CHAPTER 20

GEOLOGY

Doctoral Theses

01 APURVA ALOK
Investigation of SaraswatiPalaeochannels and Associated Indus Valley Civilization in Context of Drainage Evolution and Palaeoclimate.
Supervisor : Prof. N. C. Pant
Th 25439

Abstract
(Not Verified)

The interfluve alluvial plain between Sutlej in west and Yamuna in east is constituted by >400m thick Quaternary overburden deposited by Himalayan rivers (Saini et al. 2003, 2009) possibly perennial in nature (Valdiya, 2014; Clift et al. 2012), which were affected by neotectonics, climate change and monsoonal fluctuations, mostly in the late Quaternary. These perennial rivers do not show distinct surface expression in present day geomorphology but have been supposed to be buried under the newer alluvium and deposits of aeolian activity. Tracing and validating the course of buried palaeorivers in the Quaternary fluvio-aeolian plains of NW India has been attempted for more than a century (Oldham 1893; Yashpal et al. 1980; Sahai 1999; Radhakrishnan and Merh 1999; Valdiya 2013). Many studies suggest that one major river, which is often identified as the ancient Saraswati, traversed three morpho-climatic terrains: from the humid and tectonically active Himalaya, across the semiarid plains of northwest India and the arid Thar desert margins, before emptying in the Arabian Sea. Others show that there were several channels rather than one mighty river.The complex linkage of the palaeochannel network and the settlements of the Indus Civilization and the Early Historic periods in northwest India can only be resolved by integrated studies that combine radiocarbon and other chronological dating approaches with geoscientific investigation of the sediment and their sources, and consideration of the processes of climate evolution. This study provides important linkages between the shallow sub-surface geology of the paleodrainage, mineralogical constraints on the provenance of sediments, and new age data to contribute to fill this gap. The shallow sub-surface geology is the most critical factor in this context and the present work shows the importance of this data for inferring past hydrological systems which are largely obscured now.

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02 DHIMAN (Harsha)
Study of Dinosaur Nests, Eggs and Eggshells from the Upper Cretaceous Lameta Formation of Lower Narmada Vally, India with Reference to Parataxonomy, Palaeobiology and Taphonomy.
Supervisor : Prof. G. V. R. Prasad
Th25582

Abstract
(Not Verified)

The dinosaur oological material has been studied from the continental Upper Cretaceous (Maastrichtian) Lameta Formation at Akhada, DholiyaRaipuriya, Jhaba, Jamniapura and Padlya from Bagh-Kukshi areas of Dhar district, Madhya Pradesh and BhogiyaKinali from Kheda district, Gujarat to understand parataxonomy, nesting and reproductive patterns, taphonomy, palaeoenvironment, palaeodiet and preservational conditions of proteinaceous moeities. The studied sites show 108 titanosaur nests with 285 eggs showing spherical to sub-spherical shapes and diameter between 12.0 and 17.0 cm. Microstructure and ultrastructure of the eggshells show spherulitic basic type, discretispheruliticmorphotype, compactituberculate surface ornamentation and tubocanaliculate pore system. The oospecies Megaloolithuscylindricus, M. jabalpurensis, M. dhoridungriensis, Fusioolithusmohabeyi, F. baghensis and F. padiyalensis indicate high oospecies diversity. The nest types are circular/clutch, linear and combination. The hatched eggs are represented by fragmented eggs, hatching windows and eggshell pile, while complete eggs and partial/fully intact egg outlines represent unhatching. Previous water vapor conductance studies, variably spaced and sized eggs, and eggshells within egg outlines support burial nature. Multi-shelled and ovum-in-ovo egg pathologies have been recorded. The reproductive traits are found to be similar to modern reptiles. The nests are documented from sandy limestone and calcareous sandstone, while ferruginous sandstone is also present. Autobrecciation, intraclasts, alveolar-septal fabric, spar rims, chert deposits and shrinkage cracks support palustrine environment with small lakes/ponds/wetlands in alluvial/fluvial setting. The nests laid close to pond margins suffered drowning/unhatching while those laid away hatched. Presence of Nitrogen-bearing macromolecules with 2,5-diketopiperazine in some eggshells was possible because of desiccating conditions and shielding by eggshell. Stable oxygen and carbon isotopes of the eggshells indicate that dinosaurs ate C3 vegetation and drank water from small confined pools and/or fluvial channel in semi-arid to sub-humid conditions in freshwater palaeoenvironment. The presence of similar oospecies in France, Argentina and Morocco support close palaeobiogeographic connections in Late Cretaceous.

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03 HATUI (Kalyanbrata)

Structural, Metamorphic and Geochronological Study of Delhi Supergroup Rocks from Kumbhalgarh - Sayra - Ranakpur Area, Rajasthan: Implications for the Tectonic Evolution of South Delhi Fold Belt.

Supervisor : Prof. Anupam Chattopadhyay

Th 25438

Abstract
(Verified)

The present doctoral study aims to elucidate the tectonic evolution of the South Delhi Fold Belt (SDFB) which occupies the south-western part of the Aravalli-Delhi Mobile Belt (ADMB). Field- and laboratory-based study of the SDFB rocks was conducted in the Kumbhalgarh-

Sayra-Ranakpur area, south Rajasthan, for understanding the structural, metamorphic and geochronological history of SDFB. The first deformation (D1) produced isoclinal, recumbent to reclined (DF1) folds and a pervasive metamorphic foliation (S1). Upright folds (DF2), associated with the early part of D2 deformation (i.e. D2a), are the most dominant structures in this area in both regional and outcrop-scales. Superposition of DF2 over DF1 has resulted in outcrop-scale hook-shaped folds. A regional transpressional deformation (D2b) led to the formation of a couple of steep to subvertical shear zones. The dextral-reverse slip Kumbhalgarh Steep Zone (KSZ) is marked by tectonic extrusion and granite emplacement along its axial zone, resembling a positive flower structure. A major sinistral-reverse ductile shear zone (Ranakpur Shear Zone: RSZ) marks the western boundary of the SDFB. Upright DF2 folds of SDFB were rotated and tightened within the RSZ which marks the D3 shearing event. Peak prograde metamorphic (M1) mineral assemblages define the S1 fabric, marking a major syn-D1 metamorphic event. The peak metamorphic reaction occurred at 600-635oC and 5 kbar suggesting regional amphibolites facies metamorphism during D1. Retrograde metamorphic events MR1 and MR2 occurred with the D2a and D2b deformation events respectively, whereas MR3 marks the D3 shearing. LA-ICPMS U-Pb zircon dating of one post-tectonic granite constrains the minimum age of the D2a deformation as ~850 Ma. Closely matching ages of granitoids related to D2b and D3 deformation (ca. 822 Ma and ca. 819 Ma respectively) suggests a coeval nature of RSZ and KSZ. The post-DF2 evolution of SDFB possibly occurred by regional-scale 'partitioned transpression'.

Contents

1. Introduction 2. Structural analysis 3.Metamorphic study of the calcareous rocks 4. Geochronological study of the granitoids 5. Tectonic evolution of the South Delhi fold belt 6. Discussion and conclusions. References. List of publications.

04 MAGESWARII G.

Petrology, Nd-Sr Isotopic Compositions and Geodynamic Evolution of Palaeo-Mesoproterozoic IntrusivesAlong Son-Narmada Lineament in the Eastern Part of the Son Valley, Central India.

Supervisors : Dr. AshimaSaikia, Prof. Meenal Mishra and Prof. J. P Srivastava

Th 25440

Abstract
(Not Verified)

The present 6 mafic dykes intruding Mahakoshal Group confined to within- plate, volcanic arc and N-MORB inferred to polyphasetectonothermal history. Whereas, plugs intruding Vindhyan restricted to rift setting. Sm-Nd age of 1793±49 Ma indicate emplacement of dyke activity. Therefore, enriched sub-continental lithospheric mantle source is implied. Alkaline magmatism (~1800 Ma) represented by syenite intrusion in anorogenic, rifted setting. Earlier study restricted to Rb-Sr ages, but, origin, source of magma and tectonic settings are lacking. Bari pluton compared with other plutons intruding Mahakoshal Group represent peraluminous, alkaline nature comparable to Jhirgadandipluton, suggest within-plate continental rift setting. They represent oceanic island basalt (OIB) derived A-type suites suggest mantle contribution and minor crustal contamination. This suggestsyenites formed by fractional crystallization of OIB-like basic magma from upwelling of metasomatized lithospheric mantle. Whereas, partial melting of lower crust led to granites formation. Thus, petrochemical data inferred that Post-Mahakoshal orogeny is marked with Pre-Vindhyan sedimentation and continental rifting accompanied by Bari syenite associated with alkaline magmatism in basement of Bundelkhand Craton. Intrabasinal felsic pyroclastics and rhyolite in Lower VindhyanSupergroup intruded by 3-11 m thick mafic plugs. Earlier study restricted

to petrography, however, geochemical data is lacking. They exhibit intraplate continental rift related basalts suggests crustal contamination. REE patterns and elemental ratios compared to continental rift represents mixed sources, characterize occurrence in sub-continental lithosphere. Petrochemical characteristics for bimodal volcanics to understand their magma source and tectonics.Chemico-mineralogical attributes of authigenic clays associated with altered volcanic tuffs in PalaeoproterozoicPorcellanite Formation contain evidences of hydrothermal alteration and diagenetic processes in a marine environment. Dominant illite is associated with tuffaceous beds. Subordinate montmorillonite resulted from hydrothermal alteration associated with ferruginous breccia and altered tuffs with remnants of volcanic vents. Clay minerals implied proximity to source and derived from silicified felsic tuffs available in the provenance.

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05 NAIR (Aravind S)

Landslide Susceptibility Mapping (LSM) Along Badethi – Uttarkashi National Highway (NH – 134 and NH – 108) and its Adjoining Areas, Uttarkashi District, UttarakhandInida.

Supervisor : Dr. Somendra K Singh

Th 25437

Abstract
(Not Verified)

The main objective of this study was the evaluation of Landslide Susceptibility Mapping (LSM). This process will be capable of producing more important data about the landslide activity in the region along Badethi – Uttarkashi National Highway (NH-134 and NH-108) and its adjoining areas, Uttarkashi District. To achieve the overall objective, several steps were pursued that are kept as sub-objectives of the study such as to document all past landslides on the Badethi–Uttarkashi National Highway (NH-134 and NH-108) and surrounding areas. To generate comprehensive Landslide Inventory Maps for the study area from 2000 to 2014 using a 1:50000 scale SOI topographical map (No.53 J/6) along with Satellite Remote Sensing data (IRS LISS III and Landsat 8, 2014). To determine the causative factors and identify vulnerable areas for fresh mass loss and slope collapse at 22 locations. Field truth verification needs to be carried out at all the locations of reported landslides. To generate the LSM for the study area. To share the maps generated above along with required mitigation measures and management strategies for restoration of roads along NH-108 and 3 village roads with Uttarkashi DDMA for future reduction of hazards in this area. The work has been carried out in 3 Phases. Pre-Field Investigation, Field Investigation and Post Field Analysis. Ph. 1 most of the data gathered were from the Geological Survey of India records along with the present study database. Ph. 2 the generation of maps has been made at a scale of 1:50000. Thematic maps are generated. Ph.3 Influential parameters considered in this analysis for the Landslide Susceptibility Area and the study area are Slope (Sl), River (Ri) Road (Ro) and Landcover (Lc). Such variables are used in the Analytical Hierarchy Process to generate the Landslide Susceptibility Map of the study area.

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06 NEHA UPRETI

Paleogene-Neogene RED and Yellow Paleosols of Kangra Sub-Basin in Response to Latitudinal Shift and Climate Change During the Evolution of the Himalayan Foreland Basin.

Supervisors : Prof. Pankaj Srivastava and Prof. Jayant K. Tripathi

Th25442

Abstract
(Not Verified)

The Himalayan orogeny has played a major role in evolution of Asian monsoon system that influenced global and regional climate over the Indian sub-continent. In view of this, the fluvial sedimentary record of the Himalayan Foreland Basin (HFB) provides an ideal platform to study interactions between sedimentation, tectonics, climate, and paleopedogenesis. In the present study we aimed to explore the fluvial sedimentary record of the north-west part of the Himalayan Foreland Basin. The detailed paleopedological investigation of the oldest fossil soils of a ~3.1 km fluvial succession from Kangra sub-basin shows lower 2 km part of the succession is characterized the red (10R hue) and the upper 1.1 km part of the succession by the yellow (2.5Y hue) palaeosols with varying degree of paleopedogenic development. Despite burial diagenesis (7-8 km), evidences for paleopedogenesis are still well-preserved in these paleosols in the form of structural elements, clay coating, rhizocretions, mottles, bioturbation, Fe-Mn concretions and pedogenic carbonates. The paleopedological evolution suggests four pedofacies with strongly developed (Type-A) paleosols analogous to modern Alfisols to Entisols with little or no pedogenesis as (Type-D) pedofacies. The Lower Dharamsala Formation is marked by more common occurrences of the well-developed paleosols in comparison to the Upper Dharamsala Formation with a dominance of weakly developed paleosols and incipient stages of pedogenic activity. The Lower Dharamsala Formation is also characterized by 1 to 2 m thick marly units with moderate to well-developed palaeopedological features (e.g., LJ10, LJ13, LJ26 and LJ30 paleosols). Whereas, in Upper Dharamsala Formation only one such marly unit with weakly developed paleopedological features occurs (e.g. UJ22 paleosol).Thin section analysis showed 50-60% paleopedofeatures are preserved as microstructures, b-fabric, pedogenic carbonate, bioturbation and clay coatings. The pedogenic calcium carbonate as diffused micritic nodules with thin iron oxide coatings occurs predominantly in lower part of the succession that shows its dissolution and absence in upper part of the succession. In the lower part of the succession, the clay coatings along the voids occurring together with pedogenic carbonates appear to be impure in nature, whereas in the upper part these are marked by thick to very-thick microlaminated coatings and intercalations of pure clay with no pedogenic carbonates. The sandstones associated with this pedocomplex show a decrease in their lithic and feldspar content in comparison with the overlying and underlying sandstones. A tentative age estimate for this pedocomplex based on the available age data indicates that this phase of major stable landscape and extensive weathering with 4 or more Bt-horizon-bearing paleosols occurred at about 28 Ma. However, in the case of the Upper Dharamsala Formation, Bt-horizon-bearing paleosols are uncommon and there is no such pedocomplex with many Bt horizons. This indicates the presence of rapidly aggrading surfaces in the succession of the Upper Dharamsala Formation.The clay mineralogy also shows a significant change during the transition from red to yellow paleosols, and is marked by a progressive increase of smectite, kaolin and hydroxyl interlayering of the smectite in response to the changes in the provenance and climate after 20 Ma. The increased amount of the smectite is in support of more frequent occurrences of the Bss horizons in the yellow paleosols than in the red paleosols. This indicates a gradual shift of the source contributing a large amount of smectite due to weathering of feldspar-rich rocks in the hinterland. This is also in agreement with the activation of the Main Central Thrust (MCT) at about 20 Ma. The progressive increase of the kaolin content and the hydroxyl interlayering of the smectite up-section from red to yellow paleosols suggest that climate changed to even more wet/humid conditions than during the formation of red paleosols.Bulk rock geochemistry of representative paleosol profiles of the red and yellow paleosols of Lower and Upper Dharamsala Formation were explored to evaluate source rock, weathering indices, and paleoenvironmental conditions during the paleopedogenesis in the HFB. Major and minor element composition data are presented as weight percentages of oxides and trace elements as ppm. The CIA

values (Al_2O_3 / (Al_2O_3+ CaO*+ Na_2O+ K_2O) X 100) determined for the red and yellow paleosols of Dharamsala Formations vary between very low ca. 45-50 to very high ca. 90-95. In general the CIA values are slightly higher for the red paleosols in comparison with the yellow paleosols. In case of the well-developed and moderately developed red paleosols the CIA values for the Bw and Bt horizon varies from 70-75 to 80-82 in different paleosols. However, in case of the weakly-developed and incipient stage of the red paleosols, the CIA in general do not show any major change in relation to the BC horizon or the parent matte of the paleosols. In case of the marly units/paleosols with a dominance of Bk horizons, the CIA values are very low and range from 27 to 46. The yellow paleosols on the other hand are marked by the CIA values ranging from 64 to 84. The mean annual paleoprecipitation (MAP) estimate based on CIA-K values (for Bt/Bw horizons) and CALMAG values (for Bss horizons) vary from 900 mm to 1200 mm for red paleosols of Lower Dharamsala Formation. This indicates wet conditions during the paleopedogenesis of the red paleosols. Presence of pedogenic carbonate (PC) in these paleosols with wet conditions is in agreement with PC of in Inceptisols, Alfisols, and Vertisols from humid regions at >50 cm depth with dissolution features. The paleolatitudinal history of the Indian plate and show that the formation of the red paleosols occurred in tropical conditions close to 18 N^o during the Oligocene, which shifted to subtropical conditions close to 25 N^o during the formation of yellow paleosols. The paleopedogenic features of the red paleosols, with a common occurrence of the pedogenic $CaCO_3$, shrink-swell features, and impure clay pedofeatures suggest the onset of the Asian monsoon over the Indian sub-continent during the early Oligocene. The transition from red to yellow paleosol formation at about 20 Ma indicates enhanced precipitation due to rapid uplift and erosion in the hinterland that resulted due to the activation of the MCT. This resulted in the predominance weakly developed yellow paleosols and absence of pedogenic carbonate formation in the upper 1.1 km part of the succession. The enhanced precipitation during the formation of yellow paleosols is also related to Miocene warming and a positive carbon isotope excursion at the global level.

Contents

1. Introduction 2. Methodology 3. Results and analysis 4. Discussion 5. Conclusion. References.

07 RAI (Gargi)

Petrogenesis and Tectonic setting of Palaeoproterozoic Granitoids from the Northwestern Bundelkhand Carton, Central Indian Shield : Geochemical, Isotopic and Geochronological Constraints.

Supervisors : Prof. Devesh K. Sinha and Prof. Talat Ahmad

Th 25436

Abstract
(Not Verified)

Bundelkhand craton, in the central Indian region, grew extensively during Meso-Archaean to early Proterozoic (ca. 2.5Ga). Unravelling its geochemical and petrogenetic history is a pre-requisite for elucidating the Precambrian evolution of continental crust in Central India. Crustal growth and secular evolution of the craton is distinguished by emplacement of tonalite-trondhjemite-granodiorite (TTG, ca. 3.3Ga) followed by a distinct tectono-magmatic event near the Archaean-Proterozoic boundary (~2.5Ga) resulting in voluminous magmatic (granitic-basaltic) activities. The studied granitoids from the Bundelkhand massif display a continuous series of evolution from more mafic to felsic compositions varying from dioritic through granodioritic to granitic rocks. They are mostly unscathed, massive, but at places, have undergone some deformation. Epidote-veins, quartz-veins and mafic magmatic enclaves (MMEs) are also visible, restricted along planes of weaknesses. Quartz, plagioclase and K-feldspar are amongst the essential minerals while, hornblende, biotite, pyroxenes, apatite, titanite, allanite, zircon and opaques form the accessory phases. The geochemical data on spatially close and petrologically consanguineous samples indicates that these are I-type, metaluminous and dominantly magnesian in character. The classical calc-alkaline differentiation trend displayed by most of these granitoids evinces subduction environment besides strong negative

Nb, P, Ti anomalies, favouring collisional environment. The granodioritic and granites show more enriched REE concentrations and slightly higher abundance of all the elements in the spider diagram as compared to the diorites. Difference in the trace elements and REE abundances indicates heterogeneous sources and large variation in the degree of partial melting and/or effect of crustal contamination. It is proposed that initially there was partial melting in the mantle wedge, which resulted in the generation of mafic magma that evolved to dioritic melts. The mafic magma then interacted with crustal/lithospheric sources and supplied the required additional heat and fluid flux, resulting in the generation of more felsic granodiorites and granites with varying chemical characteristics.

Contents

1. Introduction and geology 2. Field observations and petrography 3. Analytical techniques and methodologies 4. Major and trace element geochemistry 5. Geochronology and isotope geology 6. Discussion and conclusion 7. Annexures. References.

08 SHARMA (Rajesh)
Depositional Modelling, Stratigraphic Reappraisal, and Geochemical Nuamces During Late Neoproterozoic-Cambrian Transition from the Girbhakar Formation and Bilara Group of Rocks, Marwar Supergroup, Rajasthan, India.
Supervisor : Dr. Partha Pratim Chakraborty
Th 25583

Abstract
(Not Verified)

The late Neoproterozoic-Cambrian siliciclastic-carbonate sediment successions of MarwarSupergroup the topic of present study takes into its purview the clastic Girbakhar Formation and calcareous Bilara Group of rocks to understand their depositional history. Detail process-based facies analysis within the Girbakhar Formation allowed delineation of twenty-two different facies types, which are grouped under seven different facies associations. This include continental fluvial, transitional (deltaic, wave-dominated shoreface, tidal bar-interbar, tidal channel) and marine (shelf) facies associations. Bounded between a Type-I unconformity at its base and a Erosion-Transgression (E/T) surface at its top, the Girbakharlithopacakge registers deposition under three different 'Systems Tract's namely forced regression (FSST), transgressive (TST) and sea level highstand (HST). The transition from Girbakhar to Bilara is transgressive, sharp to gradational. Six different facies types are identified from the Bilara succession (BL) for which depositional environments are interpreted ranging from supratidal-peritidal to intertidal to shallow subtidal, and deep subtidal. A distally-steepened ramp geometry is visualized for the BL. From documentation of facies succession, the depositional history of BL is sudivided under two depositional cycles i.e the Depositional cycle 1 (DC-1) that records a deepening-upward facies trend, followed upward by Depositional cycle 2 (DC -2) that registers a shallowing-upward depositional trend. Additionally, metres-thick layers of soft sediment deformation (SSD) structures viz. disharmonic folds, low-angle thrusts, distorted laminae, fluidisation pipes, slump and load structures, homogeneities, diapirs, etc. at different stratigraphic levels through the BL succession, The δ13C data generated from the Bilara succession revealed four negative excursions of the magnitude -6-8 ‰, rarely going below -10‰. Considering δ13 C data from contemporaneous sections of Oman and China, attempt was made to explain the Bilara data. A first-order attempt has been made to relate the SSD structures and carbon-isotope record and intricacy in identification of Shuram-Wonoka excursion within the Bilara succession.

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09 SHARMA (Rashmi)

Physil Compositional and Cell Parameteric Evidence and Organo-molecular Structure of the PalaeoproterozoicBijawars of the Hirapur Basin, Central India: Palaeoenvironmental constraints and U Mineralization.

Supervisor : Prof. J. P. Shrivastava

Th 25441

Abstract

(Not Verified)

Previous bulk rock geochemistry studies of Paleoproterozoic, siliclastic, intra-cratonicBijawar basin metasediments suggested illite as one of the dominant clay mineral phases, derived from hydrothermal alterations and granitoids basement weathering. However, detailed chemico-mineralogical attributes of clays associated with rocks have not been understood. The XRD revealed abundance of Ill>Sm>K>Chl, Ill>K>Cor>Sm>Rec and Ill>K>Sm>Chl mineral assemblages in Bajno Dolomite, HirapurPhosphorite and Karri Ferruginous Formations, respectively. The existence of alternate humid (favourable for U oxidation and formation of U rich solutions) and semiarid-arid (suitable for precipitation, sorption, absorption of U ions) climatic cycles were accountable for complexation that facilitated U enrichment under high redox potential. Dominance of short-chain n-alkanes (C_{14}-C_{22}) together with long (C_{24}-C_{36}) and short-chain (C_{12} to C_{20}) *n*-fatty acids with maxima at *n*-C_{16} fatty acid reflecting a greater amount of marine bacterial and algal inputs as compared to the terrestrial (higher land plants) source. Significant HREE enrichment and LREE depletion is noticed in Bajno Dolomite and highly altered HirapurPhosphorite Formations. They form flat asymmetrical patterns with positive Euanamolies, pointing towards anoxic conditions. Both U-bearing organic matter and clays contain high LREE content. High Zr, Y and REE values suggest possibility of U mineralization in the area. It is apparent that the K^+ deficiency in illite is causative for bond angle distortion due to structural strain; thus, resulted in the expansion of the d_{001} peak. The heat produced by acidic and alkaline magma activities of the Delhi-Aravalli Fold belt during Middle-Early Proterozoic period and basic magmatic activities occurred in the Bijawar basin were perhaps responsible for the distortion of illite bonds and release of K^+ from the illite interlayers. With the inception of humid climatic conditions, illite hydrolysis resulted in the double layer contraction. The feeble chemical weathering led to degradation of non-swelling chlorite into swelling chlorite (corrensite).

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