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REVIEWER'S REPORT

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Title: Petrography and Geochemical Characterization of the Lame Alkalin Basalts (Southwestern Mayo Kebbi) in the Cameroon Chad Volcanic Line: Implications for Tectonic Evolution and Mantle Source

Recommendation:
Accept as it is

Rating	Excel.	Good	Fair	Poor
Originality		√		
Techn. Quality		√		
Clarity		√		
Significance			√	

Reviewer Name: Dr. Manju M

Detailed Reviewer's Report

1. Regional Geological Framework

The Lamé basalts occur within the broader tectono-magmatic province of the Cameroon Volcanic Line, a linear intraplate system stretching from oceanic islands to continental interiors. This alignment reflects deep mantle processes rather than plate boundary volcanism. Its continuity across land and sea suggests a persistent mantle source. The line's orientation indicates structural inheritance from ancient lithospheric weaknesses. Such geological corridors often channel magma repeatedly over millions of years. Understanding this framework establishes the regional significance of Lamé volcanism.

2. Geographic–Tectonic Continuity

This volcanic alignment extends offshore beneath the Gulf of Guinea and onshore toward continental basins. Such continuity demonstrates that magma generation is not restricted to crust type. Instead, mantle dynamics control eruption distribution. Oceanic and continental segments share similar geochemical signatures. This reveals that lithospheric thickness variations do not fundamentally alter magma origin. Lamé basalts therefore represent a continental expression of a larger mantle system. Their study helps bridge marine and continental volcanic models.

3. Continental Segment Significance

On land, the volcanic chain stretches from Mount Cameroon toward interior basins. This indicates that volcanism migrated inland through time. The inland progression records tectonic reactivation of ancient structures. Such migration patterns help reconstruct stress fields in Earth's crust. Lamé basalts are part of this inland continuation. Their chemistry provides clues about mantle conditions beneath continental crust. Hence they serve as geological markers of deep Earth evolution.

4. Basin-Controlled Magmatism

The volcanic system reaches toward the Lake Chad Basin, where sedimentary basins overlie ancient basement rocks. Basin environments influence magma ascent paths. Sedimentary layers may trap heat and modify eruption style. However, Lamé samples show minimal crustal interaction. This indicates

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rapid ascent from mantle to surface. Basin volcanism therefore preserves primitive magma compositions. Such settings are ideal for studying mantle-derived magmas.

5. Comparative Volcanic Provinces

Chad hosts several volcanic provinces, notably the Tibesti Volcanic Province. Comparing Lamé rocks with these regions reveals geochemical parallels. Similar alkaline compositions suggest shared mantle sources. Regional comparisons strengthen correlations between distant volcanic centers. They also help identify temporal volcanic pulses. Lamé basalts fit within this broader magmatic province. Thus they contribute to reconstructing Central African volcanic history.

6. Reference Volcano Analogue

The geochemical similarity between Lamé basalts and lavas from Emi Koussi supports a common petrogenetic process. Both show alkaline signatures and enrichment in incompatible elements. Such parallels imply similar melting depths. They also suggest comparable mantle source compositions. Studying analog volcanoes validates interpretations drawn from limited samples. Lamé basalts therefore gain context through regional comparison. Analog studies reduce uncertainty in petrogenetic models.

7. Structural Control Mechanism

Regional tectonics are influenced by the Central African Rift System, which reactivated older Pan-African structures. Rift-related stresses facilitate magma ascent. Faults act as conduits linking mantle reservoirs to the surface. Lamé volcanism likely exploited these structural weaknesses. This explains the linear distribution of volcanic centers. Rift systems often coincide with alkaline magmatism. Hence tectonics and magmatism are genetically linked.

8. Local Geological Setting

The basalts were sampled in the Mayo Kebbi massif, an area with limited volcanic exposure. Sparse outcrops make each sample geologically valuable. The massif consists mainly of Precambrian basement rocks. Volcanic intrusions here therefore represent later tectonic events. Their presence indicates episodic mantle melting. Even small volcanic remnants can record large-scale mantle processes. Thus this locality provides crucial geological evidence.

9. Objective of the Study

The primary objective was to determine the petrographic and geochemical characteristics of Lamé basalts. Researchers aimed to identify mineral composition, magma evolution, and mantle source type. Another goal was to compare Lamé rocks with regional volcanic suites. This approach helps establish tectonic affiliation. Determining whether magmas are primitive or evolved was also essential. Ultimately, the study sought to clarify their role in Central African geodynamics.

10. Field Sampling Strategy

Field campaigns focused on collecting fresh, unaltered rock specimens. Careful selection ensured reliable chemical data. Weathered samples can distort geochemical signatures. Researchers documented color, texture, and mineral visibility. These observations guided laboratory analyses. Nine representative samples were chosen. This systematic approach ensured analytical consistency.

11. Laboratory Preparation

Samples were cut, crushed, and powdered under controlled conditions. Crushing equipment avoided contamination from foreign metals. Powder homogenization ensured uniform composition. Fusion with lithium borate produced stable glass pellets. Dissolution in acid allowed precise chemical analysis. Such

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preparation is essential for reproducible results. Accurate preparation underpins reliable geochemical interpretation.

12. Analytical Techniques

Chemical analyses were conducted at ALS Geochemistry-Loughrea using ICP-AES and ICP-MS methods. These techniques measure major and trace elements with high precision. ICP-AES quantifies major oxides. ICP-MS detects trace elements at very low concentrations. Combined methods provide a full geochemical profile. Spectral corrections remove analytical interference. Such high-quality data enable robust interpretations.

13. Petrographic Characteristics

Microscopic examination shows a microlitic porphyritic texture. This indicates rapid cooling after eruption. Phenocrysts formed earlier in magma chambers. The fine matrix crystallized during final cooling. Such textures are typical of basaltic lava flows. They reveal magma ascent history. Texture analysis complements chemical data.

14. Mineralogical Composition

The basalts contain dominant clinopyroxene and olivine with minor plagioclase. Opaque oxides occur as accessory phases. Mineral proportions indicate mafic composition. Zoned olivine crystals suggest changing magma chemistry. Altered plagioclase reflects post-eruption processes. Mineral assemblages confirm alkaline basalt classification. Mineralogy therefore supports geochemical evidence.

15. Major Element Geochemistry

Silica contents range from ~44–50 wt.%, typical of basalts. MgO values indicate relatively primitive magma. Stable Al_2O_3 suggests limited plagioclase fractionation. Decreasing Fe_2O_3 and MgO with silica indicates crystal removal. These trends reflect fractional crystallization. Chemical correlations confirm magmatic differentiation. Major elements thus record magma evolution.

16. Trace Element Signatures

High Cr and V contents point to mantle origin. Enrichment in Ba and Sr reflects incompatible element concentration. Positive correlations with Th indicate progressive differentiation. Declining Cr with Th confirms crystal fractionation. Trace elements act as fingerprints of magma processes. Their patterns match intraplate basalt signatures. Hence trace chemistry validates tectonic interpretation.

17. Rare Earth Element Patterns

The basalts display enrichment in light rare earth elements. Heavy rare earth elements are comparatively depleted. Such patterns indicate melting in the presence of garnet. Parallel REE curves resemble ocean-island basalt trends. Slight Eu anomalies suggest minor feldspar influence. REE data are powerful mantle indicators. They constrain melting depth and source composition.

18. Fractional Crystallization Evidence

Binary diagrams show systematic oxide decreases with increasing silica. This reflects removal of olivine and clinopyroxene during cooling. Mg# values below primary magma levels confirm differentiation. Constant Sr despite rising Rb also supports fractionation. These trends reveal orderly magma evolution. No chaotic mixing is evident. Thus differentiation occurred in a closed magmatic system.

19. Absence of Crustal Contamination

Geochemical ratios such as La/Nb remain low. Such values indicate minimal interaction with continental crust. If contamination occurred, these ratios would increase. Stable Sr values also argue against crustal

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assimilation. Therefore magma ascended rapidly. This preserved primary mantle signatures. The basalts are thus geochemically pristine.

20. Mantle Source Characteristics

High Nb/U ratios and trace element patterns indicate a HIMU-type mantle source. HIMU sources are enriched in recycled oceanic material. Garnet presence (4–8%) implies deep melting conditions. Partial melting degrees of 3–8% were estimated. Such low melting fractions produce alkaline magmas. The mantle source was metasomatized previously. Hence Lamé basalts reflect deep mantle heterogeneity.

21. Tectonic Evolution Implications

The results support a model of intraplate volcanism linked to lithospheric reactivation. Ancient structural zones acted as magma pathways. Regional geochemical similarity suggests a shared mantle plume or enriched domain. The Lamé basalts therefore represent northern continuation of the volcanic line. They confirm large-scale mantle control of volcanism. This strengthens the concept of a unified magmatic province. Such insights refine tectonic reconstructions of Central Africa.

22. Significance and Recommendations

This study demonstrates that small volcanic outcrops can reveal major geodynamic processes. Lamé basalts provide clear evidence of mantle-derived alkaline magmatism. Their pristine chemistry makes them valuable reference samples. Future work should include isotopic analyses for precise source tracing. Expanded sampling across the region would refine melting models. Integrating geophysics with geochemistry could map mantle structures. Continued research will improve understanding of continental intraplate volcanism.