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Opportunities for conducting practical work and field trips in petrography didactics in General Education Colleges (CEG) without laboratories, leveraging the local context: The case of the Gouré municipality, Zinder Region (Niger)

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Abstract

This study aims to analyze the obstacles hindering the organization of practical work and field trips in petrography didactics in general education colleges (CEG) without laboratories in the city of Gouré (Zinder region, Niger) in order to identify local opportunities to remedy this situation. The methodological approach was based first on a survey conducted in the city's five secondary schools using questionnaires sent to ten life and earth science (LES) teachers who regularly teach second- and third-year classes where petrography is taught. Investigations were then carried out in the urban environment and the immediate geological surroundings of Gouré in order to identify the resources available for practical teaching. The results reveal that the majority of teachers (more than 50%) have poor geological qualifications, a lack of practical skills in petrography, and a lack of awareness of the educational potential offered by the local geological context. In addition, one in five schools has an unequipped laboratory. The study recommends an alternative strategy based on four levers: (1) strengthening teachers' capacities through continuing education, (2) taking advantage of the local geological context, characterized by a diversity of magmatic, sedimentary, and metamorphic rock outcrops located near or within the city, (3) exploiting the local market, which offers relevant products and materials (hydrochloric acid, magnifying glasses, hammers, etc.) at low cost, etc.), (4) and using smartphones and the internet, which could be a practical alternative to traditional field tools such as GPS and compass.

Keywords: Petrography Didactics; Practical Work; Geological Field Trips; General Education College; Gouré; Niger

1. Introduction

Science education is now a major challenge for countries' socioeconomic development [1, 2]. In Niger, geology occupies a strategic place in Life and Earth Sciences (LES) programs, as it enables students to understand, manage, and develop the country's natural resources [3]. In middle school, geology is taught across all four grades, from first to fourth year classes. Petrography, which is the study of rocks (magmatic, sedimentary, and metamorphic), is taught in the second and third grades of middle school. Petrography is an essential foundation in geological education and the development of critical scientific thinking [4, 5]. Practical work and geological field trips are essential learning tools that promote observation, manipulation, and the construction of knowledge in petrography [6, 7, 8, 9, 10]. However, several studies

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show that most secondary school teachers of life and earth sciences find it difficult to teach petrography, especially when it comes to organizing practical work and field trips [11, 12, 13]. The difficulties associated with teaching geology in general and petrography in particular are reflected in the refusal and/or opposition of some teachers to teach second and third grades life and earth sciences classes. As a result, some second and third grades classes find themselves without life and earth sciences teachers for a long period of the school year. In addition, there is a high rate of absenteeism among certain teachers, or very often they favor teaching biology at the expense of geology. With regard to practical work and field trips in petrography, despite institutional recommendations calling for active and contextualized teaching [14, 15], the teaching of petrography often remains theoretical, transmissive, and disconnected from the real world. This situation is particularly pronounced in Nigerien middle schools without laboratories, such as those in the commune of Gouré, where teachers cite the lack of equipment as the main reason for not carrying out practical activities. However, the local geological context offers a variety of accessible natural resources that could serve as a veritable open-air educational laboratory [16]. This study therefore aims to analyze the obstacles to the practical teaching of petrography in general secondary schools (CEG) without laboratories in Gouré, and to identify local opportunities to overcome them. Specifically, it aims to (1) determine the qualifications and experience of life and earth science teachers in the city of Gouré, (2) to identify the teaching resources available for practical work and field trips in schools in the city of Gouré, (3) to characterize teachers' mastery of content and teaching approaches for practical work and geological field trips, and (4) to identify local opportunities that could enable practical work and geological field trips to be carried out effectively. To achieve these objectives, surveys were conducted in various secondary schools, in the city environment and in the field (around the city of Gouré).

2. Theoretical framework

2.1. Overview of the teaching/learning of petrography in secondary schools

In many countries around the world, the teaching of petrography has long been based on direct observation, practical work, and field trips, which are considered the foundations of geoscience education [3, 7]. However, several research studies reveal persistent difficulties among teachers and learners related to the conceptual complexity of rocks, the lack of scientific approach, and the lack of sample handling [11, 17, 18]. In many developing countries, geology teaching remains mainly theoretical due to a lack of laboratories, teaching materials, or specialized teacher training [9, 12, 13]. However, practical work and educational field trips are essential tools for developing observation, critical thinking, manipulation, and scientific interpretation skills [6, 8, 10]. In Niger, although the official science curriculum (Tables 1 and 2) recommends the study of rocks and the organization of experimental and field activities in middle school classrooms, their implementation remains limited due to a lack of laboratories, teaching resources, and insufficient initial and continuing teacher training [19, 20, 21]. This observation highlights the need to promote the local natural environment as a realistic teaching alternative.

Table 1 Topic on sedimentary rocks, content, objectives, and comments/observations

Content	Objectives	Comments/observations
CHAPTER 5.1: Study of some sedimentary rocks: -General characteristics -Formation process (no objective) -Physical and chemical properties - Simple classification	-Identify the general characteristics of sedimentary rocks based on field observations, documents, and samples viewed under a binocular microscope -Define: rock, sedimentary rock, sediment, ore, mineral - Determine the physical and chemical properties of sedimentary rocks - Explain the process of sedimentary rock formation - Classify sedimentary rocks according to the origin of the sediments - Explain the origin of salt deposits	- The aim is not to study rocks one by one, but to conduct a comparative study in order to determine the general characteristics of sedimentary rocks (stratification, presence of fossils) - We will study their characteristics and properties (loose, cohesive, porous, permeable, soluble, etc.) - The main focus will therefore be on the reactions of these rocks to water and/or acid, using a few simple experiments. - The aim is to distinguish between detrital, chemical, and biological sedimentary rocks. - Here, we will explain the phenomena of dissolution, precipitation, and evaporation in saline rocks. - With regard to clay, a simple explanation of its impermeability will be given. - NB: The different types of sand will not be discussed here

CHAPTER 5.2: Importance and management of sedimentary rocks - Importance of sedimentary rocks - Management of sedimentary rocks	Explain the importance of sedimentary rocks - Discover the concept of sediment and deposition (layering) - Rationally exploit sedimentary rock deposits	- To justify the term "sedimentary" in relation to these rocks, we will limit ourselves to the single characteristic of their layered or stratified arrangement. - Some examples of sedimentary rocks: sand, clay, table salt, gypsum, limestone, sandstone, coal, etc. - The importance of sedimentary rocks: the aim is to show that building materials (clay, limestone, sand, etc.), energy resources (oil, coal, etc.), minerals (gold, copper, iron, uranium, salts (table salt, natron, etc.)) are sedimentary rocks. - Avoid the excessive exploitation of sedimentary rocks (building materials and energy resources) as this leads to their depletion and environmental degradation.

Table 2 Topic on igneous and metamorphic rocks, content, objectives, and comments/observations

Content	**Objectives**	**Comments/observations**
CHAPTER 6.1: Volcanism - Volcanic eruptions: effusive and explosive types; - Products resulting from volcanic eruptions; - Distribution of volcanoes on the Earth's surface	- Characterize the different types of volcanic eruptions; - Recognizing the main products of volcanism (solids, liquids, gases); - Diagram the structure of a volcano - Locate volcanoes around the world;	The definitions of the concepts: volcano, volcanism, magma, magmatism should be derived from the learning activities carried out - The characteristics of volcanic eruptions can be discovered through the use of a film or other document - Simulations of volcanic eruptions can be carried out to illustrate the phenomenon; - An experiment involving the melting and cooling of sulfur can be carried out to show students that crystals can form from a hot liquid that cools down. - Maps showing the distribution of the world's major volcanoes, available in textbooks, can be used to locate volcanoes around the world. - NB: The teacher should be sure to show the difference between a volcano and a volcanic eruption. At this stage, there is no need to discuss plate boundaries.
CHAPTER 6.2: The Formation of Magmatic Rocks - The formation of magma; - Volcanic rocks: formation and structure; - Plutonic rocks: formation and structure;	- Identify some magmatic rocks; - Explain the formation of igneous rocks; - Explain the structure of igneous rocks - Create a simple classification table for magmatic rocks	Observing a sample of basalt and granite with the naked eye, then with a magnifying glass, allows you to recognize the structures of igneous rocks
CHAPTER 6.3: Formation of metamorphic rocks - Metamorphism - Metamorphic rocks: formation and structure	- Explain the factors involved in metamorphism - Identifying the characteristics of different types of metamorphism and their location	Based on observations of metamorphic rock samples, the teacher will introduce the concept of metamorphism, highlighting the initial rocks (sedimentary, igneous) and the conditions of transformation (temperature and pressure).

	- Explain the process of metamorphic rock formation - Determine the characteristics common to metamorphic rocks.	

2.2. Geological context of the Gouré locality

The geology of the Gouré department, commonly known as the "Mounio province" (Figure 1), is characterized by ancient Paleo- to Neoproterozoic formations, Late Carboniferous to Permian *"Younger Granites"* [16, 22, 23] and a recent sedimentary cover. (1) The ancient formations of the Mounio province are characterized by metasediments (schists and gneisses) and granites of Paleozoic to Neoproterozoic age [24, 25, 26]. They outcrop in a more or less isolated manner west of the town of Gouré (Figure 1). The metasediments are the result of metamorphism in the Green Schist to Amphibolite Facies [27]. (2) The *Younger Granites* in the department of Gouré occur as sporadic or continuous domes in the southern part, while in the north, in the area around the town of Gouré, they form a ring-shaped structure called *the " ring complex*." This ring-shaped complex consists, from the outside to the center, of volcanic, hypovolcanic, and plutonic rocks [24, 26, 28, 29]: (i) Volcanic rocks include pyroclastic rocks, rhyolites, and trachytes. (ii) Hypovolcanic rocks are characterized by microgranites. (iii) Plutonic rocks consist of granites and syenites [26, 28, 29]. (3) The sedimentary cover consists of dune sand, clay deposits, and sandstones from the Hamadian Continental [24, 29].

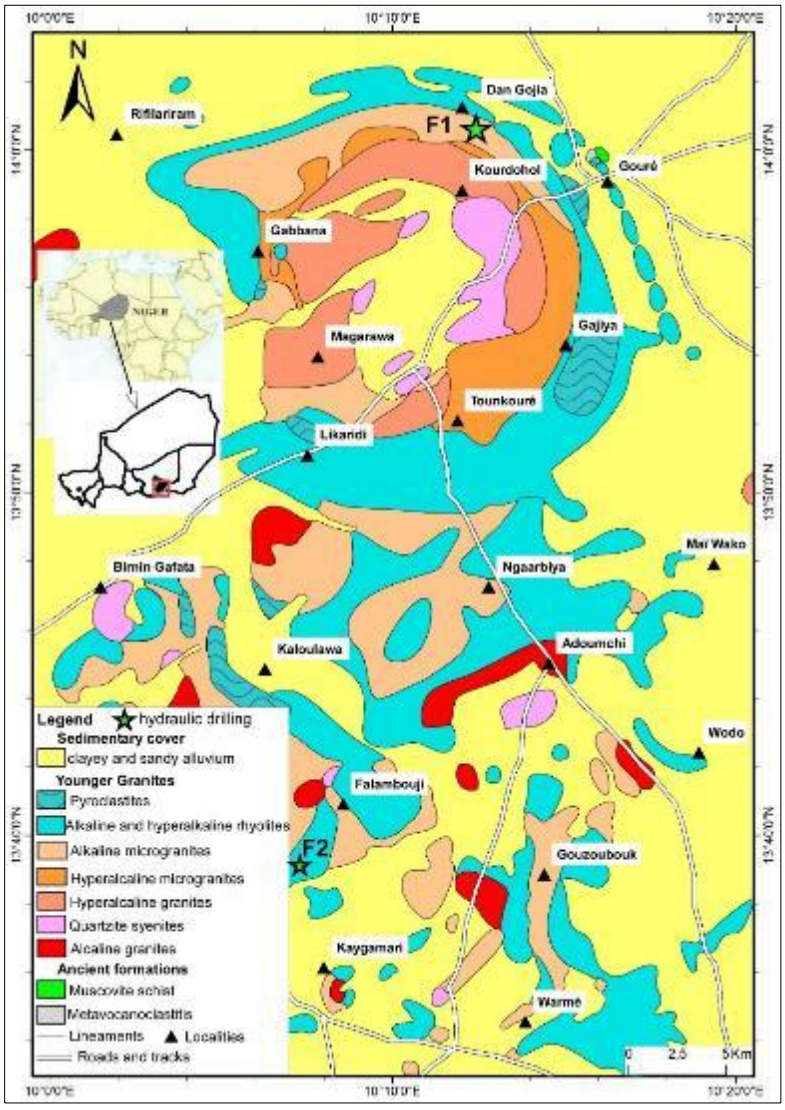

Figure 1 Geological map of the Mounio province [30]

3. Materials and methods

The methodological approach used in this study focused on three (3) areas.

- A survey was conducted in secondary schools in the town of Gouré (Zinder region, Niger). It covered all five public and private schools (Secondary Education Complex (CES), Private Secondary Complex (CSP), General Education College (CEG)) covered by the Gouré Secondary Education Inspectorate. The study targeted 10 Life and Earth Sciences (LES) teachers (Table 3) from secondary schools who usually teach second and third grades classes, to whom a questionnaire was sent. It should be noted that in Niger's secondary education system, petrography is taught in the 2nd and 3rd years of general education colleges. The questions asked were designed to gather information on teachers' qualifications and experience, the teaching resources available for practical work and field trips in secondary schools in the town of Gouré, teachers' mastery of the content and teaching approach for practical work and geological field trips, and knowledge of local opportunities for practical work and geological field trips. For this study, we chose to use a questionnaire as our data collection tool because it has the advantage of eliciting responses that can be quantified and summarized, particularly thanks to closed-ended questions. It also has the advantage of being able to be used with a large number of respondents, while respecting their anonymity and allowing them to express their opinions freely. The questionnaire given to teachers is preceded by a collection of personal information used to define the profile of the teacher concerned.

This survey was conducted in two phases :

  - Phase 1: This was the questionnaire testing phase. It consisted of introducing the questionnaire to five target teachers (teachers, educational advisors, and inspectors) in order to verify the relevance and effectiveness of the questionnaire.
  - Phase 2: This was the data collection phase. This phase lasted two months. All the target teachers received a questionnaire submitted to the administration of their school. All the teachers asked agreed to respond to our questionnaire.

The teachers' responses were entered and processed using Word and Excel.

- (2) A bibliographic search was conducted on the local geological context of the municipality of Gouré. Then, using the geological map of Mounio (Gouré), a field visit was conducted around the city to verify the existence of outcrops of magmatic, sedimentary, and metamorphic rocks (Figure 2) shown on the map. GPS readings were taken during this verification.
- (3) A survey was conducted in the city to verify the availability of the products and materials needed for practical petrography work and field trips (hydrochloric acid, hammer, magnifying glass, etc.).

Table 3 Secondary schools in the city of Gouré and teachers surveyed

No.	School	Neighborhood	Number of teachers surveyed	Existence of laboratory
1	CES MMT	Sabon Gari	2	Yes
2	CSP Liman Cherif	Administrative District	2	No
3	CSP Borko	Limandi	2	No
4	CES/FA Gouré	Tchadian	2	No
5	CEG 2 Gouré	Garin Toudou	2	No

Figure 2 Outcrop of volcanic magmatic rock (rhyolite)

4. Results

4.1. Teachers' qualifications and experience

The survey provided information on each teacher's status, qualifications (degree, specialization, and knowledge of geology), and length of service in teaching life and earth sciences. In Nigerien secondary education, there are three categories of teacher status: tenured, contract, and national civic service (ASCN). Tenured teachers are civil servants; contract teachers are teachers on fixed-term contracts; and ASCN teachers are recent graduates who voluntarily commit to two years of community service in various fields, including education. The survey results show that 30% of the teachers surveyed are permanent, 60% are contract, and 10% are national civic service volunteers (ASCN) (Table 4). This predominance of teachers with precarious status (contractual and ASCN, i.e., 70%) is not conducive to quality education, given the lack of stability and difficult living conditions compared to tenured teachers.

Table 4 Distribution of teachers by status

Status	Tenured	Contract	ASCN	Total
Staff	3	6	1	10
Percentage	30%	60%	10%	100%

The academic backgrounds of the teachers surveyed show a predominance of bachelor's degrees (40%) and diplomas from the Baccalauréat (BAC) +4/5 (Master's, Engineering, DEA, Master) (40%) (Table 5). It should be noted that in Niger's secondary education system, teachers qualified to teach middle school classes are those with a minimum of a BAC +2 degree. However, those with a BAC +4/5 degree are the most qualified. The latter category represents 40% of the sample in our study (Table 5), which is significant in Gouré compared to other localities in Niger. However, there is a lack of highly qualified graduates (BAC level) and a total absence of DAP/CEG or Licence/CEG degrees from the Ecole Normale Supérieure or faculties of education (Table 5), which are highly qualified degrees for teaching LES in middle schools in Niger.

Table 5 Distribution of teachers according to their qualifications**.**

Degree	Ing/Master's/DEA	Master (BAC+4)	Bachelor	DAP/CEG	BAC/CFEEN	Total
Staff	3	1	4	0	2	10
Percentage	30%	10%	40%	00%	20%	100%

Ing: Engineering degree. DEA: Advanced Studies Diploma. DAP/CEG: Diploma of Aptitude for Teaching in General Education Colleges. BAC: Baccalaureate. CFEEN: Teaching Diploma.

With regard to teacher training, it appears that only 10% (1), or one in ten teachers, have a degree in geology (biology + geology) (Table 6), compared to 90% (9/10) whose degree specialization is not geology (Table 6). This low percentage of teachers specializing in geology seriously hinders the teaching of geology in general and petrography in particular. Worse still, most (60%) of these teachers have degrees that are not relevant to the teaching of life and earth sciences (management, economics, human resources management, health technician, etc.).

Table 6 Distribution of teachers according to their degree specializations

Specializations of degrees	Biology	Geology	Biology + Geology	Psychology	Other	Total
Staff	1	0	1	2	6	10
Percentage	10%	00%	10%	20%	60%	100%

With regard to training in geology in general and petrography in particular, 70% of the teachers surveyed stated that they had received training in petrography (continuing or initial and continuing), with only one (1) having received initial and continuing training, compared to six (6) who had received only continuing training in petrography (Table 7). However, a considerable number (30%) of teachers surveyed reported never having received initial or continuing training in geology (Table 7). Among teachers (70%) who had received training (initial and/or continuing) in geology, 50% considered the content of the training insufficient to enable them to carry out practical work in petrography. These results reveal that a significant number of teachers (8/10) teach petrography without any training in geology or with insufficient training. However, all teachers reported having participated in several continuing education courses during their careers. It is therefore regrettable that the continuing education resources in geology available to teachers are, in a way, insufficient and only concern a minority of them. The teachers surveyed pointed out that continuing education courses in life and earth sciences often favor biology over geology because biology occupies the largest number of hours in secondary school life and earth sciences courses.

Table 7 Distribution of teachers according to the type of training in geology, particularly in petrography

Geology training (petrography)	Initial training	Continuing education	Initial and continuing training	None	Total
Staff	0	6	1	3	10
Percentage	00%	60%	10%	30%	100%

The survey revealed that only 30% (3/10) of teachers have less than 5 years' experience. This means that the majority of teachers (7/10, or 70%) have sufficient experience to teach the petrography chapters (Table 8). This proven experience of teachers is synonymous with a significant improvement in their teaching skills.

Table 8 Teachers' seniority by age group

Seniority (years)	Less than 5 years	5 to 10 years	More than 10 years	Total
Staff	3	4	3	10
Percentage	30%	40%	30%	100%

4.2. Availability of teaching resources for practical work

The survey examined the teaching resources recommended by Niger's official curriculum for organizing practical work in petrography. The teaching resources to be used by teachers consist of the official middle school science curriculum (content, objectives, recommendations), magmatic rocks (plutonic and volcanic), sedimentary rocks (detrital, chemical, and biochemical), metamorphic rocks (schists, gneisses), mineral scale (talc, gypsum, calcite, fluorite, apatite, orthoclase, quartz, topaz, corundum, diamond), hydrochloric acid (HCl), magnifying glass, water, and educational models (strata, fossils, etc.). When answering questions relating to official recommendations, 100% of the teachers surveyed emphasized compliance with the official curriculum guidelines. However, only one (1) of the city's five (5) schools has a laboratory at its disposal. This single laboratory in the municipality has very few of the teaching resources needed for practical work in petrography (hydrochloric acid and a few igneous rocks) (Table 9). This almost total

absence of laboratories and teaching materials for practical petrography work in the various schools in the urban municipality of Gouré (Table 9) proves that practical petrography work is not being carried out.

Table 9 Teachers' responses on the availability of teaching resources for practical work

Teaching resources for practical work	Staff	Percentage
Magmatic rocks	2	2%
Metamorphic rocks	0	0%
Sedimentary rocks	0	0%
Mineral scale	0	0%
Hydrochloric acid (HCl)	2	20%
Magnifying glass	0	0%
Water	10	100%
Models (Strata, fossils, etc.)	0	0%

4.3. Mastery of content and teaching approach for practical work and field trips

In order to carry out practical petrography work in an optimal manner, it is essential that teachers have the ability to describe rocks (magmatic, sedimentary, and metamorphic). In addition, the ability to organize practical work through the preparation of teaching sheets is an additional necessary asset. Furthermore, in geology, organizing field trips is key to consolidating the knowledge acquired during practical work.

With regard to the description of rocks, which is one of the specific objectives of teaching petrography and is essential for organizing practical work, it appears that 80% (8/10) of the teachers surveyed do not know how to describe rocks correctly (Table 10). Therefore, only 20% (2/10) of teachers know how to describe rocks correctly (Table 10).

Table 10 Distribution of teachers according to their ability to describe rocks

Ability to describe rocks	None	Poor	Average	Very good	Total
Staff	3	5	0	2	10
Percentage	30%	50%	00%	20%	100%

With regard to practical work in petrography, it appears that the overwhelming majority of teachers surveyed (80%) have little or no ability to carry it out (Table 11). This constitutes a major shortcoming in the teaching of petrography.

Table 11 Distribution of teachers according to their ability to carry out practical work

Ability to perform practical petrography work	None	Low	Average	Very good	Total
Staff	5	3	0	2	10
Percentage	50%	30%	00%	20%	100%

Geological field trips are also one of the main focuses of teaching/learning petrography. Teachers' ability to organize field trips is therefore essential. This study shows that the majority of teachers surveyed (8/10) have no ability to organize a field trip with students (Table 12). This is not surprising, as 80% of the teachers surveyed have neither sufficient training in petrography, nor a proven ability to describe rocks, nor a real ability to organize practical work. Many teachers justify this shortcoming by citing a lack of teaching materials for field trips, but also the complexity of geology, which they describe as a difficult subject. Many teachers say they would be able to use the internet to fill in the gaps in their knowledge if the necessary materials were available.

Table 12 Distribution of teachers according to their ability to organize a field trip

Ability to organize a field trip	None	Low	Average	Very good	Total
Staff	8	0	2	0	10
Percentage	80%	00%	20%	00%	100%

4.4. Knowledge of local opportunities for practical work

In Niger, the overwhelming majority of secondary schools do not have laboratories. Nevertheless, Niger's official curriculum strongly recommends the organization of practical work and field trips for teaching petrography. It turns out that Niger has a rich and diverse geology that offers the possibility of carrying out practical geology work even for schools without laboratories. Indeed, certain localities in Niger have the educational resources necessary to carry out practical work and geological field trips in their local context.

During this study, teachers of life and earth sciences in the town of Gouré were asked about their knowledge of local opportunities available in Gouré for organizing practical work and field trips in petrography teaching. The town of Gouré is surrounded by sites that are suitable and instructive for school geological excursions. These areas are also favorable for collecting rock samples (magmatic, sedimentary, and metamorphic) needed for the practical petrography work included in the official science curriculum in Niger. This survey shows that half (50%) of the teachers interviewed have no idea about the opportunities for practical work and field trips offered by the local geological context of the town of Gouré (Table 13). Only 50% of science teachers in the city of Gouré claim to be aware of some (but not all) of the opportunities for practical petrography work (Table 13), namely the availability of rocks (magmatic, sedimentary, and metamorphic), products for conducting rock identification tests (hydrochloric acid, water) and equipment used to describe rocks (magnifying glass), as well as suitable geological sites for geological excursions and the necessary equipment (GPS, compass, hammer, magnifying glass, geological map, etc.).

Table 13 Distribution of teachers according to their knowledge of local opportunities for practical work and field trips in petrography.

Knowledge of local opportunities for practical work and field trips	None	Low	Average	Very good	Total
Staff	5	3	2	0	10
Percentage	50%	30%	20%	00%	100%

5. Discussion

5.1. Discussion of the results obtained

The results of this study reveal, first and foremost, the precarious status and professional situation of teachers, who are predominantly contract workers and civic service volunteers. This finding is consistent with the analyses of [11, 13], which show that Earth science education in several countries relies on teachers who are not very stable and often insufficiently trained, making it difficult to engage in practical and innovative activities. This fragility is accentuated in Gouré by the scarcity of teachers with training in geology, confirming the idea already defended by [20]: the weakness of initial and continuing training is one of the main didactic obstacles in petrography. The very poor mastery of petrographic description, the organization of practical work, and field trips also illustrates a deficit in contextualized professional skills. This result reinforces the findings of [12, 17, 18], according to whom petrography is perceived as a complex discipline that requires hands-on, experimental contact with rocks in order to be taught effectively. However, as [9] show, the lack of hands-on activities significantly reduces students' understanding of geological concepts. The study also confirms that the lack of laboratories and teaching resources is a major institutional obstacle. This result is not isolated: it is recurrent in African and Maghreb education systems, where the teaching of geology remains theoretical, transmissive, and decontextualized [11, 19]. However, the literature has long emphasized the decisive role of practical work, hands-on activities, and direct observation in the construction of geological knowledge [6, 7, 8, 10].

5.2. Local opportunities for implementing practical work and field trips in petrography teaching in Gouré.

The teaching of petrography in Niger's general education middle schools involves practical work in the laboratory or classroom and the organization of field trips. In terms of practical work, the official Life and Earth Sciences (LES) program at secondary school includes the description of samples of igneous rocks (volcanic and plutonic), sedimentary rocks (detrital, chemical, and biochemical), and metamorphic rocks (schists and gneisses). In addition, the recognition of some common minerals (orthoclase, quartz, biotite, etc.) in crystalline rocks is strongly recommended, hence the study of the mineral scale. The same applies to the experiment involving the melting and cooling of sulfur. Tests for recognizing sedimentary rocks are also required in petrography teaching, namely: hydrochloric acid test and water test. Field trips involve taking students to sites where they can observe outcrops of igneous (volcanic and plutonic), sedimentary (detrital, chemical, biological), and metamorphic (schist and gneiss) rocks. This field trip is also an opportunity to introduce students to reading geological maps, orientation in the field using GPS and a compass, and finally, rock sampling using a geologist's hammer.

As secondary schools in the town of Gouré do not have the laboratories and teaching resources needed to carry out practical work and field trips in petrography, local opportunities can be exploited. (1) In terms of the availability of outcrops and rock samples, the geological context of the Gouré department is characterized by a diversity of igneous, sedimentary, and metamorphic rocks, which is a major asset for teaching petrography. The geology of the Gouré department is characterized by Younger granites that have intruded into Pan-African terrain (ancient rocks) [16, 30]. These ancient rocks are almost entirely covered by alluvial deposits (clay, sandstone, sand, etc.). These Younger granites consist of volcanic rocks (rhyolites, pyroclastites, trachytes), hypovolcanic rocks (microgranites), and plutonic rocks (granites and syenites) [30]. The ancient rocks consist of schists and metavolcanoclastites (gneiss) [30, 31]. Most of the outcrops of these rocks are located near the town of Gouré (less than 1 km away) (Figure 1). Better still, some outcrops can be found in certain neighborhoods of the town. Sedimentary rocks (clay, sandstone, sand, kaolin, limestone) are found throughout the city. This proximity of rock outcrops to the city could undoubtedly facilitate geological excursions and the collection of all types of rock samples recommended by the official petrography teaching program. (2) As for the products and equipment needed to organize practical work and field trips, the local context still offers the possibility of acquiring them at low cost. For example, hydrochloric acid, used to test for limestone, is available at an affordable price at the city's main pharmacy and at various pharmaceutical warehouses. The water used for testing the solubility, permeability, impermeability, and porosity of sedimentary rocks is free. Hammers and magnifying glasses can be purchased at hardware stores at affordable prices. GPS and compass applications are available on the PlayStore for Android phones. These applications can be installed on Android phones, which most teachers and students already have. For geological or topographical maps of the geological excursion area, the internet can be used to download and print several types of maps.

Thus, by mobilizing the local environment as an open-air laboratory, it is possible to circumvent the lack of infrastructure, in line with the recommendations of [15], who value the "real world" as a privileged space for the construction of scientific knowledge. This perspective is also in line with the European vision of science education based on investigation, autonomy, and experience [1, 2], as well as the epistemology of [4], for whom scientific knowledge is constructed by breaking with abstraction and confronting reality. Finally, teachers' lack of knowledge about local opportunities reveals a lack of field culture, which is nevertheless central to geology [5]. This shows that continuing education should not only reinforce petrographic content, but also develop contextualized professional skills: site identification, sample collection, field trip design, and educational scripting. Furthermore, this study contributes to an approach already present in the literature: making the local context and natural resources a sustainable, realistic, and equitable teaching tool [6, 7, 8].

6. Conclusion

This study shows that teaching petrography at the secondary level in the municipality of Gouré faces several constraints: lack of laboratories, insufficient material resources, poor geological training for teachers, and low participation in practical activities. However, contrary to prevailing perceptions, these obstacles are not inevitable. The rich and accessible local geological context offers educational opportunities for low-cost practical work and field trips. Promoting the natural environment, strengthening continuing education, pooling teaching resources, and providing institutional support are realistic ways to improve the teaching of petrography in Nigerien secondary schools without laboratories. This approach would not only help to strengthen teachers' skills, but also improve student engagement, motivation, and success.

Compliance with ethical standards

Disclosure of conflict of interest

All the authors declare no conflicts of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study

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