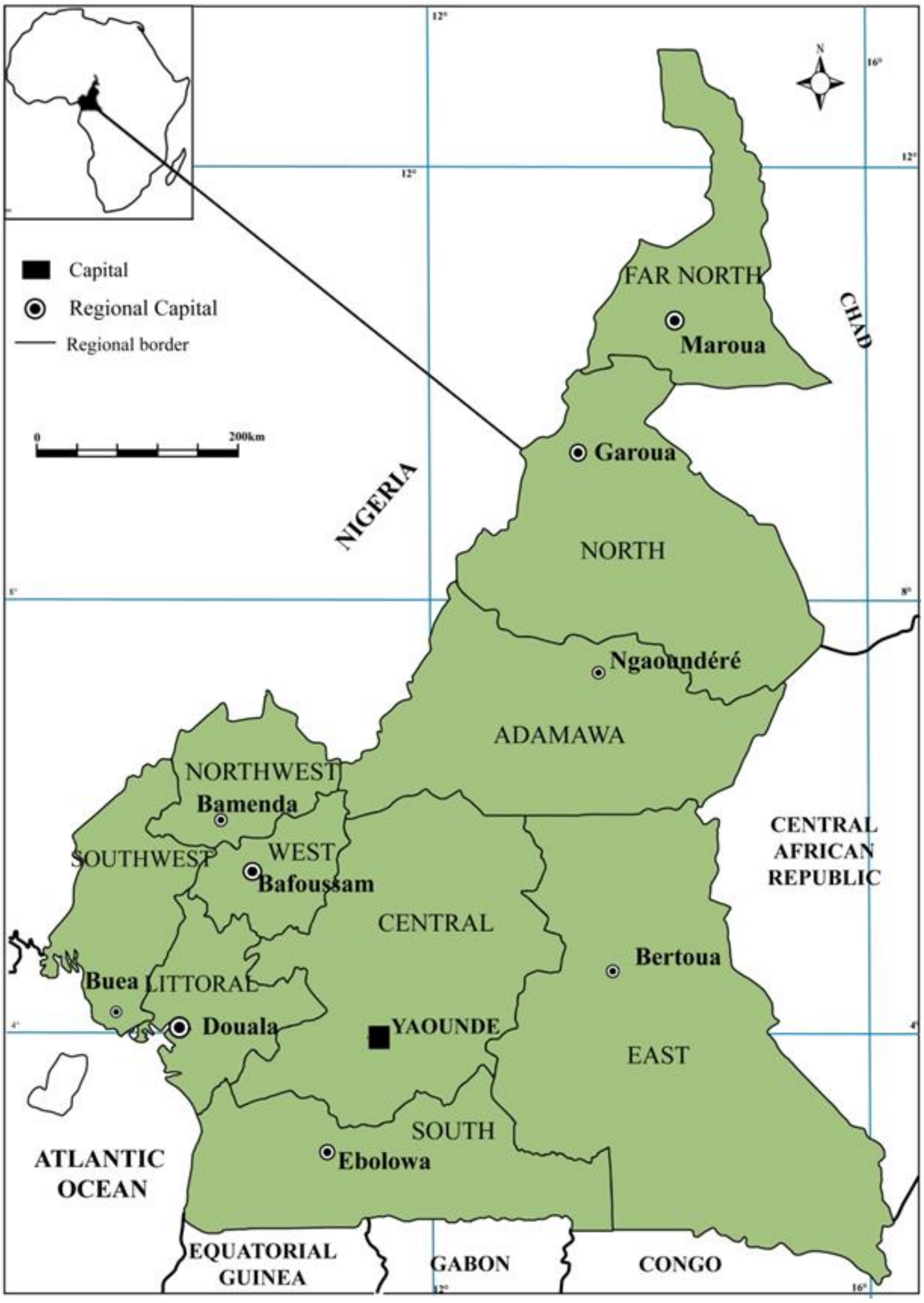
Annexure 1: Geographic map of Cameroon



Annexure 2: Distribution of thermal springs in Cameroon (Le Maréchal, 1976)

Region	District	Name	Coordinnates Long/Lat.	Temperatures (°c)
Adamawa	Ngaoundéré	Bajanga	14°00'35'' 7°17'10''	23.8
	Meiganga	Baja	18°06'10'' 7°08'55''	40.0
	Meiganga	Barkeje	14°45'40'' 7°00'50''	23.0
	Tignère	Bemlari	12°13'30'' 7°44'25''	25.0
	Tignère	Burlel 1	12°18'55'' 7°37'15''	27.0
	Tibati	Damfili	13°00'00'' 6°96'00''	25.6
	Tignère	Deodeo	12°02'10'' 7°28'25''	28.5
	Tignère	Donkere	12°13'35'' 7°46'25''	26.4
	Meiganga	Dzir Koya	14°40'25'' 6°56'00''	28.0
	Tignère	Falkoumre	12°35'30'' 7°19'35''	23.0
	Meiganga	Gbengubu	14°26'30'' 6°46'30''	23.0
	Ngaoundéré	Gogarma	14°15'30'' 7°18'25''	25.6
	Tignère	Guisire	12°24'25'' 7°25'10''	25.4
	Ngaoundéré	Katil Foulbe	13°56'00'' 7°06'00''	40.0
	Meiganga	Koulama	14°25'11'' 6°45'50''	26.0
	Ngaoundéré	Laobalewa 1	13°42'25'' 7°11'00''	23.4
	Ngaoundéré	Laofuru	13°35'25'' 7°12'10''	24.4
	Ngaoundéré	Laopanga	13°41'00'' 7°11'10''	40.0
	Tignère	Lasum	12°17'35'' 7°44'10''	28.8
	Meiganga	Mala0	14°02'20'' 6°46'40''	25.4
	Ngaoundéré	Matari	13°28'10'' 7°16'30''	23.0
	Tignère	Mayo Baleo	12°16'00'' 7°41'25''	25.2
	Tignère	Mayo Lidi	12°06'55'' 7°23'05''	37.0
	Tignhe	Nalti	12°28'00'' 7°49'30''	24.5
	Banyo	Nialan	11°35'25'' 6°31'00''	23.4
	Tignhe	Patarlay	12°19'40'' 7°37'35''	25.0
	Meiganga	Sep Sep Djarandi	14°58'40'' 7°05'00''	30.0

	Meiganga	Sep Sep Maloko	13°27’50’’ 6°21’20’’	23.0
	Banyo	Voure Mba	11’54’50” 6’59’30”	23.8
	Banyo	Voure Yelel	11°55’45’’ 6°58’55’’	23.6
	Tignère	Woulnde	12°28’30’’ 7°26’10’’	74.0
	Meiganga	Yaisunu	14°48’20’’ 7°01’35’’	23.0
	Tignère	Burlel 2	12°01’25’’ 7°29’25’’	25.4
	Tignère	Malam Jubairu	12°03’50’’ 7°28’15’’	23.3
	Tignère	Mamdugu	12°04’20’’ 7°29’25’’	26.0
	Tignère	Mberduga	12°09’20’’ 7°30’00’’	33.0
West	Manjo	Abang	9°45’50’’ 4°56’40’’	25.2
	Bangen,	Ahio-Ekanjo	9°41’30’’ 4°56’30’’	28.0
	Mamfé	Ayukaba	9°08’50’’ 5°41’55’’	28.6
	Bamenda	Bambui 2	10°15’25’’ 6°14’50’’	26.0
	Mélong	Bare 1	9°58’00’’ 5°00’35’’	25.8
	Mélong	Bare 2	9°57’20’’ 5°00’30’’	26.5
	Mélong	Ebuku	9°58’10’’ 5°02’50’’	26.4
	Bamenda	Fongakie	10°15’45’’ 6°03’25’’	23.4
	Foumbot	Fossette	10°38’40’’ 5°29’25’’	29.0
	Wum	Foundong Meteuf	10°14’20’’ 6°19’25’’	25.0
	Foumban	Kuchuantium	10°38’55’’ 10°50’10’’	23.8
	Foumban	Koutaba	5°36’45’’ 5°42’10’’	24.4
	Ekundu Titi	Lobe	9°05’25’’ 10°15’00’’	49.0
	Nkongsamba	Manengouba	9°53’10’’ 9°55’20’’	25.2
	Mélong	Mbuedum	4°51’20’’ 5°08’30’’	24.6
	Melong	Melong	9°59’05’’ 10°18’20’’	26.6
	Wum	Ndi	5°9’45’’ 6°26’30’’	25.2
	Bangen	Ndibisi	9°45’00’’ 9°46’10’’	28.5
	Manjo	Ngol	5°06’00’’ 4°51’45’’	31.0
	Njinikom	Nilli	10°16’30’’ 9°49’55’’	33.3

	Manjo	Nsoung	6°02’00’’ 5°00’00’’	35.0
	Nwa	Ntem	11°00’00’’ 10°17’55’’	27.0
	Wum	Nyos	6°20’00’’ 6°27’15’’	24.8
	Mamfé	Ebinsi	9°09’15’’ 5°41’20’’	28.0
	Mamfé	Mbakan	9°08’55’’ 9°01’25’’	25.0
	Mamfé	Akan-Mbe”	5°40’40’’ 5°42’55’’	27.6

Annexure 3: Questionnaire

Enquiry of Master's students in Geology, University of Yaounde I-Cameroon

Hello Madam, Sir, as part of a university research, we are conducting a study with geologists to know the level of information of academics regarding geothermal energy in Cameroon. This questionnaire is short and will only take a few minutes. Thanks for your help.

1. Have you ever heard about geothermal energy?
Not at all ☐ A little ☐ Moderately ☐ Enough ☐ Deeply ☐

2. How did you hear about it?
University ☐ Mass Media (Radio, Television) ☐ Internet ☐
Other: ....

3. To your knowledge what are the other sources of energy that are found in Cameroon?
Hydroelectric ☐ Solar ☐ Wind ☐
Biomass ☐ Nuclear ☐ Hydrocarbons ☐
Other: ....

4. How do you rate the level of energy production in Cameroon in relation to the demand?
Insufficient ☐ Unsatisfactory ☐ Satisfactory ☐ Very satisfactory ☐
I don't know ☐

5. In your opinion, what can be the obstacles to energy self-sufficiency in Cameroon?
Lack of financial resources ☐ Lack of qualified human resources ☐
Lack of partnership ☐ Lack of appropriate technology ☐
Other: ....

***Geothermal energy** refers to energy from the **heat** contained within the earth that can be used for **electricity** generation, mainly in volcanic regions and tectonic plate boundary areas.*

6. Do you think geothermal energy is a source of energy?
Renewable ☐ Non-renewable ☐ I do not know ☐

7. Do you think that geothermal energy can be developed in Cameroon?
YES ☐ NO ☐ I do not know ☐

8. To explore geothermal energy in Cameroon, who can be the main actors?
Geologists ☐ Engineering Engineers ☐ Physicists ☐
Environmentalists ☐ Hydrologists ☐ I do not know ☐

9. In your opinion, who can be the main actors for the development of the energy sector in Cameroon?
State/Government ☐ Private Enterprises ☐ Foreign Investors ☐
University ☐ Industries ☐ I do not know ☐

10. Do you think that by developing a new source of energy in Cameroon the population will have energy at the low prices?
YES ☐ NO ☐ I do not know ☐
Justify your answer:……………………………………………………………………………………..