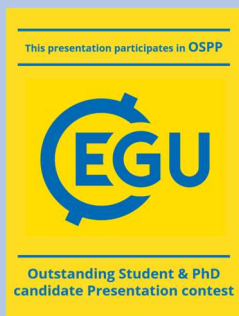# Structural attributes of Pachmarhi Deccan dykes and Newer Dolerite dykes of Singhbhum Craton: implications in magma emplacement mechanism

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# Deccan Continental Flood Basalt
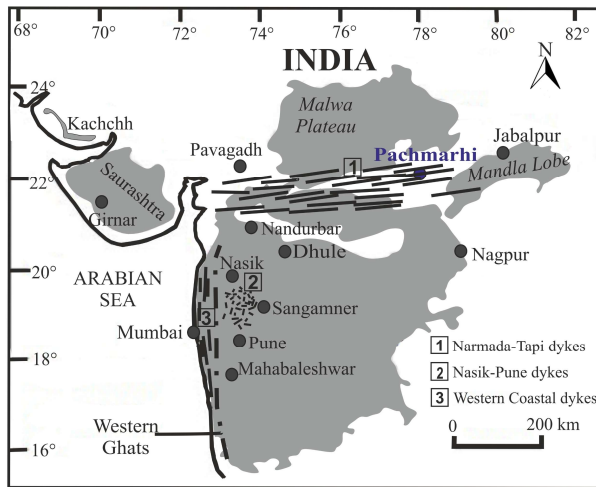
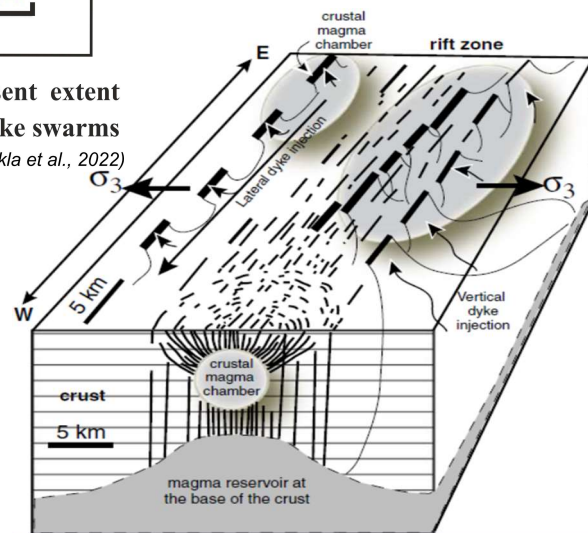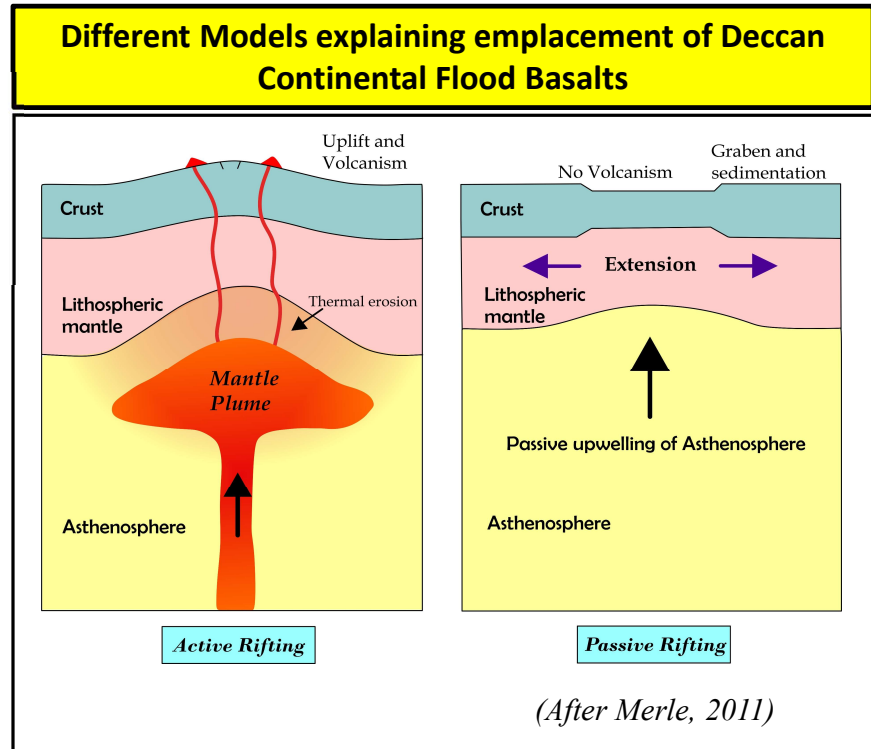**Map of Central-Western India with the present extent of the Deccan flood basalts with three major dyke swarms**
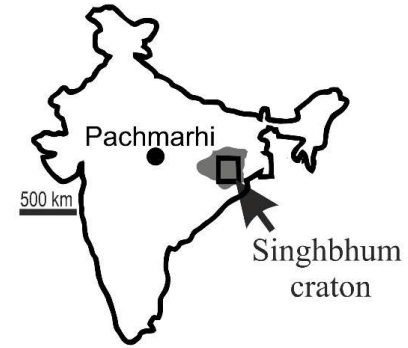
*(Sheth, 2005 & Shukla et al., 2022)*

Magma Emplacement *(Ray et al. 2006)*

**Different Models explaining emplacement of Deccan Continental Flood Basalts**

*Active Rifting*

*Passive Rifting*

*(After Merle, 2011)*

# GEOLOGICAL BACKGROUND

**Map of India**



Newer Dolerite dykes of Singhbhum Craton

Legend:
- Newer Dolerite dykes
- KOLHAN
- UPPER BONAI
- DANGOAPASI / JAGANNATHPUR
- DHANJORI
- JOJOHATU ULTRAMAFICS
- LOWER BONAI
- ONGARBIRA TRAPS
- GORUMAHISANI
- SINGHBHUM GRANITE COMPLEX
- OLDER METAMORPHICS
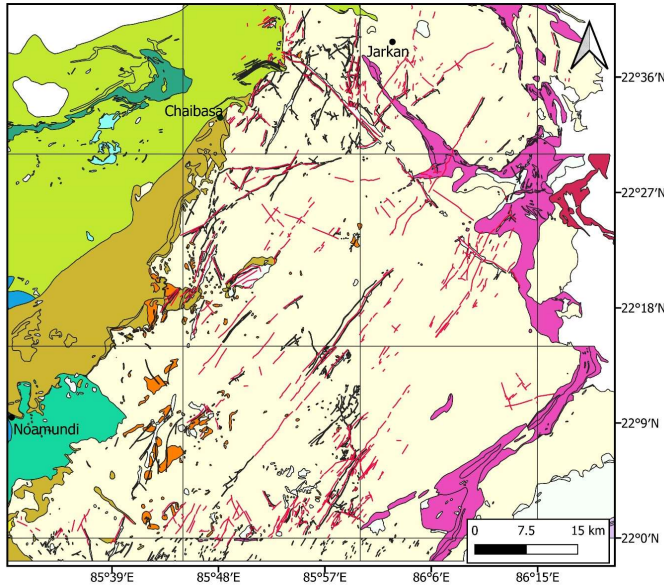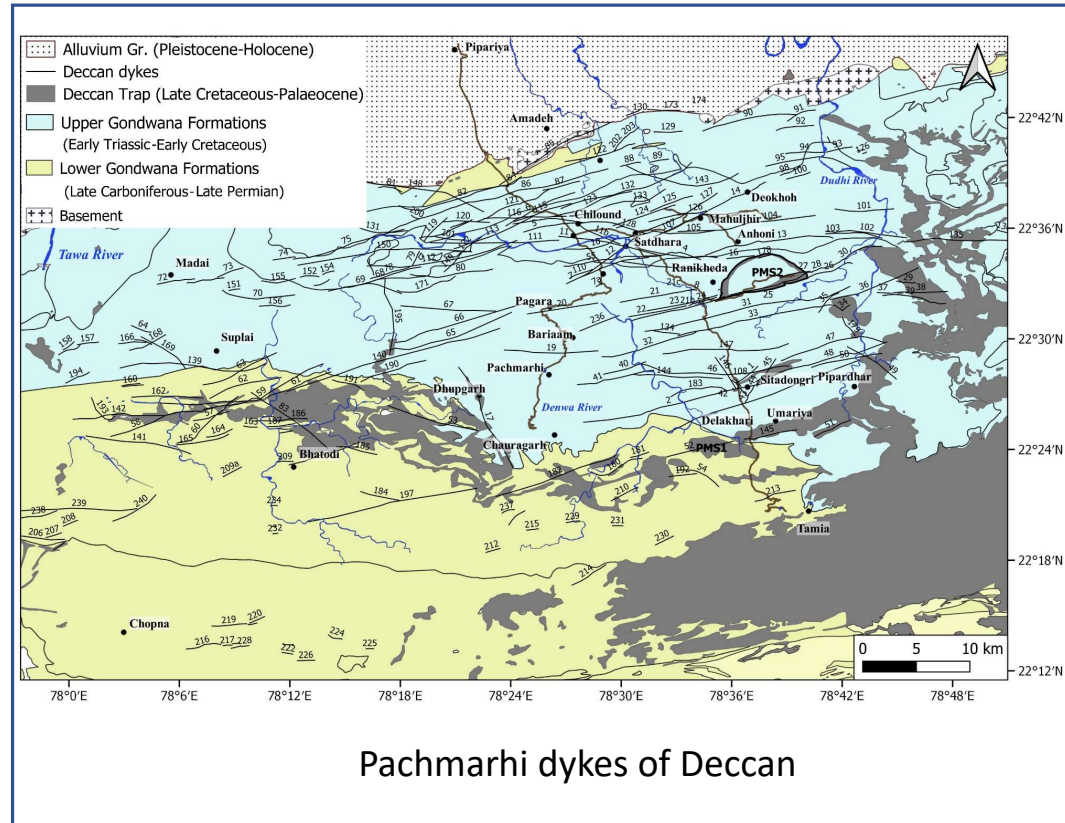
Pachmarhi dykes of Deccan

Legend:
- Alluvium Gr. (Pleistocene-Holocene)
- Deccan dykes
- Deccan Trap (Late Cretaceous-Palaeocene)
- Upper Gondwana Formations (Early Triassic-Early Cretaceous)
- Lower Gondwana Formations (Late Carboniferous-Late Permian)
- Basement

## METHODOLOGY

- To measure the strike, length(L) and thickness ($b_{max}$) of the Pachmarhi and Newer Dolerite dykes (NDDs)

- Calculated the aspect ratio (length/thickness) of dykes

- Calculated the Magmatic overpressure ($P_o$) during dyke emplacement

- Infer the source depth of the magma chamber (z) for Pachmarhi and N-D Deccan dykes and compare the same with Early-Neoarchean to Late-Paleoproterozoic Newer dolerite dykes of Singhbhum craton.

Formulas,

## Magmatic Overpressure

$$P_o = \frac{b_{max} E}{2L(1 - v^2)}$$

*(Babiker & Gudmundsson, 2004)*

## Source depth of the magma chamber

$$z = \frac{P_0}{(\rho_r - \rho_m)g}$$

*(Gudmundsson, 1983)*

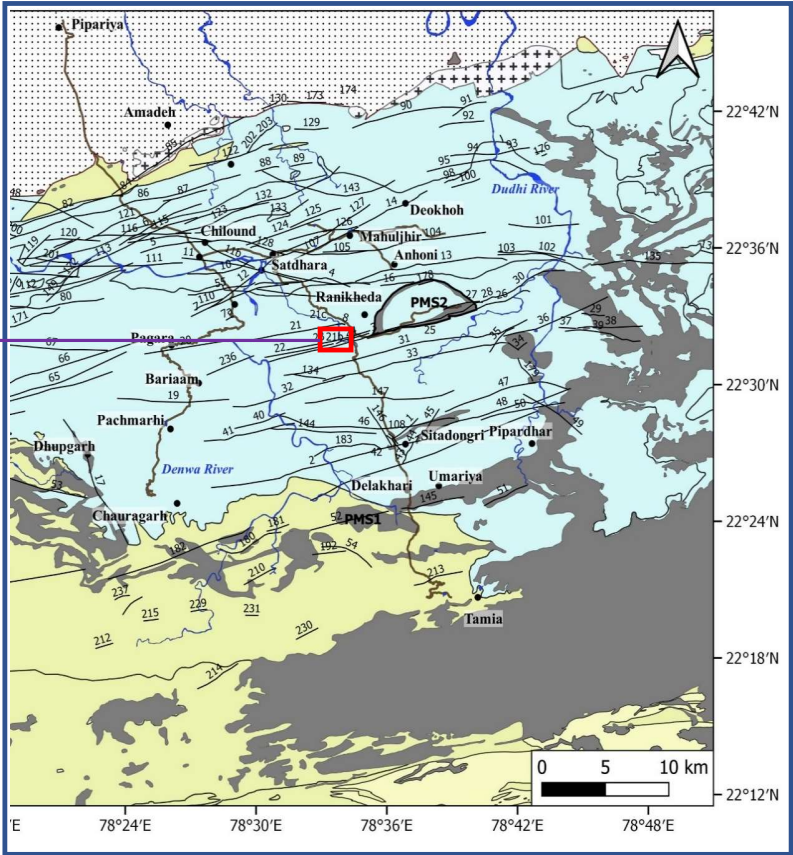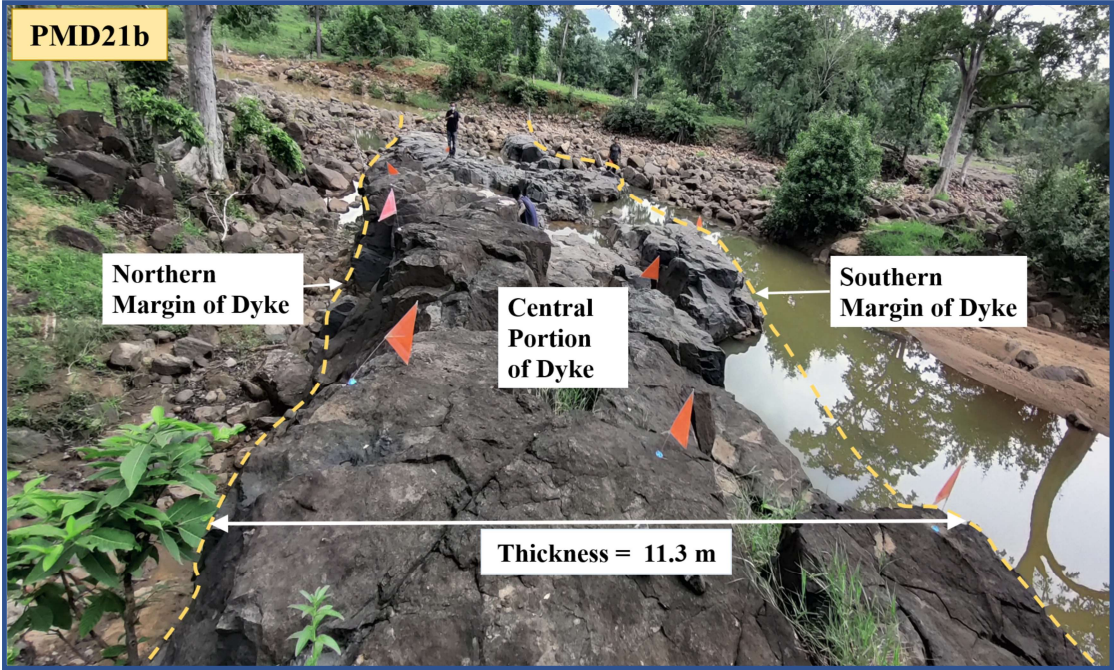where,   L is length and $b_{max}$ is thickness of the dykes

E is young's modulus and $v$ is Poisson's ratio of host rock.

$\rho_m$ is density of magma

$\rho_r$ is average density of crustal rock

g is acceleration due to gravity ($9.8 m/s^2$)

**Dyke Trend** = 75°

**Length** = 140 m

**Thickness** = 11.3 m

**Host rock** = Gondwana Sandstone

**Dyke composition** = Basalt

**Rock texture** = Fine grained

PMD11 & PMD12

PMD11

PMD12

PMD11

Sandstone ← Contact between sandstone and PMD12
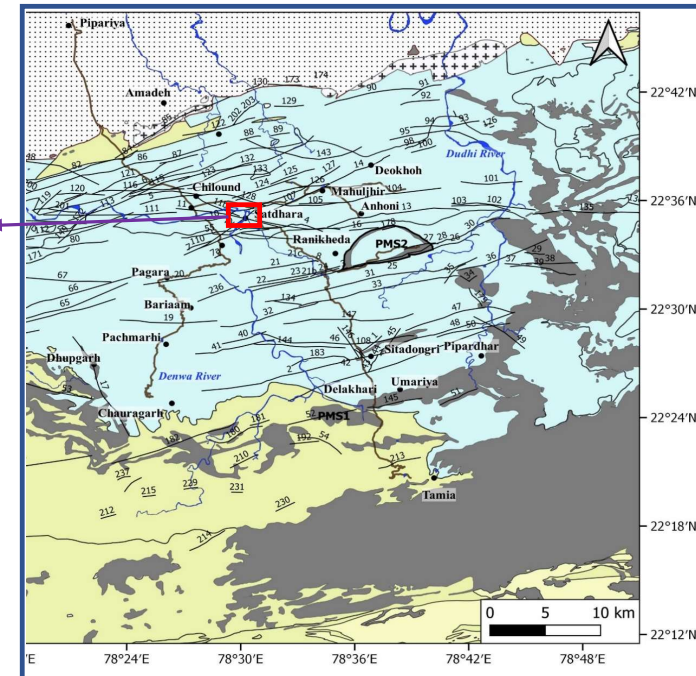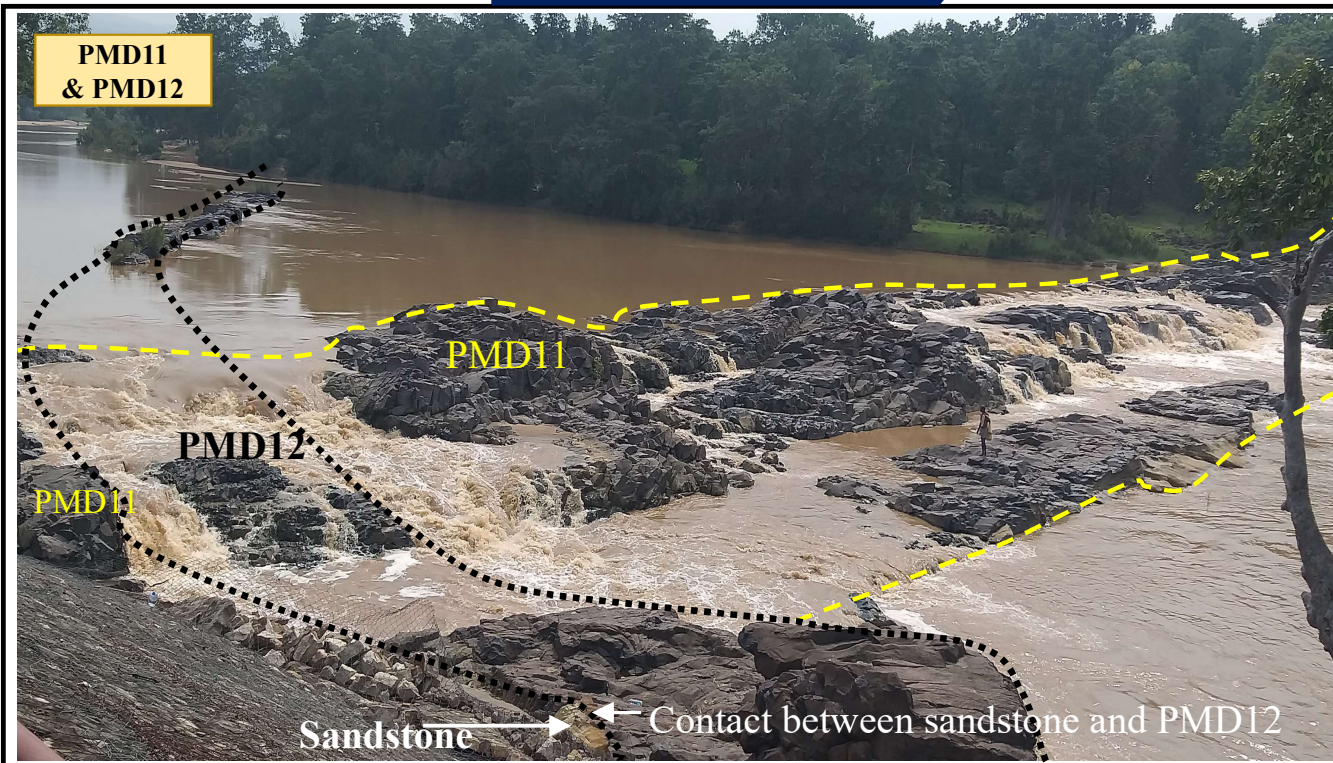
**PMD 11**

**Dyke Trend** = N100.64°, **Length** = 9.36 km, **Thickness** = 27.4 m

**Host rock** = Gondwana Sandstone

**Dyke composition and Texture** = Basaltic rock, fine-grained

**PMD 12**

**Dyke Trend** = N56.1°, **Length** = 7.47 km, **Thickness** = 15 m

**Host rock** = Gondwana Sandstone

**Dyke composition and Texture** = Basaltic rock, fine-medium grained

**Deccan dykes of Pachmarhi and Nandurbar-Dhule**

*Mean length of N-D dyke is 5.4 km with Avg. thickness of 17 m,*



Avg $P_0$= 8.09
Avg z = 8.26

Avg $P_0$= 23.08
Avg z = 11.21

*Mean length of PMDs is 5 km*
*PMDs Avg. thickness 13.3 m*
*Avg. aspect ratio = 393.71:1*

- Pachmarhi dykes (n=165)
- N-D dykes (n=15)

Range of z in km

Range of $P_0$ in Mpa (E= 7.5 Gpa & E=11 Gpa for N-D & Pachmarhi dykes, respectively)
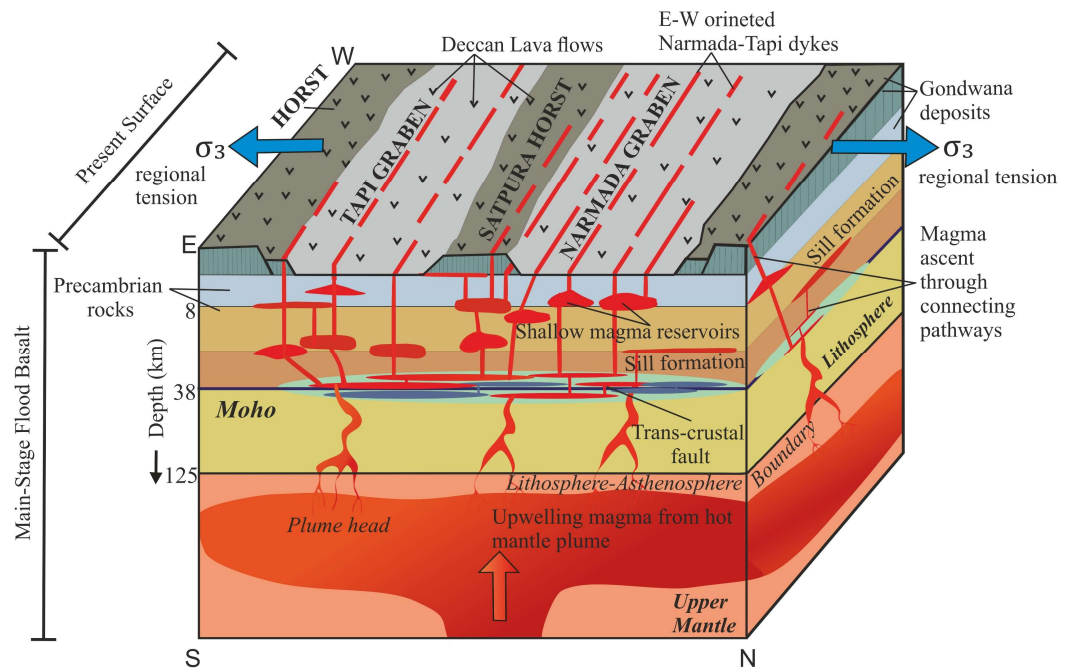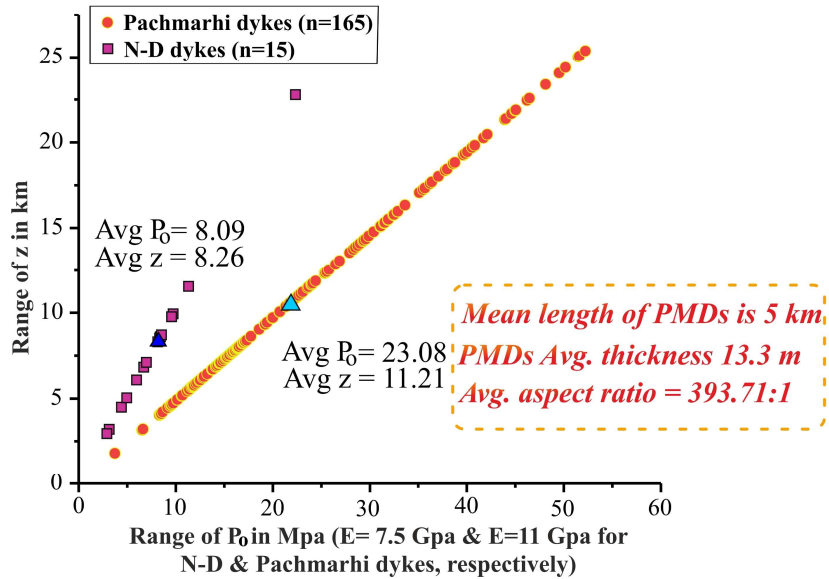


**Multiple smaller magma reservoir model for Pachmarhi (PMDs) and Nandurbar -Dhule (NDs) dykes** *(Mittal et al.,2021 & Shukla et al., 2022)*

**Newer Dolerite dykes (NDDs) of Singhbhum Craton**

NDD dykes (n=555)

NDDs mean length ~ 1.38 km
Avg. thickness is ~23.9 m
Avg. aspect ratio = 77.22:1

Avg $P_O$ = 268
Avg z = 130

Range of z in km

Range of $P_0$ in MPa (for E=20 Gpa)

Random oriented dykes

Magma ascent through connecting pathways

Present Surface

NDD's emplacement by Plume induced SCLM (ca. 2.8 Ga-ca. 1.8 Ga)

Depth (km)

Archean Granitic crust

Older Metamorphic Group (OMG)

SCLM

Metasomatized SCLM

Sill formation

Moho

Plume head

Plume head

Plume head

Asthenosphere

Upwelling magma from hot mantle plume

Upper Mantle

**Possible mechanism of emplacement of Newer- Doleritic dyke swarms in the Singhbhum granitoid complex** *(Pandey et al., 2021 & Shukla et al., 2022)*

## Conclusion

1. Magmatic overpressure for Pachmarhi dykes varies in the range of 3.71 MPa to 52.22 MPa, with an average of 23.08 MPa (considering E=11 GPa), with Poisson's ratio of 0.29 for Sandstone as a host rock.

2. The depth range of magma chamber (z) for PMDs varies between minimum, average and maximum depths are 1.81 km, 11.21 km and 25.38 km, respectively for E=11GPa.

3. We have compared the Pachmarhi dyke swarms and N-D dyke swarms, and both have numerous shallow magma chambers in the upper crustal levels instead of a larger one, supplying magma to the surface with each of the magma reservoirs undergoing REAFC (Recharge-Eruption-Assimilation-Fractional crystallization) process, supporting the theory of Mittal et al., 2021.

4. Po for NDDs varies in the range from 6.56 to 720 MPa with an average of 268 MPa (for average E=20 GPa) and Magma Source Depth range for NDDs varies in the range from 3.2 km to 350 km with an average depth of 130 km (for average E=20 GPa).

5.Thus we conclude that the magma chamber of NDD's is deeper compared to that of Pachmarhi and N-D dyke.

6. NDD's of Singhbhum have few shallow crustal magma chambers compared to the Pachmarhi and Nandurbar-Dhule dykes of Deccan. The emplacement of NDD's can be directly from the plume-induced Sub-Continental Lithospheric Mantle (SCLM) and/or from the shallow crustal magma chambers which may act as a trap or barrier to store the magma from deeper magma sources.

Extracted from: Shukla, G., Mallik, J., Mondal, P., 2022. Dimension-scaling relationships of Pachmarhi dyke swarm and their implications on Deccan magma emplacement. Tectonophysics 843. https://doi.org/10.1016/j.tecto.2022.229602

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# Thank you

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