

Clay Minerals as Climate Change Indicators—A Case Study

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ABSTRACT

The clay mineralogy of the Late Pliocene-Early Pleistocene Pinjor Formation of the type area, northwestern Himalaya, India has been investigated to understand the paleoclimatic conditions and paleotectonic regime prevailing in the frontal Himalayan terrain during 2.5 Ma to 1.7 Ma. The clay minerals were investigated by X-ray diffraction analysis and scanning electron microscope studies. Study of the oriented aggregates of 47 representative clay samples of the Pinjor Formation of the type area reveals that illite is the most dominant mineral followed by chlorite, kaolinite, vermiculite and mixed layer clay minerals. The distribution of the clay minerals in the three lithostratigraphic units of the Formation, namely the Kora Clay Member, the Tanda Bhagwanpur Wacke Member and the Chanda Nallah Pebbly Bed Member which are well exposed along the Barwah-Mandhana section, the Kora-Kamandawala section and the Ghaggar River-Chanda Nallah section, is nearly uniform suggesting thereby the prevalence of similar sedimentation environments in the Himalayan foreland basin. The presence of illite and kaolinite suggests their derivation from crystalline rocks containing feldspar and mica as also from pre-existing soils and sedimentary rocks. Further, the paleo-climatic conditions were moderate. Presence of chlorite suggests the weathering of intermediate and basic crystalline rocks and low grade metamorphic rocks in the positive areas. The presence of kaolinite in the Pinjor Formation is mainly attributed to the weathering and subsequent leaching of the mineral from granitic and basic rocks in the hinterland. Vermiculite has been mainly formed by weathering and transformation of biotite. Warm and humid climatic conditions prevailed for a major part during the deposition of the detritus which favored weathering and transformation of minerals. During the terminal phase of sedimentation there was renewed tectonic activity which had a significant impact on climate as precipitation and mechanical weathering rates increased substantially. Post 1.7 Ma there was a marked shift in temperature patterns and subsequent cooling of the landmass, which resulted in a decreased vegetation cover and a subsequent decrease in animal population thriving on it.

Keywords: Clay Minerals; Climate; Pinjor; Siwalik; Himalaya; India

1. Introduction

Clay mineral assemblage of the Late Pliocene-Early Pleistocene Pinjor Formation of the type area in northwestern Himalaya is of significant importance in understanding the paleo-climatic and paleotectonic conditions prevailing in the positive and negative areas and their inter-relationship; types of source rocks, modes of sediment transport, sedimentation environments and post-depositional changes experienced by the sediments.

The Himalayan orogenic belt is topographically divided into three major sub divisions, namely the southernmost frontal Himalaya comprising the low lying Siwalik Hills, the middle Lesser Himalaya and the northern Great Himalayan belt. The Siwalik Group of northwestern Himalaya in India is exposed in a linear fashion along the Himalayan foothills for a distance of about 2400 km, from near Jammu in the West to near Tripura in the East.

It represents a huge thickness of sediments ranging from 3300 m to 6300 m [1] which were deposited in a fore-deep. The Late Pliocene-Early Pleistocene Pinjor Formation (1.7 Ma - 2.5 Ma) of the Upper Siwalik Subgroup is very well exposed in the type area Pinjor and surrounding regions (Figure 1). The Formation attains a thickness of 700 m to 1500 m. It overlies the Tattot Formation (2.5 Ma - 5.6 Ma) and is underlain by the Boulder Conglomerate Formation (0.7 Ma - 1.7 Ma). The Pinjor Formation has a conformable gradational contact with underlying and overlying formations. Lithologically, the Formation consists of poorly to moderately indurated light grey to pale brown, medium to coarse grained, pebbly sandstones and pale brown to chocolate brown sandy clays. Reference [1] observed that the Siwalik Group of the western Himalayan is a product of two coarsening up mega cycles. The first mega cycle is represented by the Lower Siwalik/Nahan Formation which is characterized

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**Raymond N. Yong, Catherine N.
Mulligan, Masaharu Fukue**



Clay Minerals As Climate Change Indicators A Case Study:

Climate Change Adaptation, Risk Management and Sustainable Practices in the Himalaya Sanjeev Sharma, Jagdish Chandra Kuniyal, Pritam Chand, Pardeep Singh, 2023-03-10 This volume analyzes ecological and socio economic risks due to climate change in the Himalayan mountain ecosystems communities and proposes adaptation strategies and sustainability practices In order to better understand the potential actions required to improve natural resource conservation and the development of mountain people s livelihoods The authors discuss the current status of local knowledge system on various environmental aspects of conservation and sustainable use of mountain resources in the Himalaya The book addresses the institutional capacities gaps and priority areas of capacity building to strengthen policies and governance in regard to climate change landuse management biodiversity conservation and sustainable management in the Himalayan region The aim of this book is to enhance coordination building among policymakers planners mountain communities to foster collaboration between different stakeholders by understanding local perceptions of climate change as well as variability issues and establishing adaptation strategies to cope with these impacts The chapters incorporate theoretical and applied aspects and may serve as baseline information for the sustainability of mountain ecosystems through the contribution of multidisciplinary and interdisciplinary expertise from the Himalayan region The book will be useful for students teachers and researchers working in different areas pertaining to mountain ecosystems as well as policymakers and planners working on issues related to the sustainability of the mountain ecosystem **Handbook of Green Concept** Ms.

Kity Maurya and Dr. Aneeta Sen, This book mainly focuses on Green concept i e Green Chemistry Green Economy Green Finance and various environmental issues This book makes the Green concept crystal clear in different disciplines It is beneficial for individuals of Science Commerce as well as Arts streams Thus it is a web of various fields coming together woven in a better way to understand the Environment and the requirement of understanding its different corners The green concept is not very new concept but still its difficult to understand in regarding to its various fields This Handbook is written in language which could be easily understood which makes the targeted concept clear in a better way Various diagrams tables and examples have been included which makes the book more attractive for the readers **Chemical,**

Mineralogical and Isotopic Studies of Diagenesis of Carbonate and Clastic Sediments Ihsan Al-Aasm, Howri Mansurbeg, 2021-06-10 Diagenesis of carbonates and clastic sediments encompasses the biochemical mechanical and chemical changes that occur in sediments subsequent to deposition and prior to low grade metamorphism These parameters which to a large extent control diagenesis in carbonates and clastic sediments include primary composition of the sediments depositional facies pore water chemistry burial thermal and tectonic evolution of the basin and paleo climatic conditions Diagenetic processes involve widespread chemical mineralogical and isotopic modifications affected by the original mineralogy of carbonate and clastic sediments These diagenetic alterations will impose a major control on porosity and

permeability and hence on hydrocarbon reservoirs water aquifers and the presence of other important economic minerals In this Special Issue we have submissions focusing on understanding the interplay between the mineralogical and chemical changes in carbonates and clastic sediments and the diagenetic processes fluid flow tectonics and mineral reactions at variable scales and environments from a variety of sedimentary basins Quantitative analyses of diagenetic reactions in these sediments using a variety of techniques are essential for understanding the pathways of these reactions in different diagenetic environments

Climate Change and Himalaya: Natural Hazards and Mountain Resources J. Sundaresan, P. Gupta, K.M. Santosh, R. Boojh, 2014-01-01 The book *Climate Change and Himalaya Natural hazards and mountain resources* presents the resources of Himalaya along with the potential natural hazards It consists twenty two chapters from researchers working in different institutions with multi disciplinary approach More than seven hundred glaciers were monitored and discussed in one of the chapter of this book This book will be highly useful to researchers policy makers students and is an essential document to libraries of universities colleges research institutions and personnel collections

Principles of Environmental Geochemistry G. Nelson Eby, 2016-04-20 Many geochemists focus on natural systems with less emphasis on the human impact on those systems Environmental chemists frequently approach their subject with less consideration of the historical record than geoscientists The field of environmental geochemistry combines these approaches to address questions about the natural environment and anthropogenic effects on it Eby provides students with a solid foundation in basic aqueous geochemistry before discussing the important role carbon compounds isotopes and minerals play in environmental issues He then guides students through how these concepts apply to problems facing our atmosphere continental lands and oceans Rather than broadly discussing a variety of environmental problems the author focuses on principles throughout the text leading students to understand processes and how knowledge of those processes can be applied to environmental problem solving A wide variety of case studies and quantitative problems accompany each chapter giving each instructor the flexibility to tailor the material to his her course Many problems have no single correct answer illustrating the analytical nature of solving real world environmental problems

Climate Change and Environmental Impacts: Past, Present and Future Perspective Binita Phartiyal, Rahul Mohan, Supriyo Chakraborty, Venkatesh Dutta, Anil Kumar Gupta, 2023-01-17 Earth's climate varies even without human influence but the acceleration in the changing pattern with cause and effect by to the civilisation is a matter of concern to scientists These patterns are lessons to understand future trends and ways and means for mitigation The extreme weather events in almost every region of the globe involving excessive loss of human life and property are causing anxiety in society and posing challenges before scientists and planners Cyclical variations in the Earth's climate occur at multiple time scales from years to decades centuries and millennia Cycles at each scale are caused by a variety of physical mechanisms In the last 65 Ma only there have been several cycles of glacial advances and retreat with the abrupt end of the last ice age about 11 700 years ago marking the beginning of the modern climate era and human

civilization A multidisciplinary approach in studying the Earth's changing climate will provide a holistic view and guide us in future planning and programming

The Ecology of Sandy Shores Omar Defeo, Anton McLachlan, 2025-02-06 The Ecology of Sandy Shores Fourth Edition provides both a holistic and conceptual introduction for the beginner yet at the same time gives an in depth and cutting edge analysis for the researcher interested in sandy shores There is no other book covering the ecology of sandy beaches despite the extent and economic importance of these systems This guide is designed to both introduce students to the basic principles of sandy shore ecology to serve as a ready reference for doctoral students and researchers working on these systems and to provide a handbook for land and coastal managers This new edition will focus on humans as part of the sandy beach environment including aspects such as global change in coastal systems and its impacts on sandy littoral zones through coastal squeeze Further prominence will be given to resource use such as artisanal fisheries and to the critical area of coastal zone management and governance Considering these two main issues the concept of sandy beaches as social ecological systems will be developed together with an illustrative framework related to this approach Comprehensively covers the crucial topic of sandy shores as ecosystems examined ecologically environmentally socially and economically Fully updated edition of the preeminent book on sandy shores Focuses on human impacts and beaches as social ecological systems Includes aspects such as global change in coastal systems and its impacts on sandy littoral zones through coastal squeeze Offers the most updated information based on recent scientific findings presented with an illustrative framework

Geoenvironmental Sustainability Raymond N. Yong, Catherine N. Mulligan, Masaharu Fukue, 2006-07-27 Industrialization urbanization agriculture and resource exploitation are activities associated with a developing society Geoenvironmental Sustainability focuses on such a society's geoenvironment and the natural capital that defines it The book explains these elements in systematic detail particularly with respect to their relationship to five

Soil Carbon Stabilization to Mitigate Climate Change Rahul Datta, Ram Swaroop Meena, 2021-08-25 Carbon stabilization involves capturing carbon from the atmosphere and fix it in the form of soil organic carbon stock for a long period of time it will be present to escape as a greenhouse gas in the form of carbon dioxide Soil carbon storage is an important ecosystem service resulting from interactions of several ecological processes This process is primarily mediated by plants through photosynthesis with carbon stored in the form of soil organic carbon Soil carbon levels have reduced over decades of conversion of pristine ecosystems into agriculture landscape which now offers the opportunity to store carbon from air into the soil Carbon stabilization into the agricultural soils is a novel approach of research and offers promising reduction in the atmospheric carbon dioxide levels This book brings together all aspects of soil carbon sequestration and stabilization with a special focus on diversity of microorganisms and management practices of soil in agricultural systems It discusses the role of ecosystem functioning recent and future prospects soil microbial ecological studies rhizosphere microflora and organic matter in soil carbon stabilization It also explores carbon transformation in soil biological management and its genetics

microbial transformation of soil carbon plant growth promoting rhizobacteria PGPRs and their role in sustainable agriculture The book offers a spectrum of ideas of new technological inventions and fundamentals of soil sustainability It will be suitable for teachers researchers and policymakers undergraduate and graduate students of soil science soil microbiology agronomy ecology and environmental sciences

Confronting Global Climate Change Mark Harris, 2019-06-07 This book offers a solutions based approach to climate change problems which potentially impinge on human beings within the tropics It largely comprises research articles with supplementary applications and illustrations The effects of atmospheric phenomena energy acquisition wind power CO₂ sequestration are linked with soils aquatic life reducing deforestation rainwater harvesting and clay pot farming climate plant disease and food security to show that no area of life is untouched by the phenomenon of climate change It discusses specific problem areas and provides an overview of geotechnical and sustainable solutions to lessen the impact of climate

Philosophical Transactions, 2002-04

Beneficial Elements for Remediation of Heavy Metals in Polluted Soil Shah Saud, Shah Fahad, Depeng Wang, 2025-02-21 Beneficial Elements for Remediation of Heavy Metals in Polluted Soils provides readers with comprehensive information on soil pollution and beneficial elements Each chapter summarizes the beneficial elements interaction in soil and its impact on the environment In addition the book covers many current environmental issues such as pollution and monitoring of various heavy metals organic pollutants and environmental hormones such as pesticides The book goes a step further by offering information on substances that have been recently confirmed and suspected to be carcinogenic chromogenic and transtoxic Toxicological issues such as the type and condition of the pollutants toxicity mechanism of action and influencing factors metabolic processes in vivo and toxic damage manifestations are also addressed Explains the impact of soil pollution on agriculture sector Enables soil scientists to design policies and management strategies for sustainable agriculture under changing climate Represent the most current scientific information regarding soil productivity under changing climate

Sustainable Practices in Geoenvironmental Engineering Catherine N. Mulligan, Masaharu Fukue, Raymond N. Yong, 2025-02-21 This third edition focuses on the application of geoenvironmental engineering procedures and practices to mitigate and reduce the adverse impacts on the geoenvironment from anthropogenic sources including emerging contaminants such as micro and nanoplastics pharmaceuticals and fire retarding chemicals Thoroughly updated with three new chapters and extensive use of case studies to showcase examples of sustainable practices this new edition discusses many activities that are still generating geoenvironmental impacts that are adverse to the quality and health of the geoenvironment It includes new tools and procedures that have been developed to evaluate and minimize adverse impacts This new edition Discusses the impacts of climate change and potential mitigation Addresses emerging contaminants of concern Introduces an entirely new chapter on sustainable nitrogen and carbon cycles Includes new case studies like the Fukushima case study on sediments and microbial induced precipitation processes Provides new practices and tools for sustainability to evaluate and to minimize adverse

impacts Discusses the aspects of social sustainability and cultural aspects of the geoenvironment This book is intended for professionals researchers academics senior undergraduate students and graduate students in geotechnical engineering geoenvironmental engineering site remediation sustainable development and earth sciences Global Climate Change and Pedogenic Carbonates R. Lal,1999-09-28 Basic concepts Analytical methods Secondary carbonates in soils of different regions **Earth Surface Processes** Philip A. Allen,2009-05-27 Earth Surface Processes is an introductory text for those studying the dynamics of fluid and sediment transport in the environments in the context of both present day patterns as well as the environmental changes decipherable in the geological record The book is divided into two parts The first deals with the global scale aspects of the earth s surface system The second part focuses on the physical underpinnings for fluid and sediment transport in a number of settings found at the earth s surface and in its oceans Earth Surface Processes fits into the literature of the broad holistic discipline of Earth System Science The author illustrates the physical principles of earth s surface processes and explains the relevant theories by quantitative practical exercises The pioneering textbook on the new sedimentology One of the first textbooks to adopt the Earth Systems approach to geology developed at Penn State and Stanford Should reinvigorate more traditional courses in physical sedimentology and dynamical sedimentology Successfully marries the innovative holistic approach to Earth Systems with the traditional reductionist approach to sedimentary processes Explains both the global scale Earth Surface System and the fluid dynamics and sedimentary transport processes that underlie this Quantitative approach is reinforced with worked examples and solutions Richly illustrated with original diagrams and a colour plate section **Bibliography of Agriculture with Subject Index** ,1993-07 **Journal of the Royal Society of New Zealand** ,1989-06 *Geochemical Signals in Dynamic Sedimentary Systems Along Continental Margins* Natascha Riedinger,Laura M. Wehrmann,Susann Henkel,2022-05-04 *How Large Igneous Provinces (LIPs) During the Triassic Shaped Modern-Day Ecosystems* Jacopo Dal Corso,Sara Callegaro,Haijun Song,2023-11-09

Deepwater Sedimentary Systems Jon R. Rotzien,Cindy A. Yeilding,Richard A. Sears,F. Javier Hernández-Molina,Octavian Catuneanu,2022-08-18 Deepwater Sedimentary Systems Science Discovery and Applications helps readers identify understand and interpret deepwater sedimentary systems at various scales both onshore and offshore This book describes the best practices in the integration of geology geophysics engineering technology and economics used to inform smart business decisions in these diverse environments It draws on technical results gained from deepwater exploration and production drilling campaigns and global field analog studies With the multi decadal resilience of deepwater exploration and production and the nature of its inherent uncertainty this book serves as the essential reference for companies consultancies universities governments and deepwater practitioners around the world seeking to understand deepwater systems and how to explore for and produce resources in these frontier environments From an academic perspective readers will use this book as the primer for understanding the processes deposits and sedimentary environments

in deep water from deep oceans to deep lakes This book provides conceptual approaches and state of the art information on deepwater systems as well as scenarios for the next 100 years of human led exploration and development in deepwater offshore environments The students taught this material in today s classrooms will become the leaders of tomorrow in Earth s deepwater frontier This book provides a broad foundation in deepwater sedimentary systems What may take an individual dozens of academic and professional courses to achieve an understanding in these systems is provided here in one book Presents a holistic view of how subsurface and engineering processes work together in the energy industry bringing together contributions from the various technical and engineering disciplines Provides diverse perspectives from a global authorship to create an accurate picture of the process of deepwater exploration and production around the world Helps readers understand how to interpret deepwater systems at various scales to inform smart business decisions with a significant portion of the workflows derived from the upstream energy industry

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Table of Contents Clay Minerals As Climate Change Indicators A Case Study

1. Understanding the eBook Clay Minerals As Climate Change Indicators A Case Study
 - The Rise of Digital Reading Clay Minerals As Climate Change Indicators A Case Study
 - Advantages of eBooks Over Traditional Books
2. Identifying Clay Minerals As Climate Change Indicators A Case Study
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Clay Minerals As Climate Change Indicators A Case Study
 - User-Friendly Interface
4. Exploring eBook Recommendations from Clay Minerals As Climate Change Indicators A Case Study

- Personalized Recommendations
- Clay Minerals As Climate Change Indicators A Case Study User Reviews and Ratings
- Clay Minerals As Climate Change Indicators A Case Study and Bestseller Lists
- 5. Accessing Clay Minerals As Climate Change Indicators A Case Study Free and Paid eBooks
 - Clay Minerals As Climate Change Indicators A Case Study Public Domain eBooks
 - Clay Minerals As Climate Change Indicators A Case Study eBook Subscription Services
 - Clay Minerals As Climate Change Indicators A Case Study Budget-Friendly Options
- 6. Navigating Clay Minerals As Climate Change Indicators A Case Study eBook Formats
 - ePub, PDF, MOBI, and More
 - Clay Minerals As Climate Change Indicators A Case Study Compatibility with Devices
 - Clay Minerals As Climate Change Indicators A Case Study Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Clay Minerals As Climate Change Indicators A Case Study
 - Highlighting and Note-Taking Clay Minerals As Climate Change Indicators A Case Study
 - Interactive Elements Clay Minerals As Climate Change Indicators A Case Study
- 8. Staying Engaged with Clay Minerals As Climate Change Indicators A Case Study
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Clay Minerals As Climate Change Indicators A Case Study
- 9. Balancing eBooks and Physical Books Clay Minerals As Climate Change Indicators A Case Study
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Clay Minerals As Climate Change Indicators A Case Study
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Clay Minerals As Climate Change Indicators A Case Study
 - Setting Reading Goals Clay Minerals As Climate Change Indicators A Case Study
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Clay Minerals As Climate Change Indicators A Case Study

- Fact-Checking eBook Content of Clay Minerals As Climate Change Indicators A Case Study
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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