Paleoenvironmental implications of trapped interbasaltic volcaniclastic rocks within Late Cretaceous Deccan volcanic province India

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Background

The Deccan volcanic province is one of the largest mafic volcanic province of world. It is extensively studied in the context of the mantle plume model, K–Pg boundary, Cretaceous mass extinction, associated climate change and biotic crises. However, fewer studies have been done on understanding the paleoenvironmental implications of trapped volcaniclastic rocks inbetween the lava flow. The Late Cetaceous interbasaltic volcaniclastic rocks i.e., named as bole beds offer a unique set-up to understand the paleoenvironmental conditions prevailing during the non-eruptive phases at the time of Deccan volcanism.

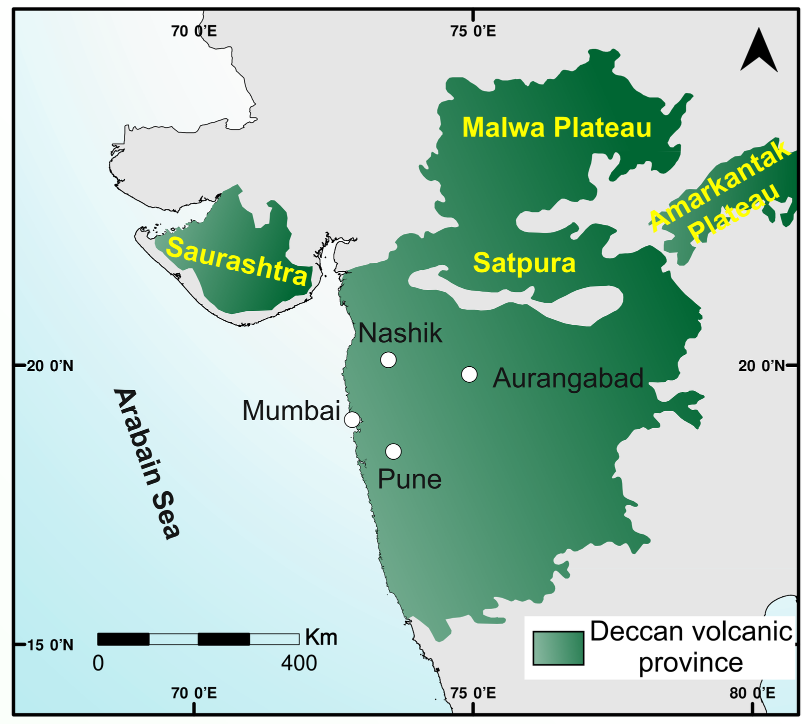


Fig. 1. Outline map of Deccan volcanic province

Objective

- The study focuses on understanding the paleoenvironmental conditions prevailing during the non-eruptive phases at the time of Deccan volcanism.
- Difference in paleoenvironment of formation of red and green bole.

Materials and Methods

A detailed field investigation was carried out near Pune, Nashik and Aurangabad in Maharashtra, India to understand different physical attributes like vertical and lateral thickness, contact with overlying and underlying basalt, bedding/lamination, variation in colour along and across the profile etc. Microscopic study of collected red and green boles were examined using optical microscope and scanning electron microscope. The mineralogical investigation of clay minerals associated with interbasaltic bole was investigated using X-ray diffraction and Fourier transform infrared spectroscopy.

Results: Field investigation

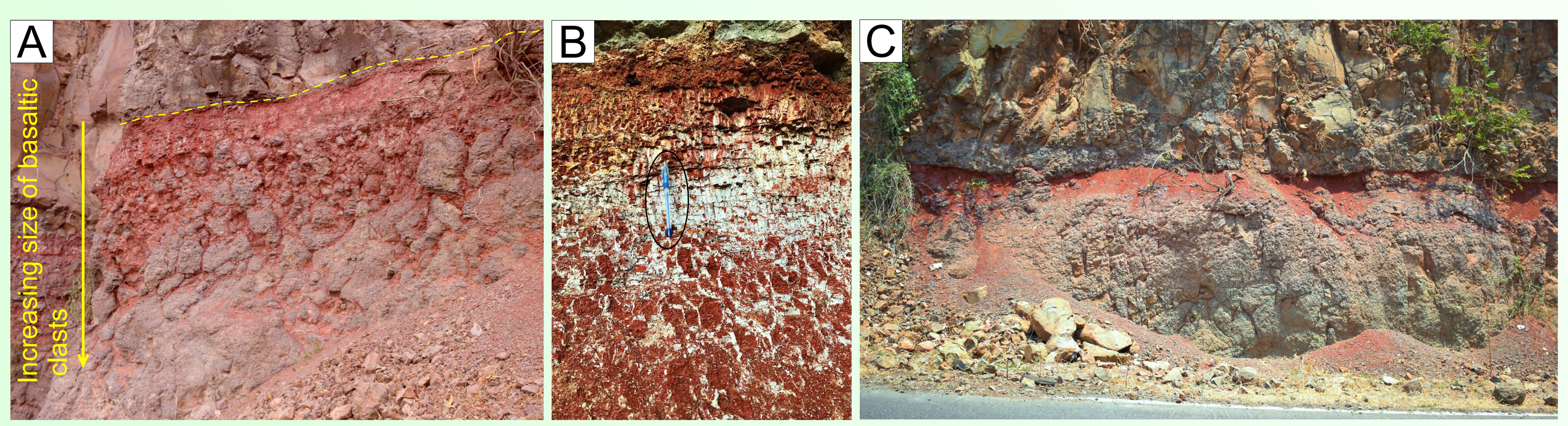


Fig. 2. Field photographs showing (A) ~2m thick prominent red bole having sharp contact with the altered sole of overlying basalt and gradational contact with underlying weathered amygdaloidal basalt. Note the size of basaltic clasts increases downward towards the massive part of lower basalt; (B) Enlarged Image of A. Note the extensive network of white secondary minerals present; (C) uneven to sharp lower contact of ~40 cm thick red bole.

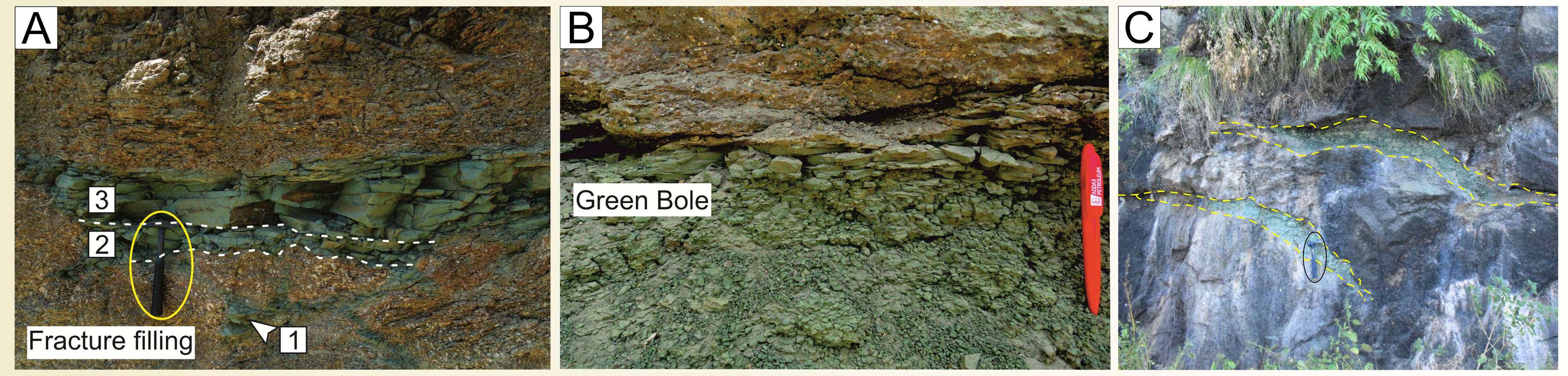


Fig. 3. Field photographs of green bole showing (A) ~ 35 cm thick isolated pocket of laminated green bed lying above the weathered flow top. The lower part of green bed occur as fracture filling; (B) ~ 20 cm thick fissile green bed on fragmentary basaltic flow top; (C) ~25 cm thick green bole occurring at the top of lava lobes.

Results: Microscopic and ultramicroscopic study

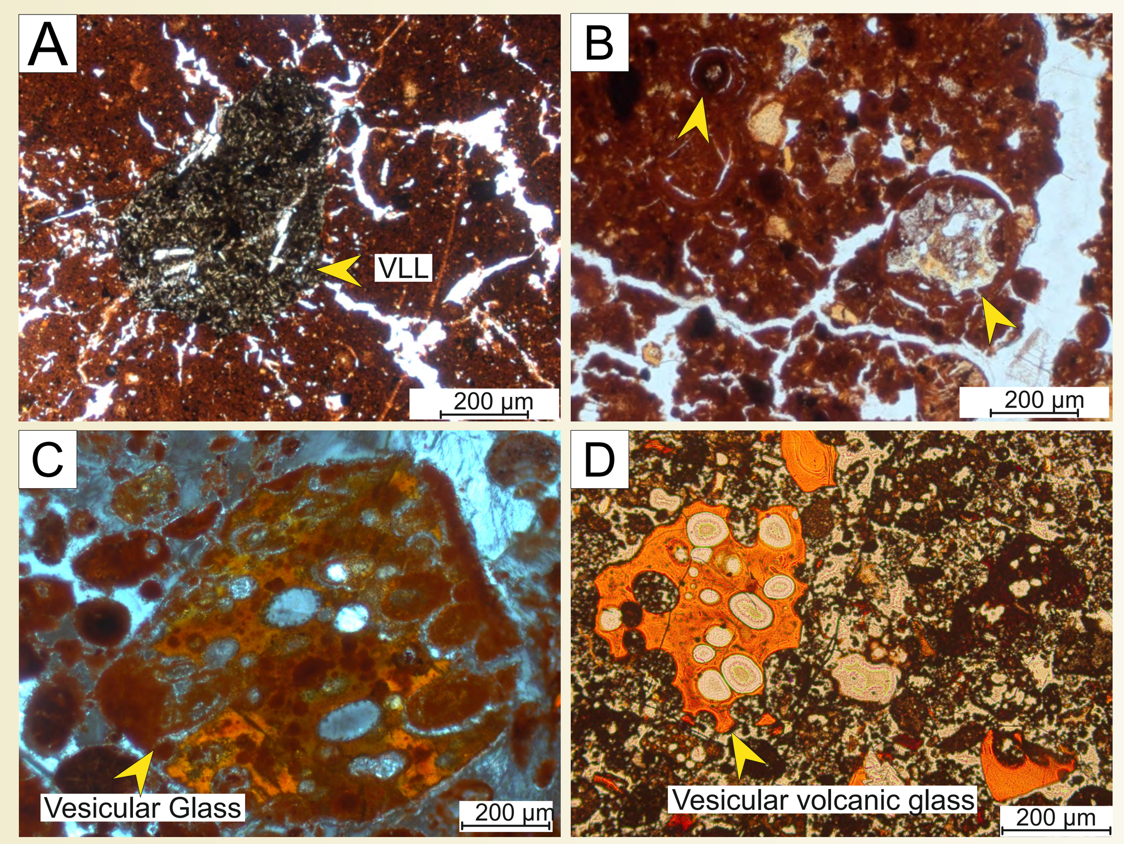
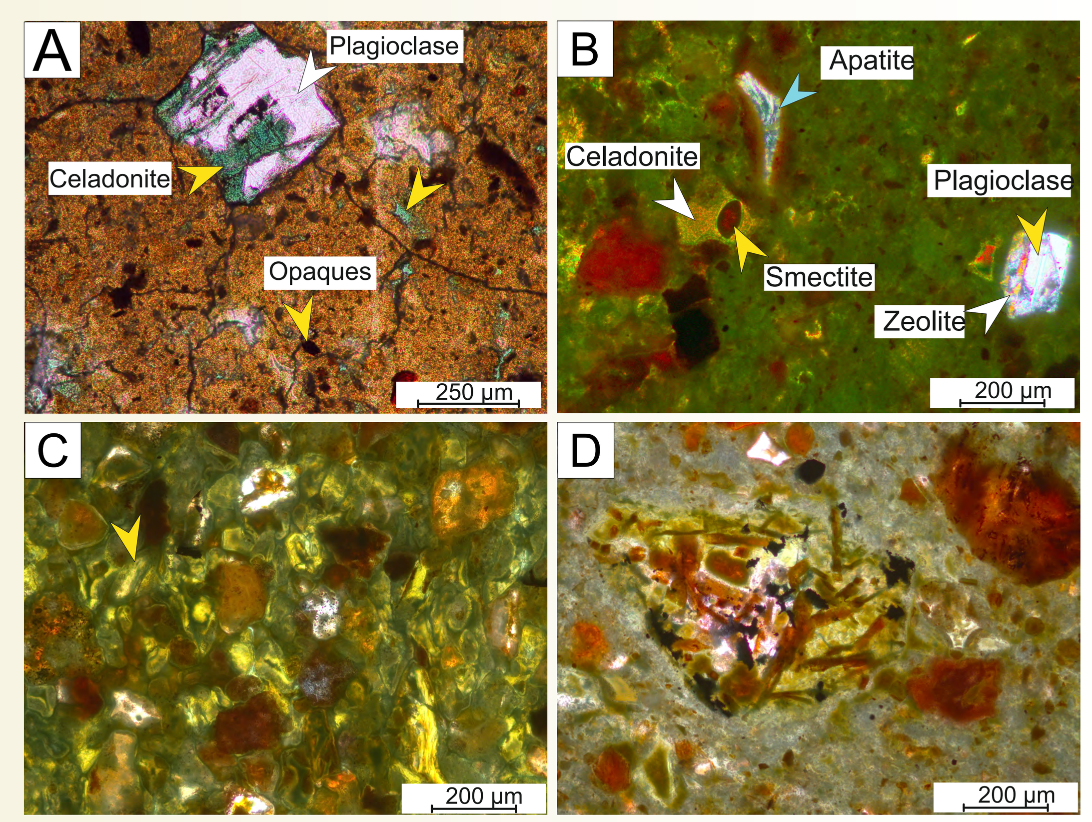


Fig. 4. Photomicrograph of red bole showing (A) subrounded basaltic volcanic lithic fragment surrounded by clayey groundmass, under plane polar; (B) rounded pisolite like structure (yellow arrow) surrounded by white veins filled with zeolites, under plane polar; (C) partially altered vesicular glass replaced by clay & iron oxide under cross polar light. The vesicles of glass are filled with zeolite; (D) relatively fresh yellow-orange vesicular glass shard surrounded by fine-grained altered material under plane polar.

Fig. 5. Photomicrograph of green bole showing (A) plagioclase altering into green celadonite along cleavages, under plane polar; (B) Fine-grained green groundmass with zeolite replacing plagioclase around rim, celadonite replacing glass shard (white arrow) under cross-polar. Note that vesicles of replaced glass shards are filled with brown smectite (yellow arrow). Sickle-shaped apatite (blue arrow) occurs as a minor constituent; (C) volcanic fragments completely replaced by green celadonite (yellow arrow); (D) volcanic fragment with altered interstitial glass,plagioclase microliths and mafic minerals.



Red bole: inciepiently to moderately pedogenised, varying content of volcanic lithic fragments, volcanic glasses, minerals (plagioclse, mafics, quatz, apatite, zircon, opaques etc.) & pedogenic features.
Green bole: rich in volcaniclastic fragments and green clay (i.e. celadonite)

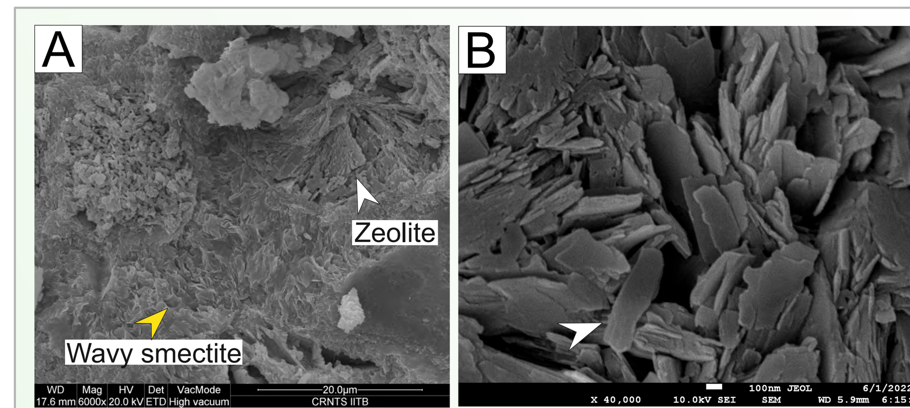


Fig. 6. Scanning electron microscope image of (A) red palaeosol showing wavy structure, characteristic of smectite clay and zeolite occurring as cavity fill; (B) elongated lath-like euhedral celadonite grain (white arrow) in green bole.

Results: Mineralogical investigation

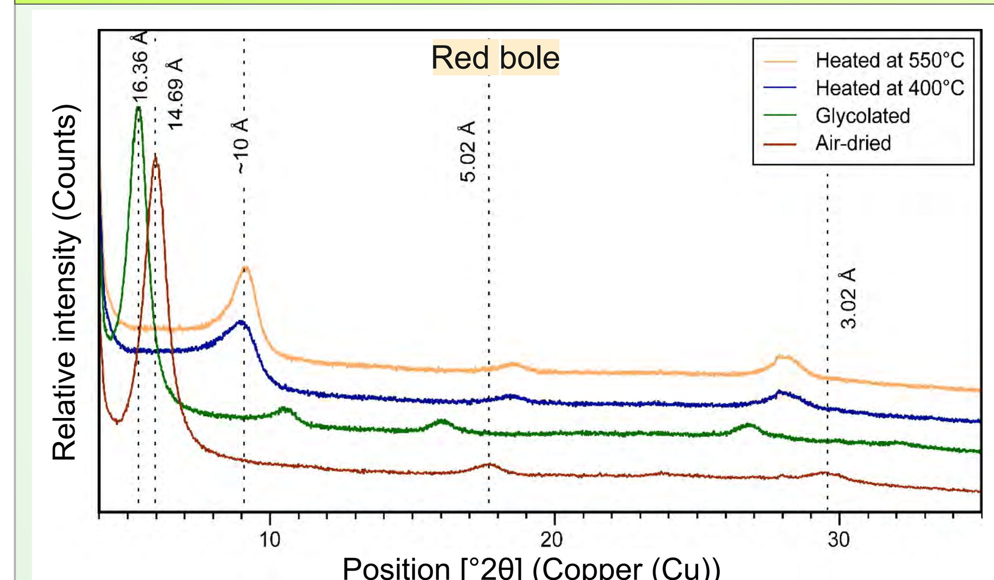


Fig. 7. XRD diffraction of <2 µm oriented clay mount of red bole, shows 001 reflection at ~15 Å under air dried condition, which shifts to ~16 Å on glycolation and collapses at 10 Å on heating at 400 °C and 550°C for 90 minutes.

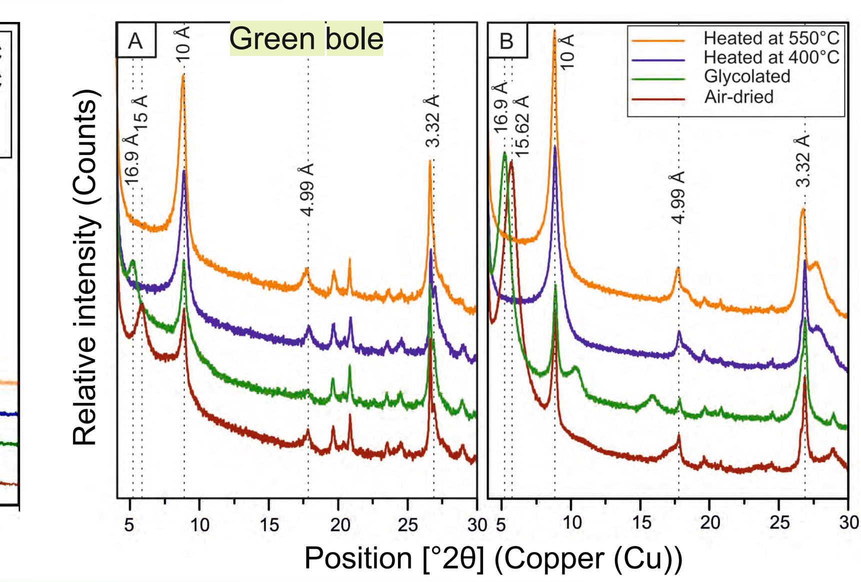


Fig. 8. XRD diffraction of <2 µm oriented clay of green bole. It shows sharp peak at ~10 Å & ~15 Å, under airdried conditions. On glycolation, 10 Å peak remains unaffected, but ~15 Å peak shifts to ~16.9 Å. On heating at 400°C & 550°C (90 min), ~16.9 Å peak collapse to ~10 Å.

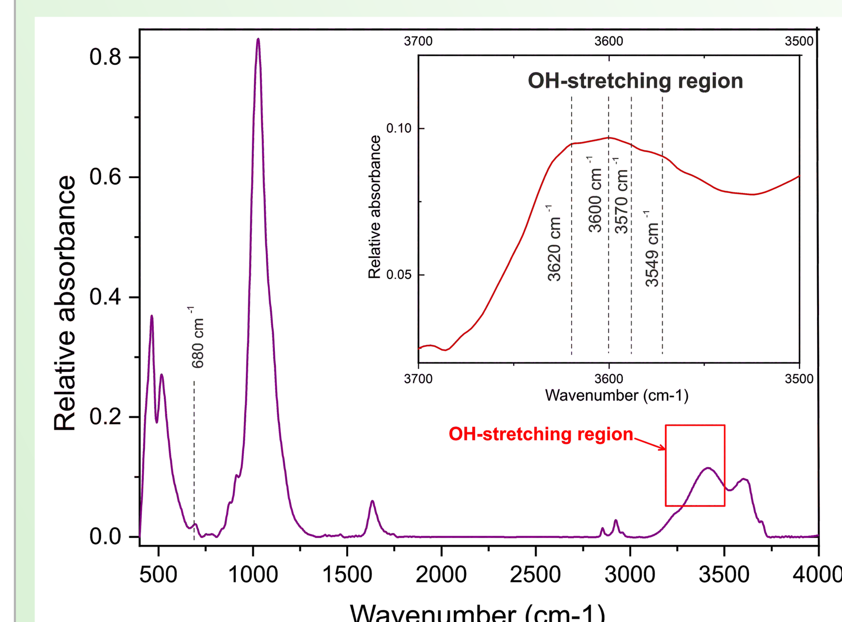


Fig. 9. FTIR absorbance spectra of <2 µm clay separated from red bole, shows characteristic absorption in OH-stretching region.

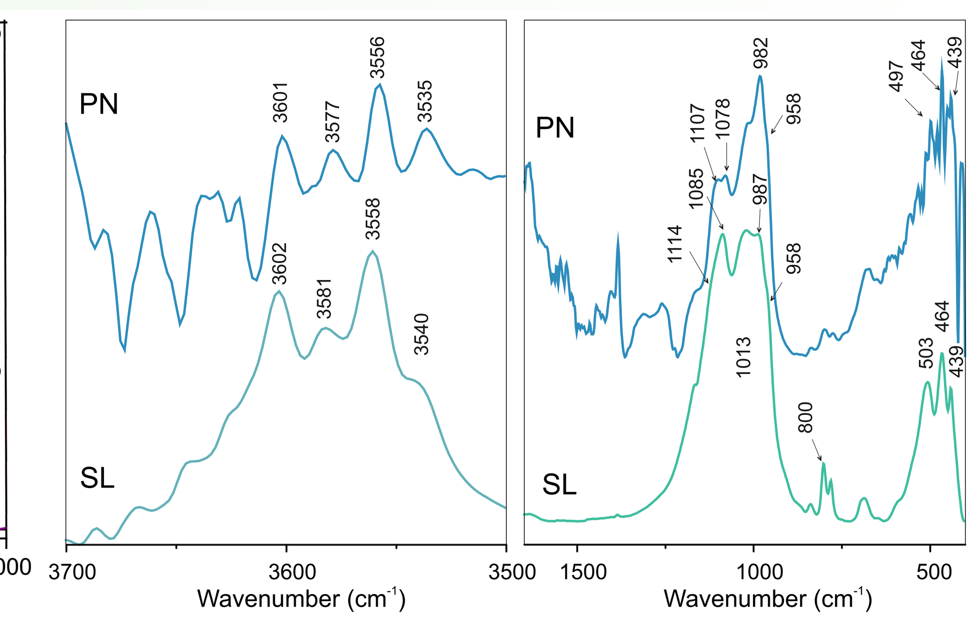


Fig. 10. FTIR absorbance spectra of < 2 µm clay of green bole, shows 3 sharp bands in Si-O bending vibration, 4 prominent peaks in Si-O stretching region and 3 sharp bands with shoulder in OH-stretching region.

Conclusions

- Textural & mineralogical characteristics of red bole indicates varying degree of pedogenesis. Thick red bole with sharp contact with upper basalt & gradational contact with lower basalt, exhibit pedogenic features and indicates significant hiatus in Deccan volcanism & a prolonged subaerial weathering of flow top basalt, under oxic conditions. Red bole with sharp contact with upper & lower basalt is incipiently pedogensised.
- Green volcaniclastic rocks: Incipiently developed; Celadonite and smectite as dominant clay mineral and green colour is imparted by celadonite clay.