

Supplementary Data #2:

Lithostratigraphic Data of Deccan Volcanic Province

2.1 DISTRICT-WISE LITHOSTRATIGRAPHIC COLUMNS

The lithostratigraphic classifications of the DVP were first formally proposed by officers of the Geological Survey of India in their internal reports (not available publicly), but published in parts in the Special Publication of the Gondwana Geological Society (Deshmukh and Nair, 1986).

This was subsequently expanded, elaborated and compiled in the form of District Resources Map series of the Geological Survey of India which are listed in the reference listing given below. Although published at different times between 1999 and 2005, we have collectively cited them in the main paper as Geological Survey of India, (2001).

This lithostratigraphy for the Deccan Volcanic Province is based on the field mapping of the characters and exposed continuity of the basaltic flows. The attached Ms Excel file (***Data_Repository_File_DR4.xlsx***) gives the district-wise stratigraphy across the DVP, for the states of Maharashtra and Madhya Pradesh compiled from the DRM series of maps.

Four Groups have been recognized in different sectors of the DVP by GSI (2001) as against only one Group identified on the basis of chemostratigraphy (Subbarao and Hooper, 1988). GSI (2001) has not elaborated upon the relative stratigraphic positions of these Groups with respect to each other barring exceptional cases. For example, the Upper Ratangarh Formation of Sahyadri Group occurs below the Ajanta Formation of Satpura Group (in the Aurangabad DRM), suggesting that the Upper Ratangarh Formation may provide a basis for lateral equivalence between them. Similar examples exist but are rare.

The lowest and highest elevations of the Deccan flows occurring in a particular district are captured using elevation data from Google Earth & Survey of India toposheets, with limited inputs from actual field studies where the contact elevations have been captured using GPS. We have reliable elevation controls across the Western and Southern parts of DVP, Satpura, Narmada – Tapi valleys and southern parts of the Malwa subprovinces. Similarly, for the Mandla and Kutch subprovinces, published literature provided validations for this data.

This database (***Data_Repository_File_DR4.xlsx***) also gives the underlying stratigraphic unit in the district where the Trap-basement is exposed. Large parts of the DVP do not expose the base of the Deccan Traps; and it is only along the fringes that this can be established. Some inputs are also available on the Trappean thickness from geophysical studies and the drilling through them (e.g. West, 1958,

Kaila, 1988, Sengupta and Deshmukh, 1996, Harinarayana, et al., 2007; Gupta, et al., 2015).

Based on the characters of the basaltic flows listed in the DRM maps, as well as additional inputs from field studies by us, we have classified the flows in the individual formations into 4 basic classes. Much of this classification in the DRM sheets, into types of flows is based on the descriptions given by Deshmukh (1988). Mixed flows imply that within the same formation compound as well as simple flows are present. There are some limitations in this classification from the volcanological perspective as discussed in the main text. We have not inserted our observations in this database to ensure that it reflects the undiluted views of GSI (2001). They are color coded in the attached database spreadsheet as follows:

1. Simple / a'ā flows	
2. Compound pāhoehoe flows	
3. Mixed (Simple and Compound)	
4. Unclassified / Not defined	

It is noted that DRM sheets are not available for some newly formed districts like Alirajpur (split from Jhabua), Burhanpur (split from Khandwa), and Mandla, and hence their separate lithologs are not plotted, but are represented in their parent district. This compilation has some inherent limitations that we have taken into account in our work.

1. Some of the DRM sheets do not have any stratigraphic names assigned, and the basaltic flows are simply listed as Deccan Traps. We have not included any stratigraphic name in such cases.
2. No equivalences between the Groups from different provinces is elaborated in GSI (2001), barring the continuity of some formations in exceptional cases as mentioned above. No stratigraphic equivalence between different Formations or Groups from adjoining districts in the spreadsheet is implied other than that given the DRM sheets.
3. The descriptions of the flow-types are limited to the Index of the DRM sheets where one of the first three types is listed or no descriptions are available. No additional elaboration is available. When plotting the lithologs (given below), we have included our observations that are based on volcanological considerations; but they are not covered in the spreadsheet.
4. Megacryst flows (GPBs) have been marked separately in many DRMs. We have not included them in the spread-sheet, but have plotted them in the lithologs. It is significant that the mappable megacryst basaltic flows have been denoted as M1, M2, M3 and M4 in the Western and some parts of Central DVP, where they have been used as stratigraphic markers. In other parts of the DVP, their presence has been recorded in the DRMs, but they

have not been assigned any name, and have been designated in the logs with the tag 'M??'.

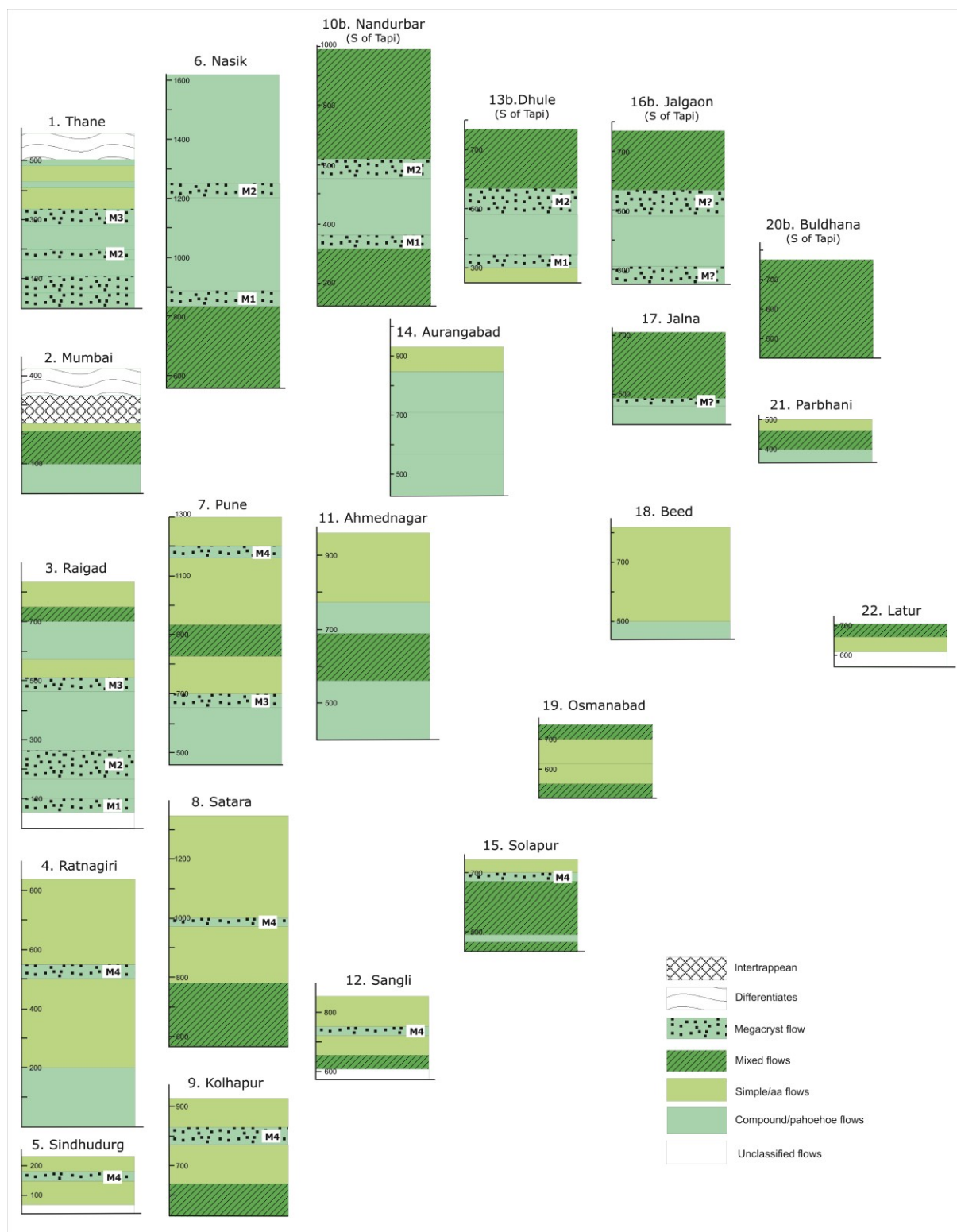
5. Intertrappean beds are recorded in the DRMs from the Malwa, Mandla, Central and Eastern subprovinces. They have been included in the lithologs (given below) but not in the spreadsheet database. The same is the case with the magmatic differentiates present in some parts of the DVP.

2.3 LITHOLOGICAL / STRATIGRAPHIC LOGS

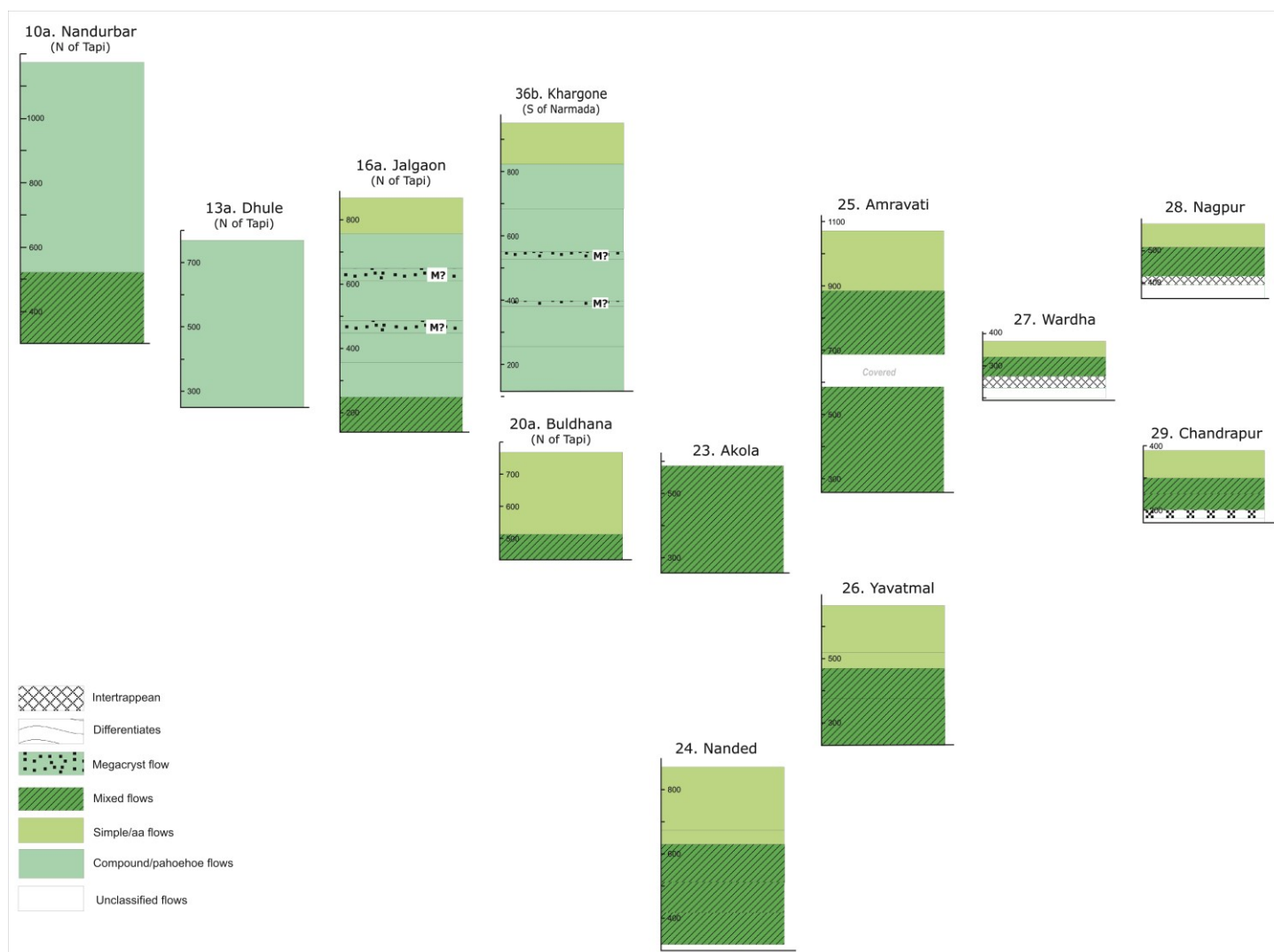
The thickness of the Deccan Basalts in each district (based on maximum and minimum elevations of the exposures as listed in the database) is used to plot the stratigraphic litholog of the district (Figs. SD#2 1- SD#2 4). Most of the DRM sheets list the character of the flow and the number and thickness of the flows present in a given Formation. Where this information was lacking or vague, data from published literature, descriptions in the DRMs of adjoining districts and our observations have been used. Note that some of the districts in the DRM database (*Data_Repository_File_DR4.xlsx*) are not represented as logs (eg: Betul, Mandla, etc), since we do not have sufficient field inputs or other inputs to enable reconstruction of the logs.

Thickness of individual formations in these logs is based on either the DRM index, elevation-differences based on Google Earth overlays, published literature or our observations. Within individual districts as well as across districts, the thicknesses of individual flow packets tend to vary because of pinching out or swelling of the flow-fields. Therefore, the thicknesses displayed in these logs are proportionate to the log thickness and indicative only.

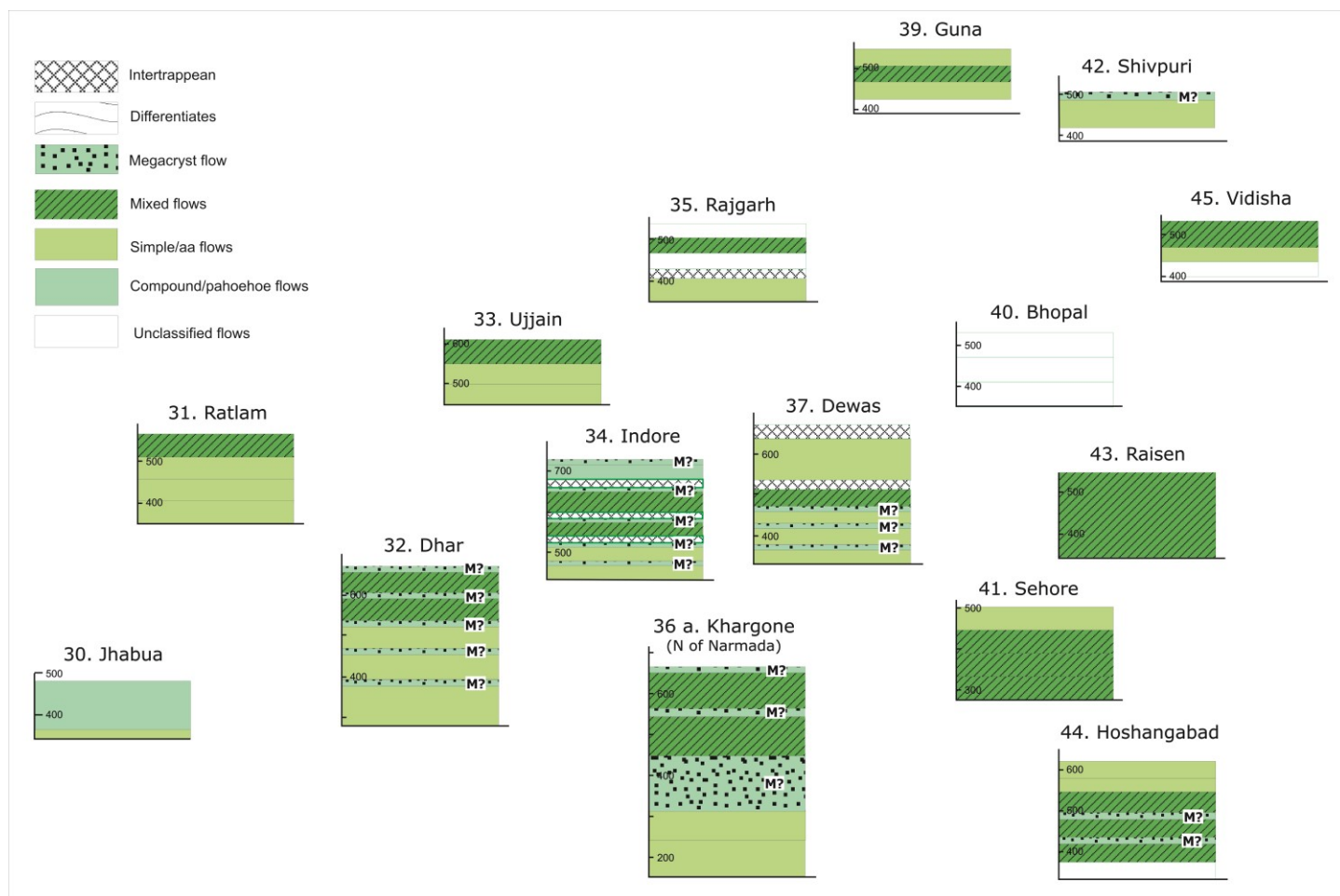
The intertrappean beds and the non-basaltic differentiates of the Deccan Traps whenever present have also been included in these lithologs in the appropriate stratigraphic position.



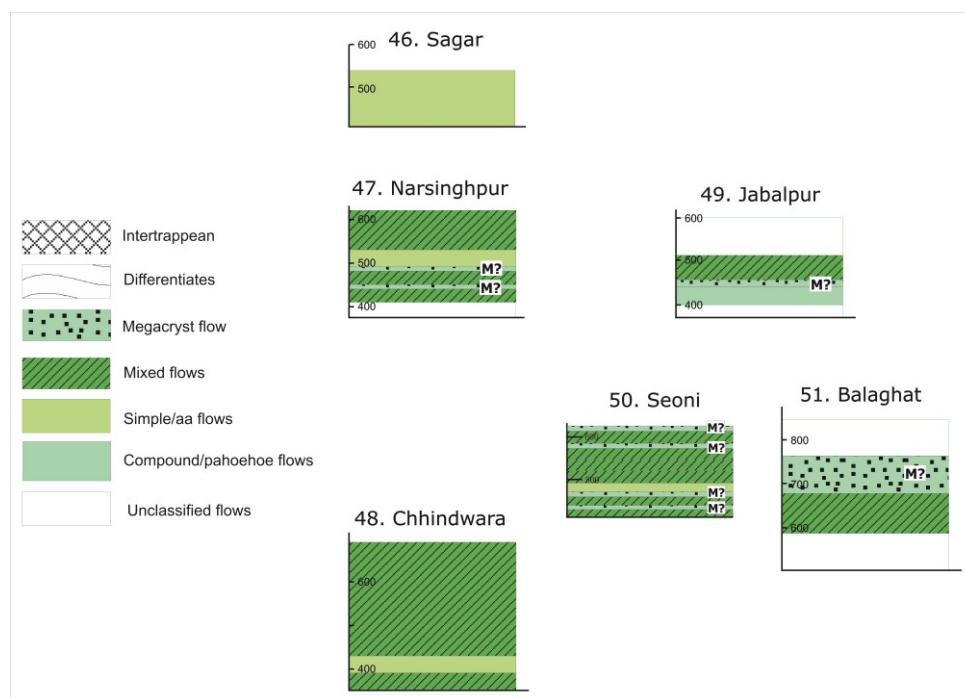
SD#2 Fig.1: Lithologies of the successions of Deccan Traps of Western DVP classified into different types of flow fields (flow packets) based on the DRM sheets (after GSI, 2001) modified with inputs of field observations by the authors. All elevations given are in meters above mean sea level.



SD#2 Fig.2: Lithologs of the successions of Deccan Traps of Central DVP classified into different types of flow fields (flow packets) based on the DRM sheets (after GSI, 2001) modified with inputs of field observations by the authors. All elevations given are in meters above mean sea level.



SD#2 Fig.3: Lithologs of the successions of Deccan Traps of Malwa Subprovince (excluding Narsimhapur and Sagar) classified into different types of flow fields (flow packets) based on the DRM sheets (after GSI, 2001) modified with inputs of field observations by the authors. All elevations given are in meters above mean sea level.



SD#2 Fig.4: Lithologs of the successions of Deccan Traps Mandla sector of DVP (& the Sagar and Narasimhapur districts from the Malwa province included here for space considerations) classified into different types of flow fields (flow packets) based on the DRM sheets (after GSI, 2001) modified with inputs of field observations by the authors. The Hoshangabad, district has been replicated here for enabling comparison. All elevations given are in meters above mean sea level.

Bibliography for Lithostratigraphy, volcanological characters and the DRM sheets

[**Note:** *All the citations*

“xxx... (200x) District Resource Map xxxxx District, xxxx, Geological Survey of India, Kolkata”

have been collectively clubbed in the main paper under the citation: “

Geological Survey of India (2001) District Resource Map Series: for Maharashtra and Madhya Pradesh: Kolkata Geological Survey of India Special Publication.]

Amarjeet Singh (2000) District Resource Map Jalgaon District, Maharashtra, Geological Survey of India, Kolkata.

Amarjeet Singh (2001) District Resource Map Ahmednagar District, Maharashtra, Geological Survey of India, Kolkata.

Amarjeet Singh (2001) District Resource Map Dhule District, Maharashtra, Geological Survey of India, Kolkata.

Amarjeet Singh (2001) District Resource Map Nandurbar District, Maharashtra, Geological Survey of India, Kolkata.

Anand, V.K., and Pathbaje, S.D. (2000) District Resource Map Nagpur District, Maharashtra, Geological Survey of India, Kolkata.

Annen, C., Lenat, J.-F. and Provost, A. (2001) The long-term growth of volcanic edifices: numerical modelling of the role of dyke intrusion and lava-flow emplacement. *Journal of Volcanology and Geothermal Research*, v. 105, pp. 263 – 289.

Bhaskar, B. (1999) District Resource Map Aurangabad District, Maharashtra, Geological Survey of India, Kolkata.

Bhaskar, B. (1999) District Resource Map Kolhapur District, Maharashtra, Geological Survey of India, Kolkata.

Bondre, N.R., Dole, G., Phadnis, V.M., Duraiswami, R.A., and Kale, V.S. (2000) Inflated pāhoehoe lavas from the Sangamner area of the western Deccan Volcanic Province. *Current Science*, v.78, pp. 1004 -1007.

Bondre, N.R., Duraiswami, R.A. and Dole, G. (2004) Morphology and emplacement of flows from the Deccan Volcanic Province, India. *Bulletin of Volcanology*, v. 66; pp. 29 – 45.

Bondre, N.R., Duraiswami, R.A. and Dole, G. (2004) A brief comparison of lava flows from the Deccan Volcanic Province and the Columbia-Oregon Plateau Flood Basalts: Implication for the model of flood basalt emplacement. *Proceedings Earth and Planetary Science*, v.113(4); pp. 809 –818.

Bose, P.N. (1884) Geology of the Lower Narmada valley between Nimawar and Kawant. *Memoirs Geological Survey of India*, v. 21 (1), p. 1 - 72.

Bose, M.K. (1980) Alkaline magmatism in the Deccan volcanic province. *Journal Geological Society India*, v. 21, p. 317 – 329.

Brown, R.J., Blake, S., Bondre, N.R., Phadnis, V.M. and Self, S. (2011) A'ā lava flows in the Deccan Volcanic Province, India, and their significance for the nature of continental flood basalt eruptions. *Bulletin Volcanology*, v. 73, pp. 737-752.

Choubey, R., and Chaurasia, A.H. (2001) District Resource Map Damoh District, Madhya Pradesh, Geological Survey of India, Kolkata.

Choubey, R., and Sahastrabudhhey, S.S., (2001) District Resource Map Sagar District, Madhya Pradesh, Geological Survey of India, Kolkata.

Choubey, V.D. (1973) Long-distance correlation of Deccan Basalt flows, central India. *Geological Society America Bulletin*, v. 84 (8), pp. 2785 – 2790.

Cox, K.G., and Hawkesworth, C.J., 1985 Geochemical stratigraphy of the Deccan Traps at Mahabaleshwar, Western Ghats, India, with implications for open system magmatic processes. *Journal of Petrology*, v. 26, p. 355–377.

Choubey, V.D. (1973) Long-distance correlation of Deccan Basalt flows, central India. *Geological Society America Bulletin*, v. 84 (8), pp. 2785 – 2790.

Deshmukh, S.S. (1988). Petrographic variations in compound flows of Deccan Traps and their significance. In Subbarao, K.V. (Ed.) *Deccan Flood Basalts*, Geological Society of India Memoir, v. 10, pp. 305 – 319.

Deshmukh, S.S. and Nair, K.K.K. (1986) Editors: *Deccan Basalts*. Gondwana Geological Magazine Special Publication, Gondwana Geological Society, Nagpur, v. 2, 543 p.

Deshmukh, S.S., Sano, T. and Nair, K.K.K. (1996) Geology and chemical stratigraphy of the Deccan basalts of Chikaldara and Behramghat sections from the eastern part of the Deccan Trap Province. In Deshmukh, S.S. and Nair, K.K.K. (Eds.) *Deccan Basalts*, Special Publication Gondwana Geological Society, v. 2, pp. 1 – 22.

Deshmukh, S.S., Sano, T., Fujii, T., Nair, K.K.K., Yedekar, D.B. (1996) Chemical stratigraphy and geochemistry of the basalt flows from the central and eastern parts of the Deccan Volcanic Province of India In Deshmukh, S.S. and Nair, K.K.K.

(Eds.) Deccan Basalts, Special Publication Gondwana Geological Society, v. 2, pp. 145-170.

Deshmukh, S. S. and Sehgal, M.N. (1988) Mafic dyke swarms in Deccan Volcanic Province of Madhya Pradesh and Maharashtra. In Subbarao, K.V. (Ed.) Deccan Flood Basalts, Geological Society of India Memoir, v. 10, pp. 323 - 340.

Dole, G.S., Bondre, N.R. Phadnis, V.M. Duraiswami, R.A. and Kale V.S. (2002) Discussion on: Arterial system of lava tubes and channels within Deccan volcanics of western India by K.S. Mishra. Journal Geological Society of India, v. 60, pp. 597-600.

Duraiswami, R.A. (2009) Pulsed inflation in the hummocky lava flow near Morgaon, western Deccan Volcanic province and its significance. Current Science, v. 97, pp. 313 – 316.

Duraiswami, R.A., Bondre, N.R., Dole, G., Phadnis, V.M. and Kale, V.S. (2001) Tumuli and associated features from the western Deccan Volcanic Province, India. Bulletin Volcanology, v. 63, pp. 435 – 442.

Duraiswami, R.A., Bondre, N.R., Dole, G., and Phadnis, V.M. ((2002) Morphology and structure of flow lobe tumuli from Pune and Dhule areas, western Deccan Volcanic Province, India. Journal Geological Society of India, v. 60, pp. 57-65.

Duraiswami, R.A., Bondre, N.R. and Managave, S. (2008) Morphology of rubbly pāhoehoe (simple) flows from the Deccan Volcanic Province: implications on style of emplacement. Journal Volcanology and Geothermal Research, v. 177, pp. 822 – 836.

Duraiswami, R.A., Dole, G. and Bondre, N.R. (2003) Slabby pāhoehoe from the western Deccan Volcanic Province: evidence for incipient pāhoehoe – a’ā transitions. Journal Volcanology and Geothermal Research, v. 121, pp. 195 – 217.

Duraiswami, R.A., Dole, G. and Bondre, N.R. (2003) Enigmatic spiracle like structures from a basaltic flow near Chekewadi, western Deccan Volcanic Province. Current Science, v. 85, pp. 101-104.

Duraiswami, R.A., Bondre, N.R., Dole, G. (2004) Possible lava tube system in a hummocky lava flows at Daund, Western Deccan Volcanic Province, India. Proceedings Earth and Planetary Science, v. 113(4), pp. 818 –830.

Duraiswami, R.A., Dole, G. and Bondre, N.R. (2005) The Songir structure: Inflated lava flow or tube? Journal Geological Society India, v. 65, pp. 357-365.

Duraiswami, R.A., and Gadpallu, P. (2016) Volcanism, past and Present – Indian Scenario. Proceedings Indian National Science Academy, Special Volume, v. 82, pp. 549-557.

Duraiswami, R.A., Gadpallu, P., Shaikh, T.N. and Cardin, N. (2014) Pāhoehoe – a’ā transitions in the lava flow fields of the western Deccan Traps, India – implications for emplacement dynamics, flood basalt architecture and volcanic stratigraphy. Journal Asian Earth Sciences, v. 84, pp. 146 – 166.

Eibl, E.P.S., Bean, C.J., Jonsdottir, I. Armann, H., Thordarson, T. Coppola, D., Witt, T. and Walter, T.R.(2017) Multiple coincident eruptive seismic tremor sources during the 2014-2015 eruption at Holuhraun, Iceland. Journal of Geophysical Research Solid Earth, doi: 10.1002/2016JB013892.

Gadadharan, A., Pathbaje, S.D. (2001) Sahastrabuddhe, S.S., (2001) District Resource Map Chandrapur District, Maharashtra, Geological Survey of India, Kolkata.

Geological Survey of India (2001) District Resources Map Series: for Maharashtra and Madhya Pradesh, Geological Survey of India Publications, Kolkata.

Geological Survey of India (2000) Seismotectonic Atlas of India and its environs. Eds: P.L. Narula, S.K. Acharyya and J. Banerjee: Geological Survey of India Publications, Kolkata.

Ghosh, M. (2003) District Resource Map Chhindwara District, Madhya Pradesh, Geological Survey of India, Kolkata.

Ghosh, M. (2002) District Resource Map Seoni District, Madhya Pradesh, Geological Survey of India, Kolkata.

Ghosh, M., Solanki, J.N., and Wankhade, S.H. (2002) District Resource Map Shahdol District, Madhya Pradesh, Geological Survey of India, Kolkata.

Godbole, S.M., and Chatterjee, A.K., (1999) A note on the Geochemistry of Lava pile Nazardeo, Jalgaon Dist, Maharashtra. In Deshmukh, S.S. and Nair, K.K.K. (Eds.) Deccan Basalts, Special Publication Gondwana Geological Society, v. 2, pp. 81-88.

Godbole, S.M., Rana, R.S. and Natu, S.R. (1996) Lava stratigraphy of Deccan Basalts of western Maharashtra. In Deshmukh, S.S. and Nair, K.K.K. (Eds.) Deccan Basalts, Special Publication Gondwana Geological Society, v. 2, pp. 125 – 134.

Godbole, S.M., Deshmukh, S.S. and Chatterjee, A.K., (1996) Geology and chemical stratigraphy of the basalt flows of Akot-Harisal section from Satpura Ranges in the eastern part of the Deccan Volcanic Province, In Deshmukh, S.S. and Nair, K.K.K. (Eds.) Deccan Basalts, Special Publication Gondwana Geological Society, v. 2, pp. 115-124.

Gupta, H.K., Arora, K., Rao, N.P., Roy, S., Tiwari, V.M., Patro, P.K., Satyanarayan, H.V.S., Shashidhar, D., Mahato, C.R., Srinivas, K.N.S.S.S., Srihar, M., Satyavani, N., Srinu, Y., Gopinadh, D., Raza, H., Jana, M., Akkiraju, V.V., Goswami, D., Vyas, D., Dubey, C.P., Raju, D.Ch.V., Borah, U., Raju, K., Chinna Reddy, K., Babu, N., Bansal, B.K., and Nayak, S. (2017) Investigations of continued reservoir triggered seismicity at Koyna, India. in Mukherjee, S., Misra, A., Calves, G., and

Nemcok, M., eds. Tectonics of the Deccan Large Igneous Province. Geological Society Special Publication 445, pp. 151 – 188, doi: 10.1144/SP445.11.

Gupta, H.K., Rao, N.P., Roy, S., Arora, K., Tiwari, V.M., Patro, P.K., Satyanarayan, H.V.S., Shashidhar, D., Mallika, K., Akkiraju, V.V., Goswami, D., Vyas, D., Ravi, G., Srinivas, K.N.S.S.S., Srihar, M., Mishra, S., Dubey, C.P., Raju, D.Ch.V., Borah, U., Chinna Reddy, K., Babu, N., Rohilla, S., Dhar, U., Sen, M., Bhaskar Rao, Y.J., Bansal, B.K. and Nayak, S. (2015) Investigations related to scientific deep drilling to study reservoir-triggered earthquakes at Koyna, India. *International Journal of Earth Sciences*, v. 104, pp. 1511 – 1522, doi: 10.1007/s00531-014-1128-0.

Gupte, R.B., Karmarkar, B.M., Kulkarni, S.R., Marathe, S.S., and Choubey, V.D., 1974 Long-distance correlation of Deccan Basalt Flows: Central India: Discussion and Reply:. *Geological Society of America Bulletin*, v. 85 (6), p. 1008 – 1010.

Harinarayana, T., Patro, B.P.K., Veeraswamy, K., Manoj, C., Naganjaneyulu, K., Murthy, D.N., and Virupakshi, G. (2007) Regional geoelectric structure beneath Deccan Volcanic Province of the Indian subcontinent using magnetotellurics: *Tectonophysics*, v. 445, pp.66 - 80.

Harris, A.J.L., Dehn, J. and Calvari, S. (2007) Lava effusion rate definition and measurement: a review. *Bulletin Volcanology*, v. 70, pp. 1 – 22.

Hooper, P.R., Subbarao, K.V. and Beane, J.E. (1988) Giant plagioclase Basalts (GPBs) of the Western Ghats, Deccan Traps. In Subbarao, K.V. (Ed.) *Deccan Flood Basalts*, Geological Society of India, Memoir, v. 10; pp. 135-144.

Jay, A.E., and Widdowson, M., 2008 Stratigraphy, structure and volcanology of the SE Deccan continental flood basalt province: implications for eruptive extent and volumes. *Journal Geological Society, London*, v. 165, p. 177 – 188.

Jay, A.E., MacNiocail, C., Widdowson, M., Self, S., and Turner, W., 2009 New paleomagnetic data from the Mahabaleshwar plateau, Deccan Flood Basalt Province, India: implications on volcanostratigraphic architecture of continental flood basalt provinces. *Journal Geological Society, London*, v. 166, p. 13 – 24.

Kaila, K.L., 1988. Mapping the thickness of Deccan Trap flows in India from DSS studies and inferences about a hidden Mesozoic basin in the Narmada–Tapti region. (in Ed: Subbarao, K.V.) *Deccan Flood Basalts*. Geological Society India, Memoir, v.10, pp. 91 – 116.

Kale, V.S. (2016). Architecture of lavas from Deccan Volcanic Province, India and its implications. 35th International Geological Congress, Cape Town, South Africa.; <http://www.americangeosciences.org/information/igc>, no. 4440.

Kale, V.S., Kulkarni, H. and Peshwa, V.V. (1992) Discussion on: A geological map of the southern Deccan Traps, India and its structural implications, *Journal Geological Society of London*, v. 149, pp. 473 - 478.

Kale, V.S., Survase, V., and Upasani, D., (2014, Geological mapping in the Koyna – Warna region. ACWADAM Technical Report no. 2014-C1, 163 p., doi: 10.13140/2.1.3098.0809

Keszthelyi, L., Self, S., & Thordarson, Th, (1999) Application of recent studies on the emplacement of basaltic lava flows to the Deccan Traps. (In Ed. Subbarao, K.V.) *Deccan Volcanic Province*, Geological Society of India Memoir, 43, pp. 485-520.

Khan, A.A. (1998) District Resource Map Bhopal District, Madhya Pradesh, Geological Survey of India, Kolkata.

Khan, A.A. (1998) District Resource Map Jhabua District, Madhya Pradesh, Geological Survey of India, Kolkata.

Khan, A.A. (1999) District Resource Map Shivpuri District, Madhya Pradesh, Geological Survey of India, Kolkata.

Khan, A.A. (2000) District Resource Map Dhar District, Madhya Pradesh, Geological Survey of India, Kolkata.

Khan, A.A. (2001) District Resource Map Khandwa District, Madhya Pradesh, Geological Survey of India, Kolkata.

Khan, A.A. (2000) District Resource Map Ratlam District, Madhya Pradesh, Geological Survey of India, Kolkata.

Khan, A.A. (2000) District Resource Map West Nimar District, Madhya Pradesh, Geological Survey of India, Kolkata.

Khan, A.A. and Pathbaje, S.D. (2002) District Resource Map Dewas District, Madhya Pradesh, Geological Survey of India, Kolkata.

Khan, A.A. and Pathbaje, S.D. (2002) District Resource Map Raisen District, Madhya Pradesh, Geological Survey of India, Kolkata.

Khan, A.A. and Pathbaje, S.D. (2002) District Resource Map Guna District, Madhya Pradesh, Geological Survey of India, Kolkata.

Khan, A.A., Bharati, R. and Wankhade, S.H. (2002) District Resource Map Rajgarha District, Madhya Pradesh, Geological Survey of India, Kolkata.

Marathe, S.S., Kulkarni, S.R., Karmarkar, B.M. and Gupte, R.B. (1981) Variations in the nature of Deccan Trap volcanicity of Western Maharashtra in time and space. In Eds. K.V. Subbarao and R.N. Sukheswala. *Deccan Volcanism and related basalt provinces in other parts of the World*. Memoir Geological Society India, v. 3, p. 143- 152.

- Marshall, P.E., Widdowson, M. and Murphy, D.T. (2015) The giant lavas of Kalkarindji: bubbly pāhoehoe lava in an ancient continental flood basalt province. *Palaeogeography Palaeoclimatology Palaeoecology*, DOI: 10.1016/j.palaeo.2015.05.006.
- Misra, K.S. (2002) Arterial system of lava tubes and channels in Deccan volcanics of western India. *Journal of the Geological Society of India* v. 59, pp. 115-124.
- Mitchell, C. and Widdowson, M. (1991). A geological map of the Southern Deccan Traps, India and its structural implications. *Journal Geological Society London*, v. 148, pp. 495–505.
- Mulay, J.G. and Peshwa, V.V. (1980) The occurrence of gabbroic intrusion in Deccan Trap basalts near Khopoli in the Konkan area (Maharashtra) *Current Science*, v. 49, p. 356 – 357.
- Nair, K.K.K., Chatterjee, A.K., and Sano, T., (1996) Stratigraphy and geochemistry of the Deccan basalts along Toranmal section, Western Satpura Region. In Deshmukh, S.S. and Nair, K.K.K. (Eds.) *Deccan Basalts*, Special Publication Gondwana Geological Society, v. 2, pp. 23-48.
- Oskarsson, B.V. and Riisshuus, M.S. (2014) The mode of emplacement of Neogene flood basalts in eastern Iceland: facies architecture and structure of simple aphyric basalt groups. *Journal Volcanology and Geothermal Research*, v. 289, pp. 170 – 192.
- Pandey, P.K., and Natesan, S. (2002) District Resource Map Shohore District, Madhya Pradesh, Geological Survey of India, Kolkata.
- Pandey, P.K., (2002) District Resource Map Vidisha District, Madhya Pradesh, Geological Survey of India, Kolkata.
- Patel, N.P. (2000) District Resource Map Ujjain District, Madhya Pradesh, Geological Survey of India, Kolkata.
- Pathbaje, S.D. and Patel, N.P. (2002) District Resource Map Indore District, Madhya Pradesh, Geological Survey of India, Kolkata.
- Peshwa, V.V. and Kale, V.S. (1997) Neotectonics of the Deccan Trap Province: focus on the Kurduwadi Lineament. *Journal of Geophysics*, v. 18, pp. 77 – 86.
- Rahate, D.N. and Solanki, J.N. (2002) District Resource Map Hoshangabad District, Madhya Pradesh, Geological Survey of India, Kolkata.
- Rahate, D.N. and Solanki, J.N. (2002) District Resource Map Narimhapur District, Madhya Pradesh, Geological Survey of India, Kolkata.
- Raina, C.B. (2000) Sahastrabuddhe, S.S., (2001) District Resource Map Beed District, Maharashtra, Geological Survey of India, Kolkata.
- Raina, C.B. (2000) Sahastrabuddhe, S.S., (2001) District Resource Map Nasik District, Maharashtra, Geological Survey of India, Kolkata.
- Raina, C.B. (2000) Sahastrabuddhe, S.S., (2001) District Resource Map Pune District, Maharashtra, Geological Survey of India, Kolkata.
- Raina, C.B. (2001) Sahastrabuddhe, S.S., (2001) District Resource Map Sangli District, Maharashtra, Geological Survey of India, Kolkata.
- Raina, C.B. (2001) Sahastrabuddhe, S.S., (2001) District Resource Map Satara District, Maharashtra, Geological Survey of India, Kolkata.
- Raina, C.B. (2001) Sahastrabuddhe, S.S., (2001) District Resource Map Solapur District, Maharashtra, Geological Survey of India, Kolkata.
- Rowland, S.K. and Walker, G.P.L. (1990) Pāhoehoe and a'ā in Hawaii: volumetric flow rate controls the lava structure. *Bulletin Volcanology*, v. 52, pp. 615 – 628.
- Sahastrabuddhey, S.S., (2001) District Resource Map Amaravati District, Maharashtra, Geological Survey of India, Kolkata.
- Sahastrabuddhey, S.S., (2001) District Resource Map Nanded District, Maharashtra, Geological Survey of India, Kolkata.
- Sahastrabuddhey, S.S., (2001) District Resource Map Akola District, Maharashtra, Geological Survey of India, Kolkata.
- Sahastrabuddhey, S.S., (2000) District Resource Map Buldhana District, Maharashtra, Geological Survey of India, Kolkata.
- Sahastrabuddhey, S.S., (2001) District Resource Map Jalna District, Maharashtra, Geological Survey of India, Kolkata.
- Sahastrabuddhey, S.S., (2000) District Resource Map Latur District, Maharashtra, Geological Survey of India, Kolkata.
- Sahastrabuddhey, S.S., (2001) District Resource Map Mumbai District, Maharashtra, Geological Survey of India, Kolkata.
- Sahastrabuddhey, S.S., (2000) District Resource Map Osmanabad District, Maharashtra, Geological Survey of India, Kolkata.
- Sahastrabuddhey, S.S., (2001) District Resource Map Raigad District, Maharashtra, Geological Survey of India, Kolkata.

- Sahastrabuddhey, S.S., (2001) District Resource Map Ratnagiri District, Maharashtra, Geological Survey of India, Kolkata.
- Sahastrabuddhey, S.S., (2001) District Resource Map Sindhudurga District, Maharashtra, Geological Survey of India, Kolkata.
- Sahastrabuddhey, S.S., (2001) District Resource Map Thane District, Maharashtra, Geological Survey of India, Kolkata.
- Sahastrabuddhey, S.S., (2000) District Resource Map Vardha District, Maharashtra, Geological Survey of India, Kolkata.
- Sahastrabuddhey, S.S., and G. Pratap Reddy (2001) District Resource Map Parbhani District, Maharashtra, Geological Survey of India, Kolkata.
- Schöbel, S., de Wall, H., Ganerød, M., Pandit, M. . K., and Rolf, C. (2014). Magnetostratigraphy and ^{40}Ar - ^{39}Ar geochronology of the Malwa Plateau region (Northern Deccan Traps), central western India: Significance and correlation with the main Deccan Large Igneous Province sequences. *Journal of Asian Earth Sciences*, v. 89, pp. 28–45 <http://doi.org/10.1016/j.jseas.2014.03.022>.
- Self, S., Keszthelyi, L. and Thordarson, Th. (1998) The importance of Pāhoehoe. *Annual Reviews Earth Planetary Science*. v. 26, pp. 81 – 110.
- Self, S., Jay, A.E., Widdowson, M., and Keszthelyi, L.P. (2008) Correlation of the Deccan and Rajahmundry trap lavas: are these the longest and largest lava flows on Earth? *Journal Volcanological Geothermal Research*, v. 172, pp. 3–19.
- Sen, B. (2017) Lava flow transition from Pāhoehoe-dominated lower pile of the Deccan Traps from Manmad – Chandwad area, western Maharashtra. *Journal Geological Society India*, v. 89, p. 281– 290.
- Sen, B., and Sabale, A.B. (2011) Flow types and lava emplacement history of Rajahmundry Traps, west of River Godavari, Andhra Pradesh. *Journal of the Geological Society of India* v. 78, pp.457-467.
- Sen. B., Sabale, A.B., Sukumaran, P.V. (2012) Lava channel of Khedrai dam, northeast of Nasik in western Deccan Volcanic Province: detailed morphology and evidence of channel reactivation. *Journal Geological Society India*, v. 80, p. 314 – 328.
- Shekhawat, L.S., and Sharma, V.P., (1996) Deccan basalts of Wankaner-Rajkot area, Gujrat. In Deshmukh, S.S. and Nair, K.K.K. (Eds.) *Deccan Basalts*, Special Publication Gondwana Geological Society, v. 2, pp. 289-100.
- Sheth, H.C. (2006) The emplacement of pahoehoe lavas on Kilauea and in the Deccan traps. *Journal of Earth System Science*, v. 115, pp. 615–629
- Sheth H.C., Ray, J.S., Senthil Kumar P, Duraiswami R.A. , Chatterjee R.N., Gurav T. (2011) Recycling of flow-top breccia crusts into molten interiors of flood basalt lava flows: field and geochemical evidence from the Deccan Traps. In Ray J.S., Sen G. and Ghosh B. (Eds.) *Topics in igneous petrology*. Springer, pp. 161–180.
- Sheth H C and Vanderkluyzen L (Guest Editors) (2014) Flood Basalts of Asia, John J. Mahoney Memorial Volume *Journal of Asian Earth Sciences*, v. 84, pp.1-200.
- Sheth H.C. (2016) Giant plagioclase basalts: Continental flood basalt–induced remobilization of anorthositic mushes in a deep crustal sill complex. *Geological Society of America Bulletin*, v.128, pp. 916-925.
- Sheth, H.C. (2018) *A photographic atlas of flood basalt volcanism*. Springer, 363 p.
- Sheth, H.C., Pal, I. Patel, V. Samant, H. (2017) Brecciated-cored columnar rosettes in a rubbly pahoehoe lava flow, Elephanta Island, Deccan Traps and a model for their origin. *Goescience Frontiers*, doi.org/10.1016/j.gsf.2016.12.004
- Sheth H, Samant H, Patel V, D'Souza J (2017a) The volcanic geoheritage of the Elephanta Caves, Deccan Traps, western India. *Geoheritage*. doi:10.1007/s12371-016-0214-z
- Sheth, H.C. Patel, V. Samant, H. (2017) Control of early formed vesicle cylinders on upper crustal prismatic jointing in compound pahoehoe lavas of Elephanta Island, western Deccan Traps, India. *Bulletin Volcanology*, v. 79, doi: 10.1007/s00445-017-1147-3.
- Solanki, J.N. (2005) District Resource Map Balaghat District, Madhya Pradesh, Geological Survey of India, Kolkata.
- Solanki, J. N., Bhattacharya, D.D., Jain, A.K., and Mukherjee, A. (1996) Stratigraphy and tectonics of the Deccan Traps of Mandla. In Deshmukh, S.S. and Nair, K.K.K. (Eds.) *Deccan Basalts*, Special Publication Gondwana Geological Society, v. 2, pp. 101-114.
- Solanki, J.N. and Chaurasia, A.H. (2001) District Resource Map Jabalpur District, Madhya Pradesh, Geological Survey of India, Kolkata.
- Subbarao, K.V. Editor (1988) *Deccan Flood Basalts*. Geological Society India Memoir, v.10; 393 p.
- Subbarao, K.V. Editor (1999) *Deccan Volcanic Province*. Geological Society India Memoir, v. 43(1 & 2), 947 p.
- Subbarao, K.V. and Hooper, P.R. (1988) Reconnaissance map of the Deccan Basalt group in the Western Ghats, India. Scale 1: 1,000,000. In Subbarao K.V. (Ed.) *Deccan Flood Basalts*, Geological Society India, Memoir, v.10 (in pouch).

- Thordarson, T. and Self, S. (1998) The Roza Member, Columbia River Basalt Group: a gigantic pāhoehoe lava flow field formed by endogenous process? *Journal Geophysical Research*, v. 103, pp. 27411 – 27445.
- Vanderkluysen, L., Mahoney, J.J., Hooper, P.R., Sheth, H.C. and Ray, R. (2011) The feeder system of the Deccan Traps(India): Insights from dike geochemistry. *Journal of Petrology*, v. 52(2), pp. 315 – 343.
- Waichel, B.L., de Lima, E.F., Viana, A.R., Scherer, C.M., Bueno, G.V. and Dutra, G. (2012) Stratigraphy and volcanic facies architecture of the Torres syncline, southern Brazil and its role in understanding the Parana – Etendeka continental flood basalt province. *Journal Volcanology and Geothermal Research*, v. 216, pp. 74 – 82.
- Walker, G.P.L. (1971) Compound and simple lava flows and flood basalts. In: Aswathanarayana U. (Ed.), *Deccan Trap and other flood eruptions: Part I. Bulletin Volcanology*, v. 35, pp. 579–590 .
- West, W. D. (1958) The petrography and petrogenesis of forty-eight flows of Deccan Trap penetrated by borings in western India: *Indian National Institute of Science Transactions*, v. 4(1), pp. 1-56.
- West, W. D. (1959) The source of the Deccan Trap flows. *Journal Geological Society India*, v. 1, pp. 44 – 52.
- Wilmoth, R.A. and Walker, G.P.L. (1993) P-type and S-type pahoehoe: a study of vesicle distribution patterns in Hawaiian lava flows. *Journal Volcanology and Geothermal Research*, v. 55, pp. 129 – 142.
- Yedekar, D.B., Aramaki, S., Fujji, T., and Sano, T. (1996) Geochemical signature and stratigraphy of the Chhindwara-Jabalpur-Seoni-Mandla sector of the eastern Deccan Volcanic Province and problems of its correlation. In Deshmukh, S.S. and Nair, K.K.K. (Eds.) *Deccan Basalts, Special Publication Gondwana Geological Society*, v. 2, pp. 49-68.