Geological and Hydrogeological Study of a Doleritic Dyke in the Adgaon–Naigavan Region

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Abstract

The Adgaon–Naigavan region, situated within the Dudhana sub-basin of Maharashtra, is characterized by extensive Deccan Trap volcanic sequences intruded by a prominent doleritic dyke. This study presents a detailed geological and hydrogeological evaluation of the dyke, integrating field mapping, petrographic analysis, structural observations, and remote sensing interpretation. The dyke, traced from Adgaon Sarak through Tanda and Hatmali to Naigavan, exhibits a thickness of ~2.2 m, with a strike direction of N40°E–S40°W, and displays bulging and pinching morphology. Three distinct joint sets—two vertical and one horizontal
—are observed, with joint density increasing toward the dyke margins. Hydrogeologically, the dyke functions variably as a groundwater conduit and barrier depending on its orientation to local drainage. Remote sensing analysis using Landsat imagery reveals a clear linear anomaly corresponding to the dyke trace.
The findings contribute to the understanding of dyke–aquifer interactions in basaltic terrains and support groundwater management in semi-arid volcanic provinces.

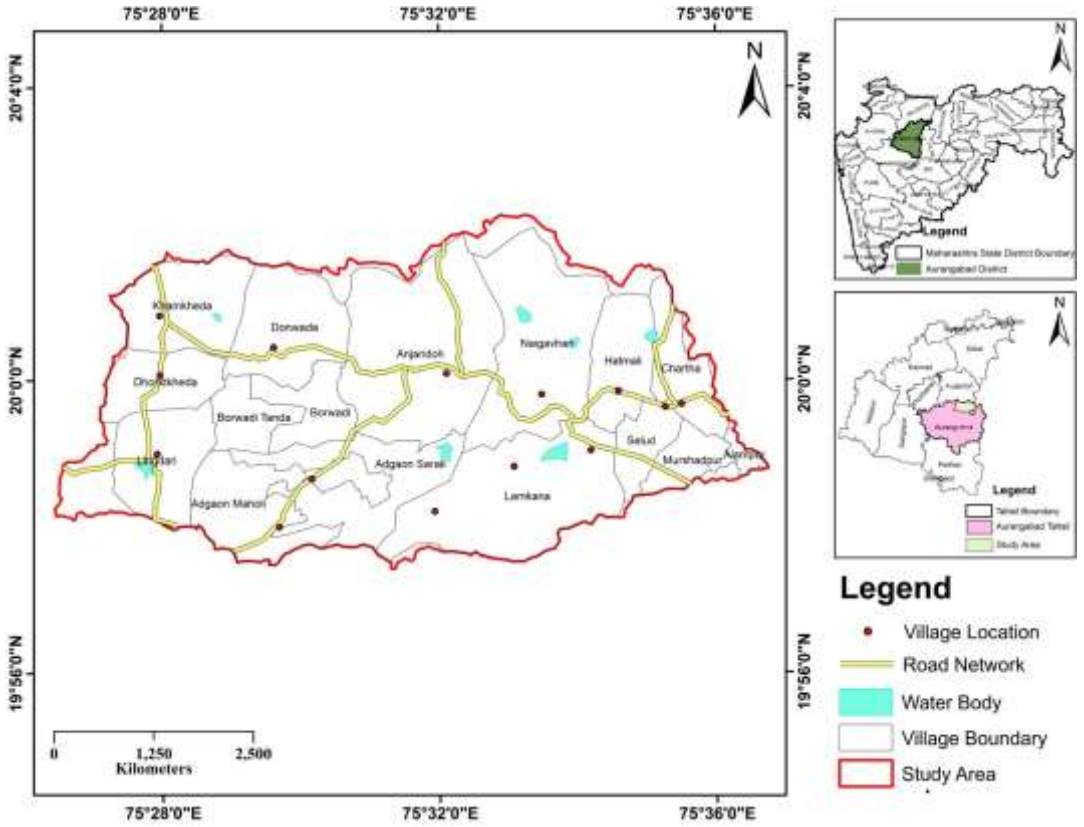
Keywords: Doleritic dyke, Deccan Traps, Adgaon–Naigavan, groundwater barrier, Landsat imagery, jointing patterns.

1. Introduction

Dykes are discordant tabular igneous bodies formed by the injection of magma into fractures or zones of weakness in pre-existing rock sequences (Best, 2003). In volcanic provinces such as the Deccan Traps of western and central India, dykes are important geological structures that not only preserve records of magmatic evolution but also exert significant control over hydrogeological systems (Krishnan, 1968; Geological Survey of India, 2018).

The Deccan Traps, one of the largest continental flood basalt provinces in the world, were emplaced during the Late Cretaceous to Early Eocene (65–67 Ma). Dykes within the Deccan basalt are commonly doleritic in composition and often aligned in regional structural trends, reflecting crustal stress regimes during emplacement (Deshmukh & Sehgal, 1988). While traditionally considered feeders to lava flows (Oldham, 1893), later studies (Agashe & Gupte, 1970) have shown that many dykes are hypabyssal intrusions without direct feeder relationships.

From a hydrogeological perspective, dykes can act as barriers to groundwater flow when oriented perpendicular to regional hydraulic gradients, or as conduits when fractured or aligned parallel to flow direction (Singhal & Gupta, 2010). The Adgaon– Naigavan dyke provides an excellent case to study such dual hydrogeological behavior in a semi-arid basaltic terrain.



[Fig. 1 – Location map of study area here]

2. Regional Geological Setting

The study area lies in the central part of Maharashtra, within the Dudhana sub- basin, and is entirely underlain by the Deccan Traps (Upper Cretaceous–Lower Eocene). The traps comprise multiple basaltic lava flows, including both Aa (compact basalt) and Pahoehoe (amygdaloidal basalt) types. The basalt pile in this region ranges from 580 to 920 m above mean sea level and exhibits lithological variations associated with vesicularity, mineral fillings, and joint patterns.

2.1 Lithostratigraphy

The lithological succession in the study area is summarized below

Sr.	Age	Formation	Lithology
1	Holocene	Soil	Black cotton soil, Kanker deposits
2	Pleistocene	Alluvium	Alluvium comprising sand, silt, clay etc
3	Upper Cretaceous to Lower Eocene	Deccan Trap	Different types of Basalt flows intruded by concordant and discordant intrusions (Tachylitic basalts and Dykes)

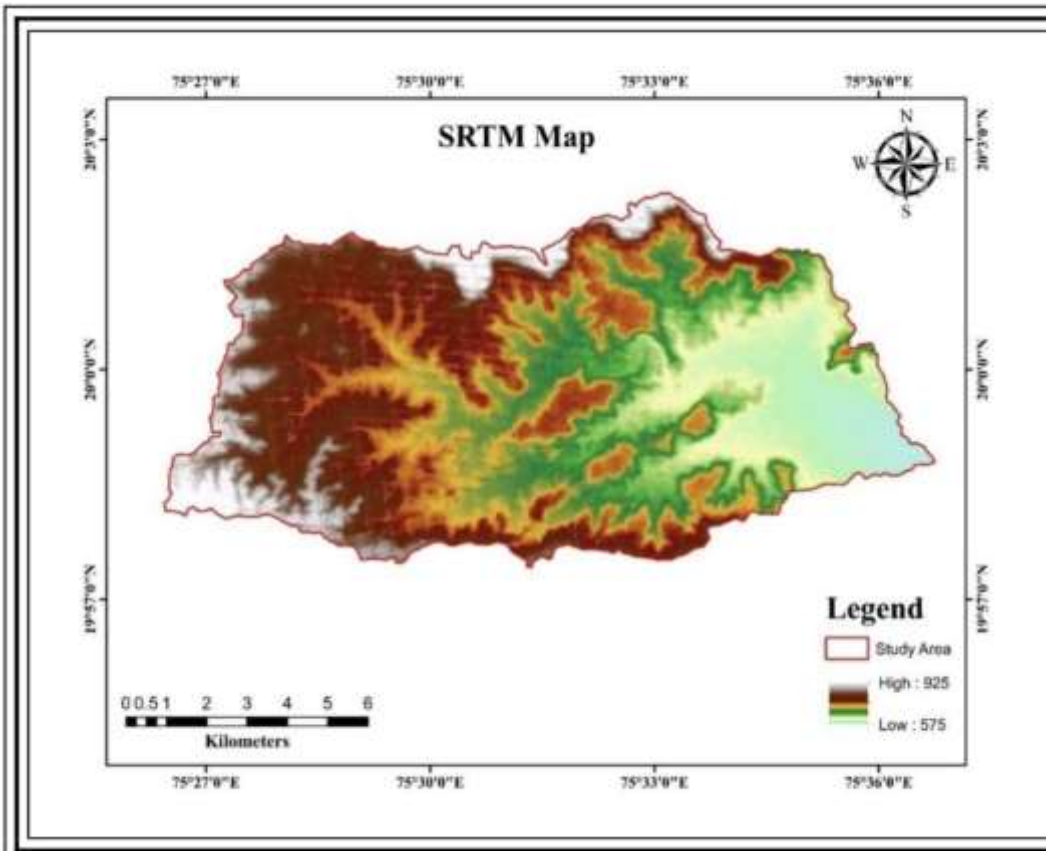
[Table 1 – Lithological succession of study area here]

Key features include:
• Compact basalt flows (Aa type) at higher elevations, jointed and massive, often forming prominent ridges.
• Thick and thin irregular amygdaloidal basalt flows at lower elevations, often weathered and hydrothermally altered.
• Tachylitic basalt intrusions between flows, locally forming red or green bole horizons.
• Doleritic dykes cutting across the lava pile, including the main Adgaon–Naigavan dyke.

3. Study Area Description

The Adgaon–Naigavan dyke traverses a rural, semi-arid landscape characterized by undulating terrain, cultivated plains, and dissected basaltic uplands. The climate is tropical semi-arid with mean annual rainfall ~700–800 mm, concentrated during the southwest monsoon. The main drainage system is the Dudhna River and its tributaries, which flow eastward.

The Shuttle Radar Topography Mission (SRTM) data shows a general elevation gradient from 925 m in the west to ~575 m in the east, with the dyke trace trending northeast–southwest across multiple geomorphic zones.



[Fig. 2 – SRTM elevation map here]

4. Geology of the Dyke and Surrounding Basalt Flows

4.1 Morphology and Orientation

Field mapping indicates the dyke has a consistent strike of N40°E–S40°W, with thickness averaging 2.2 m. It exhibits local bulging (up to 3 m) and pinching (as narrow as 1.5 m). The dyke is exposed in road cuts, stream banks, and dug wells, with best exposures near Adgaon Sarak and Naigavan.

4.2 Petrography

The dyke is composed of medium- to fine-grained dolerite, dominated by plagioclase and clinopyroxene, with accessory opaque minerals. Weathered surfaces display reddish-brown staining due to iron oxidation. The dyke margins are more altered and fractured compared to the massive central portions.

4.3 Jointing Patterns

Three joint sets are observed:

1. Two vertical sets roughly orthogonal to each other.
2. One horizontal set parallel to cooling surfaces.

Joint spacing is closer at the margins (~2–5 cm) and wider in the central part (>15 cm). This structural variation influences groundwater flow behavior.

[Fig. 3 – Field photo of Dyke.]

[Fig. 4 – Field photo of dyke close jointing here]

5. Hydrogeological Significance

The dyke plays a dual role in local groundwater systems:
• Barrier effect: Where the dyke is unfractured and oriented perpendicular to stream flow, it impedes groundwater movement, leading to upstream water accumulation.
• Conduit effect: In highly fractured zones, particularly along its margins, the dyke facilitates localized groundwater movement.

Well inventory data indicates higher water levels upstream of barrier segments, with downstream dry zones in summer. Conversely, in conduit segments, wells near the dyke margins show enhanced yields.

6. Remote Sensing Interpretation

Landsat 8 OLI imagery processed in false color composites (FCC) reveals the dyke as a linear tonal anomaly against the surrounding basalt flows. The feature is traceable for several kilometers, with minor offsets where it intersects drainage channels.

7. **Discussion**

The Adgaon–Naigavan dyke provides a clear example of how structural and textural variations within a single igneous intrusion can influence groundwater systems. Similar observations have been made in other Deccan Trap regions (e.g., Satpura and Malwa plateaus), where fracture density and dyke orientation are critical in determining hydraulic behavior (Kulkarni et al., 2000; Pawar et al., 2014).

The presence of multiple joint sets suggests cooling-related fracturing, with implications for both groundwater storage and movement. From a resource management perspective, recognizing these variations can guide well siting and recharge structure placement.

8. **Conclusions**

1. The Adgaon–Naigavan dyke is a medium-grained doleritic intrusion, ~2.2 m thick, trending N40°E–S40°W.
2. Morphological variations (bulging and pinching) occur along its length, influencing local hydrogeology.
3. Jointing is more intense at the margins, enhancing permeability locally.
4. The dyke alternately acts as a barrier and conduit for groundwater, depending on fracture density and orientation relative to flow.
5. Remote sensing is effective in mapping dyke traces in basaltic terrains.
6. Management strategies should integrate structural mapping to optimize groundwater use.

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