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December 27, 2023

## Abstract

The Cameroon Volcanic Line (CVL) and other tectonic features in Cameroon remain enigmatic, prompting ongoing debates about their detailed structure, composition, and geodynamic evolution. To shed light on these complexities, we leverage the ambient noise tomography (ANT) method to invert shear wave velocity ( $V_s$ ) and image subsurface structures, providing crucial insights into both subsurface geology and deep crustal processes. Specifically, we employed two different methods: Markov chain Monte Carlo (MCMC) and Evolutionary Algorithm (EA) inversions to robustly constrain the  $V_s$  velocity structure,  $V_p/V_s$  ratio, and density beneath the CVL and its surrounding area. Our results reveal a prominent high-velocity structure at depths of 25 to 35 km, which precisely aligns with the CVL. Within this region,  $V_s$  velocities reach up to 4.0 km/s, accompanied by a  $V_p/V_s$  ratio ranging between 1.85 and 1.88 and density varying from 2.9 to 3.1 g/cm<sup>3</sup>. These characteristics suggest the presence of cooled mafic material that has intruded the crust. Our 2D depth cross-sections along the CVL indicate that these cooled mafic intrusions are ubiquitous along the entire volcanic line. However, they are spatially separated from the upper crust's volcano-plutonic structure by a thin intermediate structure exhibiting a  $V_p/V_s$  ratio of 1.68 to 1.71 and an average  $V_s$  velocity of 3.8 km/s, indicative of felsic to intermediate crust, which may be linked to the Pan-African Orogeny. The high  $V_p/V_s$  ratio and  $V_s$  velocity structures are found closer to the surface in the recently active volcanic provinces, accompanied by a thinner low  $V_p/V_s$  structure. We posit that this thinned low  $V_p/V_s$  structure may have facilitated the ascent of mafic material, contributing to recent volcanic activity in the region. Conversely, beneath the Oubanguides belt and Congo craton, these low  $V_p/V_s$  structures appear thicker, with mafic intrusions present at depth  $> 35$  km. This observation suggests a dynamic process involving the pushing and exhumation of lower crustal material by the mafic material. Our crustal imaging results hold significant implications for our understanding of the region's geodynamic evolution, suggesting an interaction with deeper structures, may be responsible for the crustal intrusions and volcanism observed along the CVL.

# Crustal Structure Beneath the Cameroon Volcanic Line and Surrounding Area: Insights from Markov Chain Monte Carlo and Evolutionary Algorithm Based Shear Wave Velocity Inversion

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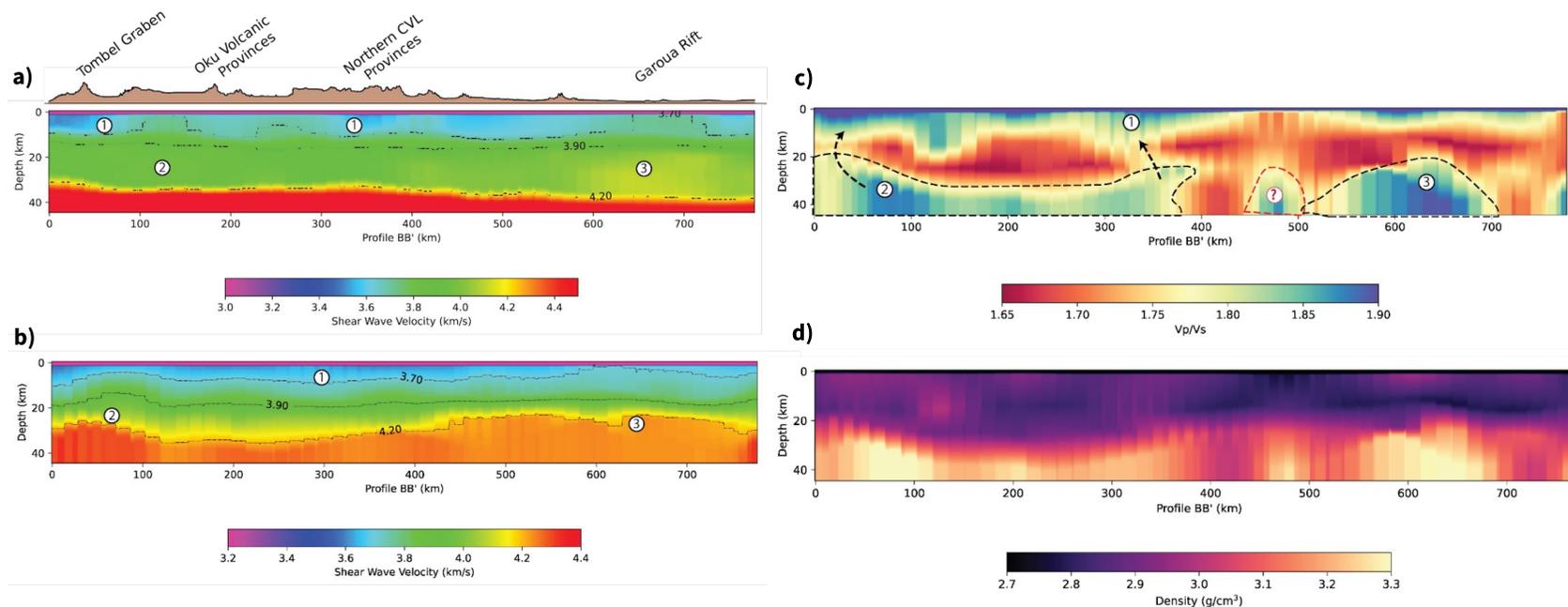
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## Highlights

- Applied Competitive Particle Swarm Optimization (CPSO) inversion of shear wave velocity and  $V_p/V_s$  inversion with ambient noise tomography.
- We identified a high-velocity structure with high  $V_p/V_s$  value beneath the Cameroon Volcanic Line (CVL) at 25-35 km depths, suggesting cooled mafic intrusions.
- Cooled mafic intrusions are spatially separated from the upper crust's volcano-plutonic structure by a thin low  $V_p/V_s$  structure is metamorphosed granulitic crust formed during Pan African Orogeny and was later thinned by the Mesozoic rifting
- Lateral variation in thickness and physical properties of crust played a crucial role in the distribution of magmatism along the CVL.

## Graphical Abstract



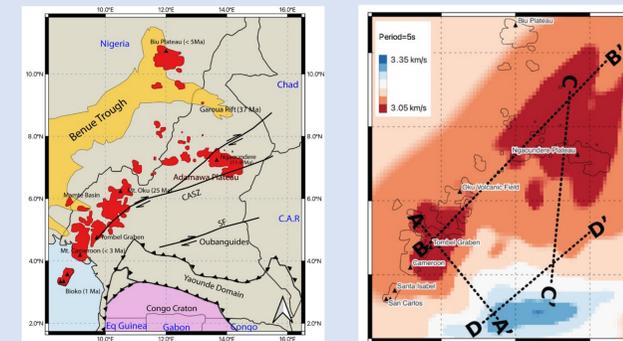
## A depth cross section along the CVL

- Shear wave velocity inversion using MCMC.
- Shear wave velocity inversion using CPSO.
- $V_p/V_s$  values obtained through CPSO inversion.
- Density estimates.

**Label 1** marks a low-velocity zone beneath the volcanic provinces characterized by a high  $V_p/V_s$  ratio which may be **potential source for magmatism**. Notably, the high-velocity zone marked by **label 2** is situated beneath the CVL, reaching as close as 10 km to the surface

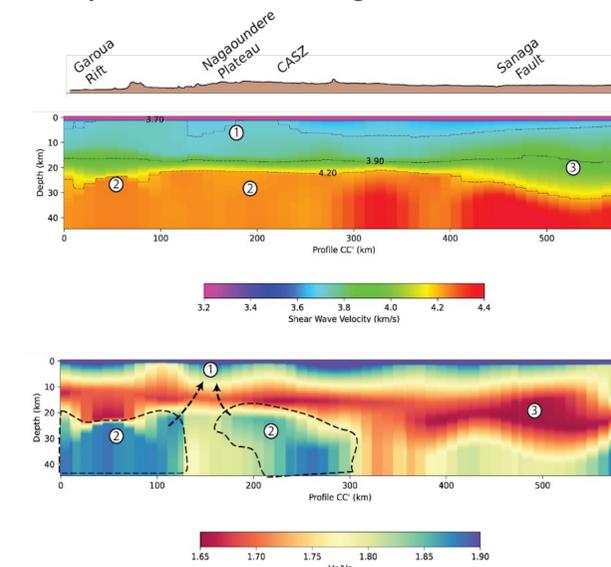
at certain places. These high-velocity zones suggest a mafic nature, **potentially indicative of cooled mafic intrusions**. Additionally, observe the **thinner mid-crustal regions** with low  $V_p/V_s$  ratios, particularly at locations of recent volcanic eruptions. It is postulated that these regions represent **thinned metamorphosed granulitic crust**. These observations suggest that recent magmatic activities may have originated from areas of crustal weakening and thinning, allowing magmatic material to ascend to the surface through the propagation of deformed zones within the Pan-African Belt (PAB) crust.

## Major Geological Features in Cameroon (Left) and corresponding Ambient Noise Tomography (Right).

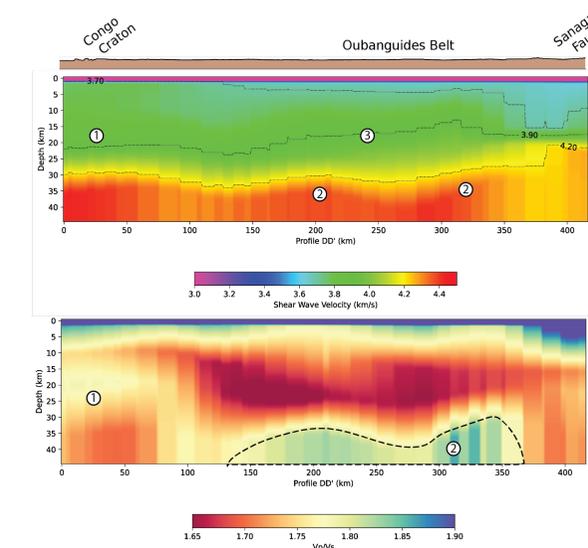


Ages of recent magmatism, do not display the typical age progression associated with the hotspot hypothesis

## Inverted depth cross section through the CVL and the surrounding areas



The presence of a **slow-velocity structure** in the northeastern part of the CVL, indicated by **Label 1**. **Label 2** highlights a high-velocity crustal intrusion beneath the volcanic region. **Label 3** may be a thick mid-crustal structure within the Central African Shear Zone (CASZ). It's noteworthy that these structures become thinner as they approach the CVL.



**Label 1** highlights the gradual increase in velocity, from 3.7 km/s in the upper crust to over 4.0 km/s in the lower crust, characteristic of cratonic regions worldwide. **Label 3** points to the presence of a thick, deformed PAB crust, characterized by slightly higher velocity and a low  $V_p/V_s$  ratio. This may be attributed to metamorphosed granulitic crust. **Label 2** identifies a high velocity underplating structure beneath the PAB, a feature commonly observed beneath various Proterozoic terrains.