CHAPTER 30

GEOLOGY

Doctoral Theses

01.   KASANA (Parv)
        **Tectonic Forcing and Morpho-Sedimentary Evolution in the Central Indian
        Forebulge: Implications for Late Quaternary Stratigraphy and Drainage
        Reorganization.**
        Supervisor: Prof. Vimal Singh
        Th 28328

Abstract

The Central Indian Forebulge (CIF), formed by the convergence of the Indian and
Eurasian plates, has not been investigated much for the landform evolution, as these
regions are considered to be experiencing extremely slow tectonics. But these regions
provide a unique opportunity to understand the evolution of the landscapes, which
is an interplay of climate, lithology, and slow tectonics. This study explores the
morpho-sedimentary evolution of the CIF region. For this study, our approach was to
use morphometric and sedimentological analysis along with optically stimulated
luminescence chronology. The morphometric results suggest significant west-to-east
variations in river basin parameters, mainly controlled by the forebulge uplift. The
modelled river steepness values and the rock strength show a strong correlation;
together, they control the occurrence of transient landforms in the CIF. The
orientation of the lineaments and fractures is parallel to the forebulge axis, which
also aligns most of the 3rd and 4th order streams. This indicates control of forebulge
uplift in the region. Results also show that the drainage divide between the
northward-flowing Ganga and the southward-flowing Narmada River tributaries is
not in equilibrium. Based on lithofacies associations, lateral correlation, and OSL
ages from the Chambal Valley, a depositional sequence comprising basal interfluve
facies (>90 ka), channel facies (80-60 ka), and overbank facies (< 50 ka) is identified.
These facies associations are found to be consistent across the entire Southern
Ganga Plains. A regional stratigraphy of the Southern Ganga Plains and a model for
its evolution are proposed in this study. The study concludes that forebulge uplift
drives the transient state of the CIF, while lithological variability modulates it.

Contents

1. Introduction 2. Geology and Geomorphology 3. Methods and Materials 4.
Geomorphic and Morphometric Analysis of the Study Area 5. Drainage Divide
Dynamics and Landscape Transience 6. Sedimentary Facies Analysis and Optically
Stimulated Luminescence Dating 7. Discussion and Conclusions. References and
appendix.

02.   SHARMA (Shubham)
        **Sustainable Water Management in Punjab: An Integrated Approach to model
        Land Surface Fluxes and Groundwater Dynamics.**
        Supervisors: Dr. Manika Gupta and Dr. Shashank Shekhar
        Th 28329

Abstract

Water resources are increasingly under pressure globally due to population growth, climate change, urbanization, industrialization, and intensive agriculture, severely affecting both surface and groundwater systems. Punjab, once a Green Revolution leader and India's key agricultural state, now experiences critical groundwater depletion driven by water-intensive cropping, subsidized irrigation, and rising climate variability. These interlinked challenges highlight the urgent need for sustainable water management in the region. This thesis presents an integrated approach to sustainable water management by bridging land surface hydrological processes, groundwater flow dynamics, and irrigation water demand (IWD) within a cohesive modelling framework. The study incorporates application of Noah Land surface model (LSM) over the agriculturally intensive region of Punjab to simulate the energy and water balance components such as soil moisture, evapotranspiration (ET), and dynamic IWD. This demonstrates significant increases in ET (31.4%) and latent heat flux (15%) during cropping seasons and enables more accurate estimation of spatially and temporally variable IWD. Building on these surface process insights, the study establishes a Groundwater Flow Model (GFM) for Bist-Doab that identifies alarming depletion trends. The model evaluates two key mitigation approaches: improved irrigation efficiency (20% reduction in abstraction) and cropping system transition (from rice-wheat to maize-millet). Deficit irrigation reduces water decline by 6 m, while crop rotation offers greater relief with a 9 m reduction in overexploited areas in 2033 relative to baseline. A key innovation of this research is the integration of LSM-derived dynamic IWD into the GFM, replacing traditional static abstraction estimates. This advancement significantly improves simulation accuracy (reducing RMSE from 5.23 to 2.36). The study presents a replicable framework for sustainable water management by linking irrigation demand with groundwater response. The findings emphasize that while technical solutions exist, their effective implementation will require coordinated action among stakeholders to ensure long-term water security in Punjab and comparable regions worldwide.

Contents

03.   SONU
Geochemical Stratigraphy of Volcano-Sedimentary Succession from Koyna (KBH-1) Core and Correlation with the Southwestern Deccan Basalt Stratigraphy.
Supervisors: Dr. Saquib Abdullah and Dr. J.P. Shrivastava
Th 28330

Abstract

Present work documents presence of 37 physically and chemically distinct lava flows in a 932 m thick volcano-sedimentary Koyna (KBH1) core succession. Further, major oxides grouped them into four Chemical Types and matching well with the two standard Deccan Stratigraphic Formations and their transitional Poladpur-Ambenali lavas. Chemical variations and calculated K_2O/P_2O_5, La/Nb, Sm/La, TiO_2/Zr, Th/Yb values define contaminant types involved in petrogenetic evolution of the lava packages. The Koyna lavas show chemical closeness with the well-established

primitive mantle derived and crustal contaminated lava flow arrays. But, latter array assumes assimilation of Gondwana sediments and Archaean TTG basement gneisses during magma ascent. The Koyna core bole beds with variable (0.5-2.5 m) thicknesses contain plenty of pyroclasts/ejecta and suggest violent eruptions with intermittent hiatuses. Calculated parameters, together with the major-oxide data plots over ternary diagrams for 307 bole bed sample suggest oxidative environment with acidic conditions and high degree of precipitation, which correspond to major phase of Deccan lava eruptions. Further, crystallographic changes, mainly expansion of b-axis of illite and montmorillonite is attributed to high temperature favored by alkaline conditions. Although, montmorillonite lattices (bearing 105 atoms and 450 bonds) of 323 bole bed samples show shortening of b-axis due to contraction of Al-O, Si-O, Fe-Ca, and Al-O bonds, causative for bond strengthening. Further, lattice distortion is due to contraction and expansion of a- and c-axes in bole bed sample 323. Presence of thick ejecta layer and incidences of crystallographic changes noticed in 307 and 323 bole beds are possibly attributed to impact induced KPB transition and also supportive of cause and effect relationships. Thus, these two bole beds have been recognized as a new precise standard stratigraphic reference points with syn- and post impact signatures in the Deccan Stratigraphy.

Contents

1. Introduction 2. Physical Stratigraphy 3. Geochemical Flow Stratigraphy 4. Mineralogy and Geochemistry of Bole Beds 5. Conclusions. References and appendix.

04.   YADAV (Akhilesh Kumar)
Process Based Insight into Groundwater Contamination in the Alluvial Aquifers of Delhi by the Potential Toxic Elements, with Special Reference to Arsenic Pollution.
Supervisor: Prof. Shashank Shekhar
Th 28703

Abstract

Hydrogeochemical processes in urbanized environments are complex and difficult to assess using conventional methods. This study for the first time, employs stable ($\delta^{18}O$, δD) and radiogenic (^{14}C) isotopes, along with chemical data, to have a Process-based insight into groundwater contamination in the Alluvial Aquifers of Delhi by the Potential Toxic Elements, with special reference to Arsenic Pollution. In most of the analyzed samples, EC exceeded drinking water limits, while Cd and 'As' frequently surpassed permissible thresholds; Pb, Cr, Cu, and Zn remained within limits, and Mn exceeded in one case. Health risk assessments showed both adults and children are vulnerable to non-carcinogenic risks, with children at higher risk. Carcinogenic risk with respect to 'As' was high in 39% of samples for adults and 42% for children, with spatial mapping indicating widespread vulnerability across the study area. The isotopic ratios ranged from -8.24 ‰ to –5.15 ‰ for $\delta18O$, and -58.43 ‰ and -39.60 ‰ for δD. The mean residence time for all the samples varied in the range of 378 to 7465 years before present (BP), and in the range of 504 to 3620 BP for the samples assumed to have been least affected by any nearby surface water body recharge. These isotope fingerprints indicate that the locally recharged meteoric water from the highly exploited aquifers of the study area had been extracted before the sampling campaign. The sampled groundwater are not locally recharged from the rainfall; rather, they are paleo water which might have travelled laterally from the proximal part of the basin along the prominent groundwater flow direction. The hydrochemistry of groundwater reflects a combined imprint of long-term geogenic

evolution due to higher mean residence time and recent anthropogenic forcings. The study reviews about 200 articles to propose cost-effective measures for the remediation of groundwater from 'As' pollution.

Contents

1. Introduction 2. Hydrogeology 3. Research Methodology 4. A Brief Review on Arsenic Mobilization and Occurrence in Groundwater 5. Major Ion Groundwater Chemistry 6. Isotopic Signatures s7. Groundwater Contamination by The Potential Toxic Elements and The Health Risk Assessment 8. Arsenic Removal Technologies 9. Process Based Insight into Groundwater Contamination 10. Conclusions and Publications.