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Rock Art Sites of Hemgir Block, Sundargarh District, Odisha: A Geological Perspective

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Abstract: *The Kanika area of Hemgir Block in Sundargarh District, Odisha, represents a significant yet underexplored geo-archaeological landscape where prehistoric rock art is closely embedded within Gondwana sedimentary formations. This paper examines the interrelationship between geological setting, sedimentary processes, and the spatial distribution of rock paintings in the region. Integrating geological observations with archaeological evidence, the study demonstrates how lithology, stratigraphy, and geomorphology influenced prehistoric site selection, artistic practices, and long-term preservation of rock art. Particular attention is given to weathering processes and anthropogenic threats affecting the sandstone surfaces and pigment stability. The analysis highlights the urgent need for multidisciplinary conservation strategies. The Kanika rock art is thus interpreted not as isolated artistic remains but as a material expression of sustained human–environment interaction shaped by geological processes over deep time.*

Keywords: *Rock art, Geo-archaeology, Gondwana sandstone, Prehistoric landscape, Hemgir Block, Human–environment interaction*

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Introduction

The archaeological record constitutes the primary medium through which the cultural, cognitive, and technological evolution of humankind can be reconstructed. Among its diverse manifestations, prehistoric rock art occupies a distinctive position, as it reflects symbolic behavior, ritual practices, social communication, and ecological knowledge of early human communities. Rock art studies worldwide have demonstrated that such artistic traditions are deeply embedded within specific geological and

environmental contexts, making geology an indispensable component of archaeological interpretation. Globally, rock art has been documented in a wide range of ecological and geological settings, including the sandstone shelters of Australia (Hiscock 2002; Slack et al. 2004), the limestone cave systems of Europe (Clark 1956; Tolan-Smith 2008), the arid and semi-arid zones of Africa (Tixier 1963; Lewis et al. 2014), the Levantine corridor (Lechevalier 1978, 1980; Yaroshevich et al. 2010), Central Asia (Derevianko et al. 2008; Rybin et al. 2016), and South Asia (Brunet 2012; Biagi 2018). These studies underline the inseparability of cultural expression from geological and geomorphological frameworks.

India occupies a prominent position in global rock art research, ranking alongside Australia and Africa in terms of the density, diversity, and chronological depth of prehistoric paintings. Since the pioneering discovery of Indian rock art by Henwood in 1856, systematic research has revealed complex regional traditions ranging from the Upper Palaeolithic through the Mesolithic and into early historic periods. Sites such as Bhimbetka have become benchmarks for understanding stylistic continuity, pigment technology, and symbolic behavior. Despite these advances, several regions—particularly eastern India—remain inadequately studied from an integrated geo-archaeological perspective. Sundargarh District in Odisha represents one such region of immense archaeological and geological potential. The district has yielded evidence of early human occupation since the Old Stone Age, notably from sites such as Lekhamunda, Chhengapahad, and adjacent localities. Within this broader cultural landscape, the Kanika area of Hemgir Block assumes particular significance due to the presence of rock paintings situated within Gondwana sandstone formations. These paintings are not merely artistic expressions but indicators of prehistoric ecological knowledge, resource exploitation, and spatial cognition.

Adopting a geo-archaeological approach, this paper critically examines the rock paintings of the Kanika area by situating them within their geological context. Rather than treating the art as isolated cultural phenomena, the study emphasizes the role of lithology, stratigraphy, sedimentary structures, and depositional environments in shaping both the creation and preservation of rock art. In doing so, it contributes to a broader understanding of prehistoric human–environment interaction in eastern India.

Location and Accessibility

The Kanika area is located in Hemgir Block in the western part of Sundargarh District, Odisha. Geographically, the region forms part of the Upper Mahanadi Basin and is characterized by undulating terrain, forested hillocks, seasonal streams, and prominent sandstone escarpments. The area is reasonably accessible by road and lies within a five-kilometre radius of key prehistoric sites such as Lekhamunda and Chhengapahad, both of which have yielded substantial archaeological evidence. The proximity of Kanika to Lekhamunda is particularly significant. The Lekhamunda rock shelters, located approximately four kilometres to the north, constitute one of the richest rock art assemblages in Odisha. Recent field surveys have documented 502 painted motifs and 36 engravings at Lekhamunda (Field Survey 2024). These shelters are strategically situated on elevated sandstone outcrops overlooking valleys, water sources, and forest tracts—topographic advantages that would have been crucial for prehistoric communities in terms of shelter, surveillance, and access to subsistence resources.

The Kanika shelters exhibit similar locational characteristics, suggesting a deliberate pattern of site selection rather than random occurrence. The spatial clustering of rock art sites within a limited geographical radius indicates sustained habitation and repeated cultural activity. This pattern reinforces

the interpretation of the region as a coherent prehistoric cultural landscape rather than a series of isolated occupation spots.

Geological Framework

Regional Geological Setting

Geologically, the Kanika area falls within the Lower Gondwana formations of the Mahanadi Master Basin, one of the major sedimentary basins of peninsular India. The basin preserves a long and complex geological history marked by fluvial, lacustrine, and marginal marine depositional environments. Geological mapping reveals two broad lithological divisions in the study area. The first consists of Precambrian crystalline rocks, including granite, pegmatite, quartzite, biotite schist, and amphibolite, which together form the basement complex and account for nearly 50 percent of the area. The second division comprises Gondwana sedimentary rocks, primarily sandstone and shale belonging to the Kamthi Formation, constituting the remaining 50 percent. According to Mallick's *Report on the Natural Arch* (Geological Survey of India 1998), the sandstones of the Kanika region are coarse-grained, gritty, ferruginous, and poorly sorted. These characteristics suggest immature sediments deposited under high-energy conditions, most likely within fluvial or fluvio-tidal systems. Such lithological properties have directly influenced erosion patterns, shelter formation, and the suitability of rock surfaces for painting.

Stratigraphic Succession

The stratigraphic succession of the region reflects multiple depositional phases within the Gondwana Supergroup. The sequence includes the Panchet Formation (Upper Permian–Lower Triassic), unconformably overlain by the Mahadev Formation (Lower–Upper Triassic), followed by the Rajmahal Formation (Lower–Middle Jurassic), and capped by the Jabalpur Formation (Upper Jurassic–Lower Cretaceous). The Kamthi Formation, to which the Kanika sandstones belong, is part of the Upper Gondwana Group and is generally associated with fluvio-tidal depositional settings. Such environments have important implications for understanding regional geomorphological evolution and the long-term preservation of rock art.

Lithological and Structural Characteristics

Bedding and Lamination

Bedding and lamination are among the most prominent sedimentary features observed in the Kanika sandstones. Bedding planes exceeding one centimetre in thickness are distinguished by variations in grain size, colour, and mineral composition, while finer laminations reflect subtle changes in sediment supply and depositional energy. The alternation of coarse and fine beds suggests episodic sedimentation, possibly linked to seasonal flooding and fluctuating river discharge. From a geo-archaeological perspective, these bedding characteristics are crucial, as they influence rock strength, weathering patterns, and surface stability—key factors governing the preservation of rock paintings.

Cross-Bedding and Cross-Lamination

Cross-bedding is a dominant structural feature within the Gondwana sandstones of Kanika. Formed by sediment avalanching under unidirectional currents (Bagnold 1954; Allen 1970; Simons et al.

1961), cross-bedded units consist of top-set, fore-set, and bottom-set beds. Analysis of these structures indicates a predominant east-to-west palaeocurrent direction, consistent with ancient fluvial systems draining the Mahanadi Basin. Archaeologically, cross-bedded sandstones weather unevenly, leading to the formation of rock shelters, overhangs, and cavities—ideal surfaces for prehistoric painting and habitation.

Herringbone Cross-Stratification

The occurrence of herringbone cross-bedding near the Brahmani cave area close to Kanika is particularly significant. This sedimentary structure, characterized by alternating foreset directions, is widely regarded as diagnostic of tidal environments (Alam, Crook & Taylor 1980). Its presence indicates periodic reversal of current flow, reinforcing interpretations of a low-gradient fluvio-tidal depositional system during the Gondwana period. Such dynamic environments would have shaped landscape stability, resource availability, and shelter formation, indirectly influencing prehistoric settlement patterns and artistic practices.

Rock Art of the Kanika Area

Motifs, Techniques, and Pigments

The rock paintings of Kanika are predominantly executed in yellow and white pigments, likely derived from naturally occurring minerals such as limonite and kaolin. The selection of mineral pigments reflects both environmental availability and the technological knowledge of prehistoric communities (Fig. 1).

Motifs can be broadly classified into faunal, geometric, and abstract categories. Faunal depictions include animals such as deer, monkeys, and lizards, which may represent hunting activities, ecological familiarity, or totemic beliefs. Geometric forms—such as honeycomb patterns and carpet-like designs—suggest ritualistic or communicative functions, possibly linked to group identity or cosmological concepts. Stylistically, the Kanika paintings show affinities with motifs documented at Bhimbetka and other Indian rock art sites, indicating broader cultural connections and shared symbolic traditions across prehistoric India.

Archaeological Context and Cultural Landscape

The Kanika rock art cannot be understood in isolation from its wider archaeological context. Stone tools, flakes, and habitation debris recovered from nearby sites such as Lekhamunda and Chhengapahad attest to continuous prehistoric occupation. The close spatial association between habitation zones and painted shelters suggests that rock art formed an integral component of daily and ritual life rather than a peripheral activity. From a geo-archaeological perspective, the repeated use of specific shelters indicates detailed knowledge of geological stability, surface durability, and environmental predictability.

Weathering Processes and Conservation Challenges

Despite their cultural and scientific significance, the rock paintings and geological features of Kanika face increasing threats from both natural and anthropogenic factors. Natural weathering

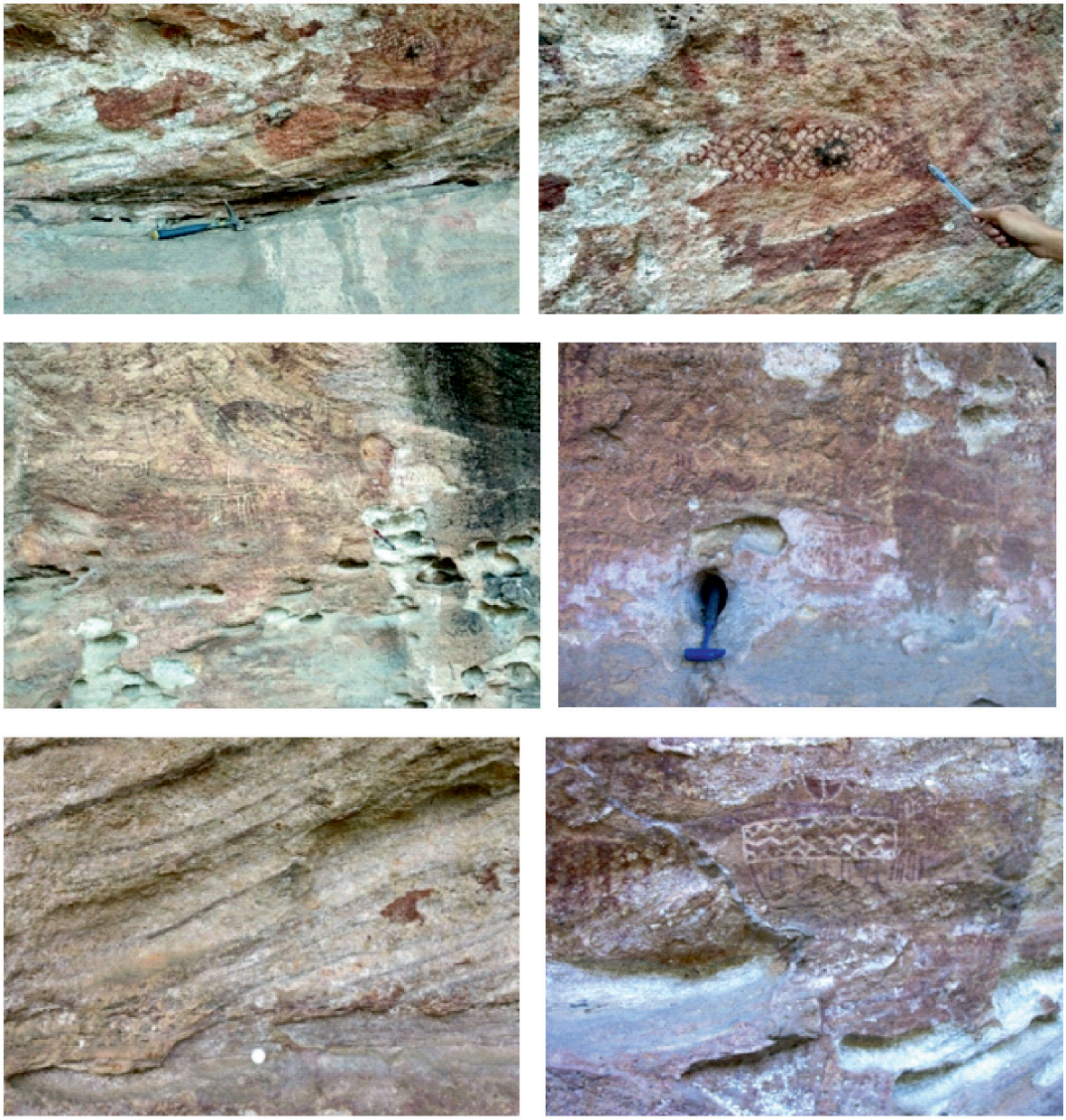

Fig. 1: Rock Paintings of Sundargarh

processes—thermal stress, moisture infiltration, chemical alteration, salt crystallization, and biological colonization—are actively degrading sandstone surfaces and pigments.Human-induced threats exacerbate this deterioration. Unregulated tourism, vandalism, deforestation, mining activities, and infrastructure development have accelerated erosion and destabilization. The absence of systematic protection measures, such as fencing, drainage management, and regular monitoring, has left these sites highly vulnerable.

Conservation and Management Strategies

Effective conservation of the Kanika rock art demands an integrated approach that recognizes the inseparability of geological and cultural heritage. Essential measures include controlled vegetation

removal, installation of drainage systems, stabilization of vulnerable surfaces using reversible materials, and regulation of visitor access. Equally important are documentation initiatives employing high-resolution photography, digital enhancement, 3D scanning, and GIS-based spatial mapping to ensure long-term digital preservation. Community participation and institutional collaboration among the Archaeological Survey of India, Geological Survey of India, and academic institutions are critical for sustainable management.

Conclusion

The Kanika area of Hemgir Block represents a rare convergence of geological complexity and cultural creativity. The coexistence of Gondwana sedimentary structures and prehistoric rock paintings offers a multi-layered archive of human–environment interaction spanning deep time. A geo-archaeological perspective reveals that these paintings are not merely artistic residues but integral components of a dynamic landscape shaped by geological processes and human agency. Preserving this fragile heritage is both a scientific responsibility and a cultural imperative. Without immediate multidisciplinary conservation efforts, the Kanika rock art risks irreversible loss, severing a vital link between the geological past and the human story it continues to narrate.

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