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Integration of Grain-Size Statistics, Sedimentary Structures and Basin Dynamics of the Nagaur Sandstone in the Shri Balaji Area, Nagaur District, Northwestern India

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Abstract

The Neoproterozoic to Early Cambrian Marwar Supergroup of western Rajasthan preserves an exceptional sedimentary archive for deciphering the paleogeographic and geodynamic evolution of the northwestern Indian shield. This study integrates high-resolution grain-size statistics, primary sedimentary structures, and directional paleocurrent data from the Nagaur Sandstone exposed in the Shri Balaji area of Nagaur District, Rajasthan, to reconstruct depositional processes, hydrodynamic conditions, and localized basin dynamics. Utilizing digital image-based petrographic measurements across ten representative sandstone samples (SBL-1 to SBL-10), the grain-size frequency distributions reveal a predominantly fine- to very-fine-grained sandy population with a prominent unimodal modal peak centered around 2.5 Φ . Field observations delineate a diverse structural inventory, including planar and parallel stratification, small-scale cross-bedding, asymmetrical current ripples, flaser-lenticular bedding, and localized desiccation structures. These features indicate persistent tractional transport under predominantly unidirectional currents, interspersed with periodic fluctuations in flow energy and episodic subaerial emergence. Azimuthal measurements from fifteen ripple-bearing horizons (n=141) define a coherent sediment-dispersal vector with a mean resultant paleocurrent direction of 295.5° (WNW). The synthesized sedimentological, textural, and directional evidence demonstrates that the Nagaur Sandstone in the Shri Balaji sector accumulated within a dynamic, current-influenced shallow-water to intertidal-marginal-marine depositional system governed by steady sediment reworking, fluctuating hydraulic energy, and stable regional paleoslopes.

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1. Introduction

Grain-size characteristics and sedimentary structures constitute fundamental components of sedimentological analysis, as they preserve vital empirical records of sediment transport dynamics, depositional energy regimes, and the physical mechanisms responsible for the accumulation and preservation of clastic successions. Granulometric distributions provide a quantitative measure of sediment texture, enabling researchers to evaluate hydrodynamic variations, transport modes, and depositional efficiency. Specifically, identifying distinct grain-size populations and their cumulative distribution patterns offers an indispensable foundation for interpreting basinal dynamics and

hydrodynamic transport mechanics (Folk & Ward, 1957; Visser, 1969; Das & Banerjee, 2025). Concurrently, primary sedimentary structures furnish complementary insights by recording the hydraulic parameters active during deposition. Diagnostic features such as planar stratification, cross-bedding, current ripples, flaser-lenticular bedding, and subaerial desiccation marks collectively chronicle fluid turbulence, fluctuations in flow velocity, alternating suspension-traction settling, and intermittent emergence.

The Marwar Supergroup of western Rajasthan preserves an extensive Neoproterozoic to Early Cambrian sedimentary record, serving as a critical archive of crustal evolution and basin development across the northwestern Indian shield

(George & Ray, 2017; Chakraborty et al., 2023). Deposited within an intracratonic setting, the supergroup is systematically subdivided into the Jodhpur, Bilara, and Nagaur groups. Among these, the Nagaur Group constitutes the terminal siliciclastic succession, recording a major influx of arenaceous and argillaceous sediments following the chemical precipitation of the Bilara carbonate platform. The Nagaur Sandstone forms a prominent stratigraphic component of this upper package, exhibiting a diverse inventory of physical bedforms that reflect dynamic depositional conditions. Previous investigations across the broader basin have interpreted portions of the Nagaur succession within fluvial, shallow-marine, coastal, and tidal frameworks, highlighting marked spatial and temporal variability in depositional environments (Kumar & Pandey, 2010; Singh et al., 2014).

Despite significant advances in regional stratigraphic syntheses, locality-scale integration of granulometric statistics, sedimentary structures, and directional paleocurrent vectors remains scarce for the Shri Balaji sector. The Shri Balaji area in Nagaur District provides an ideal natural laboratory to examine these physical sedimentological processes at a high-resolution, outcrop scale. The exposed successions display laterally continuous sandstone beds

bearing well-preserved primary sedimentary structures belonging to the Nagaur Formation. To address the existing research gap concerning local-scale depositional mechanics, the present study avoids broad whole-rock geochemical generalisations and focuses strictly on physical sedimentology. Specifically, this work utilizes digital image-based grain-size measurements from ten representative sandstone samples (SBL-1 to SBL-10), systematic structural documentation, and 141 individual paleocurrent measurements across fifteen ripple-bearing horizons (SBRD-1 to SBRD-15).

Accordingly, this investigation is guided by three principal objectives:

- To characterize the detailed grain-size frequency distributions and textural variability of the Nagaur Sandstone in the Shri Balaji sector.
- To evaluate the physical sedimentary structures and deduce their precise hydrodynamic and environmental implications.
- To reconstruct the directional paleocurrent architecture and integrate it with textural and structural data to establish a comprehensive depositional model and decipher local basin dynamics.

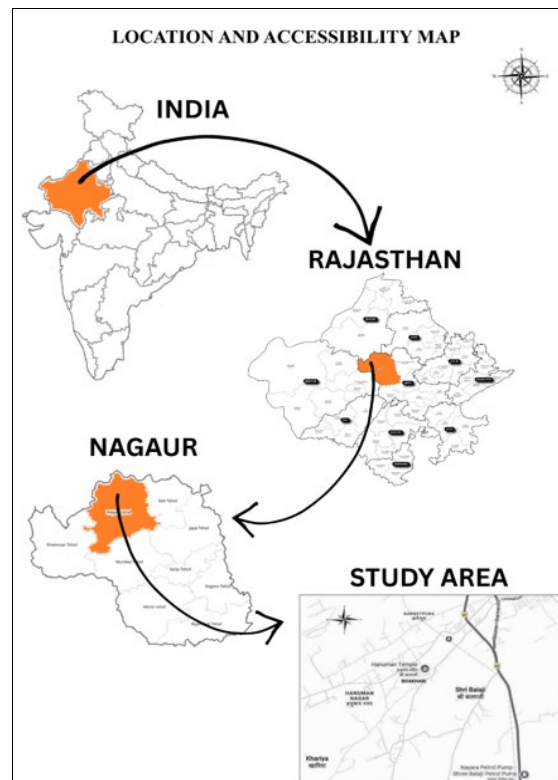


Fig 1.1: Location and Accessibility Map of study area.

2. Geological Setting

2.1 Marwar Supergroup

The Marwar Supergroup constitutes an expansive sedimentary succession exposed extensively across western Rajasthan, preserving a critical geological archive of Neoproterozoic to Early Cambrian sedimentation within the northwestern Indian shield. Regionally, the basin architecture is defined by an asymmetric intracratonic depocenter accommodated atop a heterogeneous crystalline basement. The supergroup is formally subdivided into three principal lithostratigraphic tiers in ascending order: the basal siliciclastic Jodhpur Group, the intermediate carbonate- and evaporite-dominated Bilara Group, and the terminal siliciclastic Nagaur Group. This thick

succession records major evolutionary shifts, transitioning from continental and marginal-marine clastic influxes to expansive hypersaline carbonate platforms and terminal continental red beds.

Within this established framework, the Nagaur Group represents the uppermost stratigraphic sequence, recording a major resurgence of siliciclastic sedimentation following the termination of the Bilara carbonate regime. Regional investigations indicate that the Marwar succession evolved under conditions of long-term, passive thermal subsidence, reflecting relative tectonic stability within the cratonic interior.

2.2 Nagaur Sandstone

Belonging to the Nagaur Formation of the Nagaur Group, the Nagaur Sandstone comprises the primary arenaceous succession targeted in this investigation. Lithologically, the unit is characterized by reddish-brown, pinkish, and pale-cream sandstones exhibiting notable variations in grain size and bed thickness. The strata preserve a rich inventory of primary sedimentary structures, including planar and parallel stratification, trough and planar cross-bedding, asymmetrical current ripples, and locally developed flaser and lenticular bedding. Furthermore, fine-grained interbeds occasionally preserve desiccation features, providing direct physical evidence of periodic subaerial exposure.

Previous sedimentological and ichnological evaluations of the Nagaur Sandstone have emphasized the dominance of shallow-water, coastal, and intertidal environments. The widespread presence of current-generated bedforms and emergence features underscores the role of fluctuating flow regimes, tractional sediment transport, and periodic water-level variations during deposition.

2.3 Study Area: Shri Balaji, Nagaur District

The study area is situated around Shri Balaji village within the Nagaur District of Rajasthan, where representative exposures of the Nagaur Formation are prominently developed. The primary sedimentary section examined during field investigations is located within an active quarry situated directly behind the Shri Balaji Temple. The exposed succession consists of laterally persistent sandstone strata exhibiting systematic variations in coloration, granulometric attributes, and bedding geometry. Structural measurements confirm that the beds maintain a gentle homoclinal inclination, providing an undisturbed geological window for outcrop-scale sedimentological analysis.

Geographically, the study domain lies between latitudes 27° 25'30" N" to 27° 26'50" N" and longitudes 73° 32'00" E" to 73° 33'30" E". The accessibility and pristine nature of these exposures within the Nagaur Basin render the Shri Balaji sector an ideal natural laboratory for integrating grain-size statistics, sedimentary structures, and directional paleocurrent vectors.

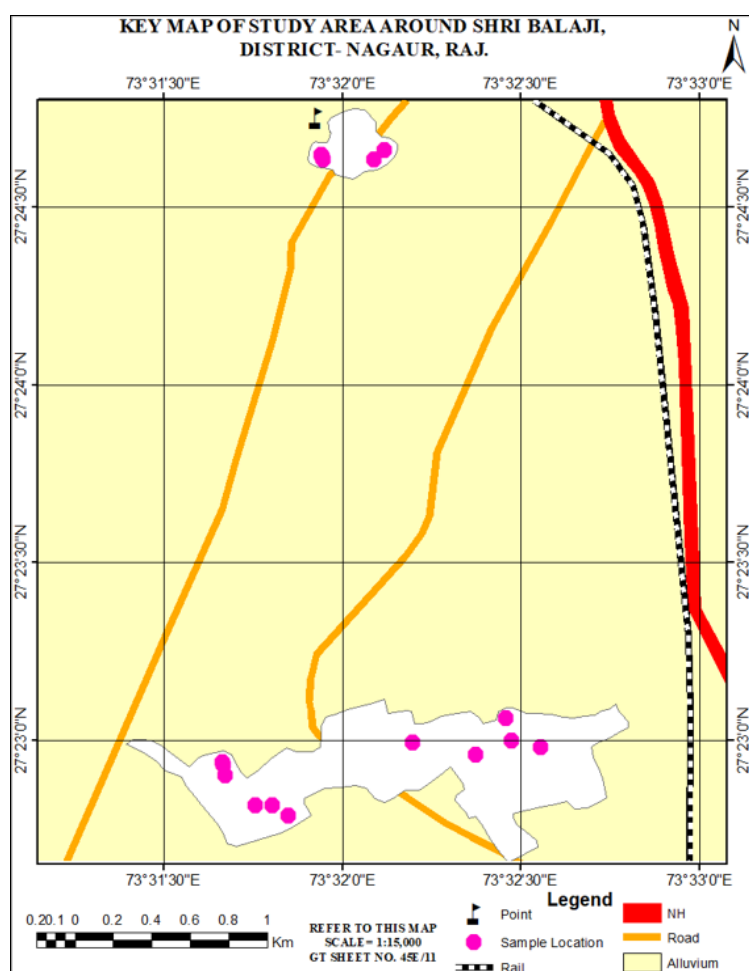


Fig 2.1: Key Map of Sample Location in Study Area.

Table 2.1: Spatial and Lithological Sample Location.

S. No.	Sample ID	Latitude (N)	Longitude (E)	Elevation (m)	Lithological Characteristics
1	SBL-1	27°24'40"	73°31'57"	300	Bedded sandstone and shale, alternating sequences
2	SBL-2	27°24'38"	73°31'59"	290	White, coarse-grained siliciclastic sandstone
3	SBL-3	27°24'36"	73°32'01"	300	Sandstone interbedded with argillaceous red shale
4	SBL-4	27°24'37"	73°32'04"	300	Yellow, heavily indurated, coarse-grained sandstone
5	SBL-5	27°24'39"	73°32'06"	300	Alternating red and white sandstone beds
6	SBLB-1	27°22'56"	73°31'40"	320	Quartzite from isolated topographic high
7	SBLB-2	27°22'52"	73°31'45"	320	Quartzite exhibiting distinct dendritic textures
8	SBLB-3	27°22'54"	73°31'40"	320	Massive quartzite, lithologically akin to Sample 7

9	SBLB-4	27°22'52"	73°31'38"	300	Ferruginous red shale
10	SBLB-5	27°22'53"	73°31'50"	310	Blocky, indurated lithofacies
11	SBLB-6	27°22'54"	73°31'51"	305	Dark gray, thinly bedded lithology
12	SBLB-7	27°22'56"	73°31'41"	300	Blocky, dark brown-gray lithology
13	SBLB-8	27°22'56"	73°32'02"	300	Dark gray facies with deformed laminations
14	SBLB-9	27°22'54"	73°31'42"	310	White lithology with secondary blue dendritic patches
15	SBLB-10	27°22'57"	73°32'22"	300	Blocky, dark gray, thinly laminated facies
16	SBLB-11	27°22'52"	73°31'38"	300	Argillaceous white shale

3. Materials and Methods

3.1 Field Investigation and Sampling

Systematic field investigations were conducted in the Shri Balaji sector of Nagaur District, Rajasthan, with a primary focus on the exposed Nagaur Sandstone succession. Detailed empirical observations were recorded regarding lithology, bed geometry, stratification styles, granulometric variations, and primary bedforms preserved on bedding surfaces. The principal bedrock exposures examined during the fieldwork are situated within active quarry sections directly behind the Shri Balaji Temple, where laterally continuous sandstone strata provide pristine surfaces for sedimentological logging

and paleocurrent measurements. A total of ten representative sandstone samples, designated as SBL-1 to SBL-10, were systematically collected across different stratigraphic horizons to capture vertical and lateral variations in grain-size distribution within the succession. Additionally, ripple-bearing bedding planes were targeted for directional paleocurrent analysis. Measurements were compiled from fifteen distinct ripple-bearing localities (SBRD-1 to SBRD-15), yielding a robust dataset of 141 individual observations of ripple-crest orientations and corresponding transport vectors.

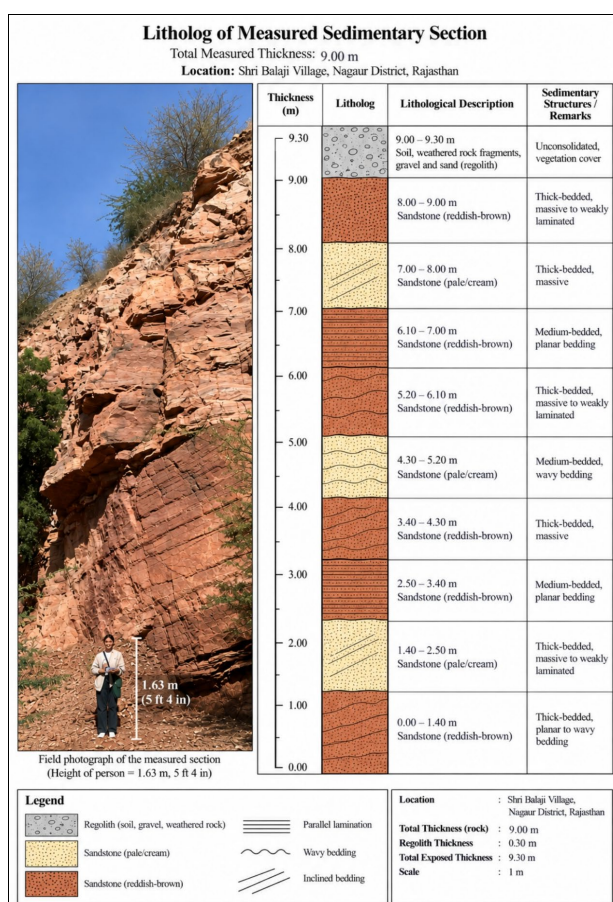


Fig 3.1: Litholog of sedimentary section 2 at Shri Balaji area.

3.2 Grain-Size Analysis

Granulometric analysis of samples SBL-1 through SBL-10 was performed using an advanced digital image-based measurement methodology. Representative high-resolution photomicrographs of the unweathered sandstone samples were acquired utilizing a petrographic microscope integrated with a digital imaging system. These images were subsequently processed using ImageJ/Fiji software for precise grain boundary delineation, measurement, and classification. Prior to data extraction, each digital frame was calibrated against a known micrometric scale to express individual grain dimensions in millimeters.

The measured grain dimensions were converted and categorized according to the phi (Φ) scale into six standardized size intervals: very coarse sand (-1 to 0Φ), coarse sand (0 to 1Φ), medium sand (1 to 2Φ), fine sand (2 to 3Φ), very fine sand (3 to 4Φ), and the silt-clay fraction ($>4 \Phi$). The abundance of grains within each respective size class was tallied for every sample, and percentage frequencies were computed relative to the total counted population. These frequency datasets were subsequently utilized to generate grain-size frequency histograms and cumulative distribution curves for comparative evaluation.

3.3 Analysis of Sedimentary Structures

Primary sedimentary structures were systematically documented in the field to identify the governing depositional mechanisms responsible for the accumulation and reworking of the Nagaur Sandstone. Special emphasis was placed on recording planar and parallel stratification, cross-bedding, asymmetrical current ripples, flaser-lenticular bedding, and subaerial desiccation features. Cross-bedding and asymmetric ripples were evaluated as indicators of tractional transport and unidirectional current activity, whereas flaser and lenticular bedding structures were analyzed in relation to fluctuating flow energy and episodic fine-grained deposition. Desiccation marks were logged as unequivocal evidence of temporary subaerial emergence.

3.4 Palaeocurrent Analysis

Directional paleocurrent analysis was executed utilizing asymmetrical ripple marks preserved on bedding surfaces across fifteen localized beds (SBRD-1 to SBRD-15), providing 141 individual measurements. Ripple-crest azimuths were recorded in the field using a structural compass, and transport directions were derived perpendicular to the crest lines based on the asymmetry of the ripple profiles. The compiled directional data were processed and graphically rendered into a standardized rose diagram. The mean resultant paleocurrent direction is computed at 295.5°, corresponding to the west-northwest (WNW) sector, which serves as the primary transport vector for regional dispersal analysis.

Table 3.1: Palaeocurrent data of asymmetric ripples.

S. No.	Sample/Bed No.	Ripple Type	Ripple Crest Azimuth (°)	Paleocurrent Direction (°)	Number of Measurements	Remarks
1	SBRD-1	Asymmetric ripple	238	320	10	Well preserved
2	SBRD-2	Asymmetric ripple	232	322	10	Good exposure
3	SBRD-3	Asymmetric ripple	290	285	5	Moderately preserved
4	SBRD-4	Asymmetric ripple	210	289	8	Well preserved
5	SBRD-5	Asymmetric ripple	225	300	10	Moderately preserved
6	SBRD-6	Asymmetric ripple	205	280	10	Good exposure
7	SBRD-7	Asymmetric ripple	185	280	10	Well preserved
8	SBRD-8	Asymmetric ripple	195	285	10	Moderately preserved
9	SBRD-9	Asymmetric ripple	200	290	10	Good exposure
10	SBRD-10	Asymmetric ripple	230	310	10	Well preserved
11	SBRD-11	Asymmetric ripple	175	275	8	Moderately preserved
12	SBRD-12	Asymmetric ripple	130	340	10	Moderately preserved
13	SBRD-13	Asymmetric ripple	195	305	10	Moderately preserved
14	SBRD-14	Asymmetric ripple	270	280	10	Moderately preserved
15	SBRD-15	Asymmetric ripple	290	285	10	Moderately preserved

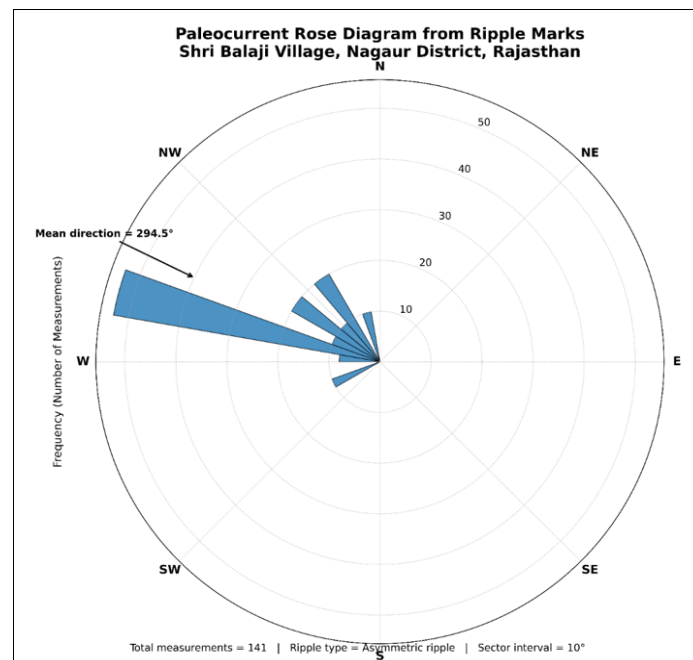


Fig 3.2: Rose diagram of Palaeoflow direction.

3.5 Integrated Sedimentological Analysis

The granulometric, structural, and directional datasets were synthesized to formulate a process-oriented interpretation of the Nagaur Sandstone. Grain-size distributions were utilized to gauge hydrodynamic energy fluctuations, while sedimentary structures provided constraints on transport mechanics. Integration with the directional paleocurrent

vectors enabled the reconstruction of local sediment dispersal pathways and basin dynamics, ensuring a robust framework for the proposed depositional model.

4. Results

4.1 Grain-Size Characteristics

Granulometric analysis conducted across the ten

representative sandstone samples (SBL-1 to SBL-10) demonstrates a predominantly fine- to very-fine-grained sandy population. The frequency distributions exhibit a broadly unimodal pattern, with the principal modal concentration consistently centered around 2.5Φ , corresponding to the fine-sand interval. Fine sand comprises the dominant fraction across all analyzed specimens, fluctuating between approximately 32% and 55%. Specifically, the highest proportions are recorded in sample SBL-7 (55%), followed closely by SBL-10 (54%), SBL-2 (52%), and SBL-6 (50%).

Medium sand constitutes the secondary major fraction, ranging from roughly 12% to 32%, whereas very fine sand contributes between 18% and 33% of the total measured population. Coarse and very coarse sand fractions occur in minor proportions, and the combined silt-clay content remains low, typically restricted between 4% and 9%. While the persistence of the fine-sand mode confirms a broadly comparable parent population throughout the succession,

minor bed-scale variations are apparent. Samples SBL-4 and SBL-9 display elevated medium-sand contents, whereas SBL-7, SBL-8, and SBL-10 exhibit greater concentrations of fine to very fine sand, reflecting localized fluctuations in transport energy.

4.2 Cumulative Grain-Size Distribution

The cumulative grain-size curves corroborate the granulometric dominance of the sand-sized fraction across all analyzed samples. At approximately 3Φ , cumulative frequencies range from 58% to 77%, escalating sharply to between 91% and 96% at 4Φ this steep upward trend confirms that the overwhelming bulk of the sediment mass is concentrated within the fine- to very-fine-sand range. While cumulative profiles maintain a uniform trend, minor shifts in curve gradients reflect variations in medium-sand populations at lower phi intervals and pronounced steepening at higher intervals for fine-sand-enriched horizons.

Table 4.1: Representation of grain size vs frequency.

Grain Size (Φ)	Size Class	SBL-1	SBL-2	SBL-3	SBL-4	SBL-5	SBL-6	SBL-7	SBL-8	SBL-9	SBL-10
0.0 to -1.0	Very Coarse Sand	1	1	1	2	2	1	1	1	2	1
1.0 to 0.0	Coarse Sand	6	4	3	8	7	2	3	4	9	2
2.0 to 1.0	Medium Sand	25	15	16	30	20	10	18	15	32	12
3.0 to 2.0	Fine Sand	43	52	40	32	35	50	55	38	33	54
4.0 to 3.0	Very Fine Sand	21	22	32	22	28	30	18	33	19	26
> 4.0	Silt & Clay	4	6	8	6	8	7	5	9	5	5
	Total (%)	100	100	100	100	100	100	100	100	100	100

Table 4.2: Representation of grain size vs grain count.

Grain Size (Φ)	Size Class	SBL-1	SBL-2	SBL-3	SBL-4	SBL-5	SBL-6	SBL-7	SBL-8	SBL-9	SBL-10
0.0 to -1.0	Very Coarse Sand	3	3	3	7	5	3	3	3	6	3
1.0 to 0.0	Coarse Sand	17	12	9	27	19	6	10	11	28	5
2.0 to 1.0	Medium Sand	70	47	46	102	53	30	59	41	99	30
3.0 to 2.0	Fine Sand	120	162	113	109	93	149	179	105	102	135
4.0 to 3.0	Very Fine Sand	59	69	91	75	74	89	58	91	59	65
> 4.0	Silt & Clay	11	19	23	20	21	21	16	25	16	12
	Total Count	280	312	285	340	265	298	325	276	310	250

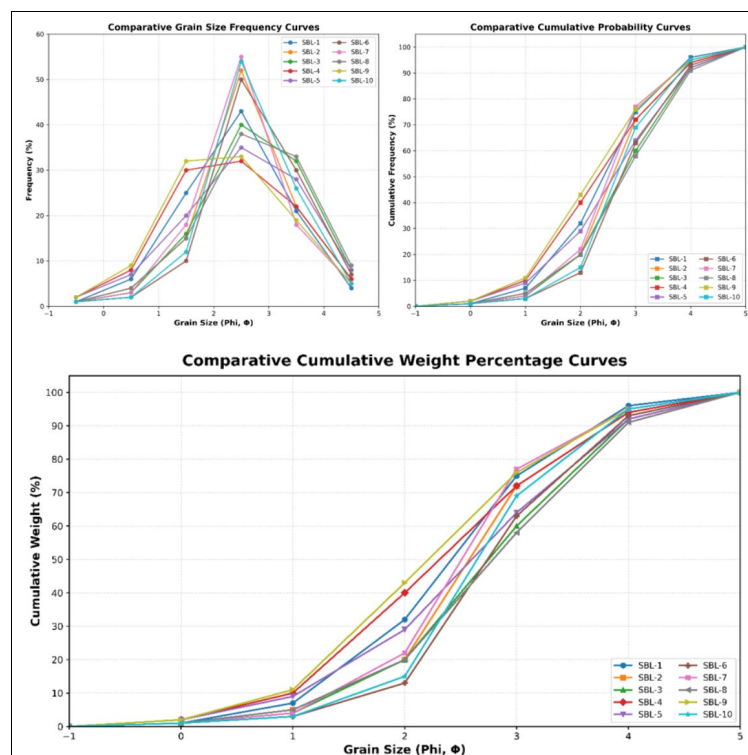


Fig 4.1: Grain size distribution and cumulative curve for all samples

4.3 Sedimentary Structures

Field observations reveal a well-preserved inventory of primary sedimentary structures within the Nagaur Sandstone at Shri Balaji. Planar and parallel stratification are ubiquitous, accompanied by prominent planar and small-scale cross-bedding. Asymmetrical current ripples are frequently preserved on bedding surfaces, providing reliable directional markers. Furthermore, subordinate flaser and lenticular bedding occur within transitional horizons, recording rhythmic alternations between sandy traction transport and finer suspension settling. Localized desiccation structures chronicle periodic subaerial emergence of the depositional surface.

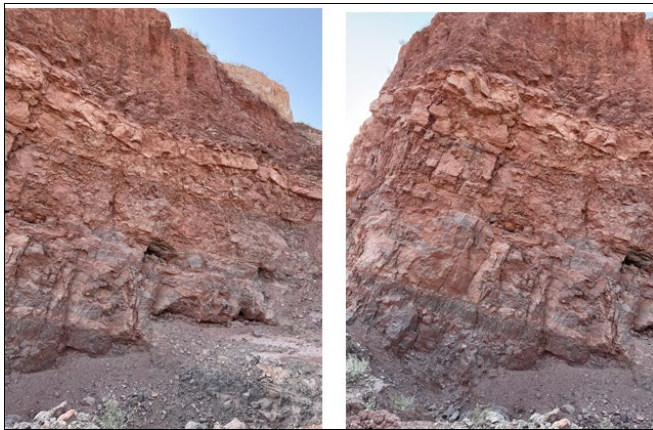


Fig 4.2: Field photograph showing gently inclined bedding.



Fig 4.3: Field photograph showing ripple marks.



Fig 4.4: Field photograph showing Cross bedding in strata.

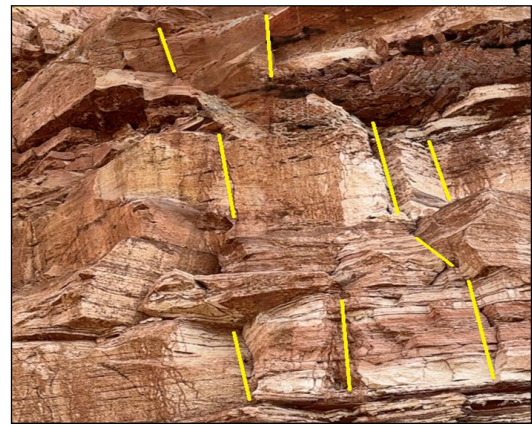


Fig 4.5: Field photograph showing fracture in strata.

4.4 Palaeocurrent Characteristics

Directional analysis derived from 141 individual measurements across fifteen ripple-bearing beds (SBLD-1 to SBLD-15) exhibits a highly concentrated azimuth distribution. Measured transport azimuths range predominantly between 275° and 340° . The calculated resultant mean paleocurrent direction is 295.5° , indicating a consistent west-northwest (WNW) sediment dispersal trajectory.

4.5 Integrated Results Summary

The synthesized results establish three core attributes of the succession: (i) a unimodal, fine-sand-dominated granulometric signature; (ii) an assemblage of tractional, hydrodynamic, and emergence structures; and (iii) a coherent WNW paleocurrent dispersal vector (295.5°), providing an empirical foundation for subsequent hydrodynamic interpretation.

5. Discussion

5.1 Grain-Size Characteristics and Hydraulic Conditions

The granulometric profiles of the Nagaur Sandstone at Shri Balaji reflect a predominantly sand-sized population strongly concentrated within the fine-sand interval. The persistence of a broadly unimodal distribution, anchored by a primary modal peak around 2.5Φ , indicates that the arenaceous succession accumulated from a relatively stable parent sediment population. While fine sand serves as the ubiquitous primary fraction across all analyzed specimens, the secondary presence of medium and very fine sand points toward minor fluctuations in transport energy. Variations such as elevated medium-sand proportions in samples SBL-4 and SBL-9 versus fine-sand enrichment in SBL-7, SBL-8, and SBL-10 are best interpreted as bed-scale hydrodynamic adjustments rather than indicators of distinct depositional regimes. Overall, the persistence of the fine-sand mode demonstrates that the overarching hydraulic regime remained stable throughout the deposition of the studied section.

5.2 Sedimentary Structures and Depositional Processes

The physical bedforms preserved within the successions offer critical proxies for deciphering depositional mechanics. The abundance of planar stratification and small-scale cross-bedding highlights active tractional transport under sustained current flow. Asymmetrical current ripples provide direct evidence of unidirectional tractive transport, which is strongly supported by directional paleocurrent concentrations. Furthermore, the presence of flaser and lenticular bedding indicates alternating hydraulic phases, wherein periods of

vigorous sand traction alternated with quieter intervals of suspension settling. Localized desiccation structures confirm that sedimentation was periodically punctuated by subaerial emergence and drying. Collectively, these structures outline a dynamic hydrodynamic setting characterized by shifting flow velocities and intermittent exposure rather than a stagnant environment.

5.3 Palaeocurrent Direction and Sediment Dispersal

The paleocurrent dataset provides a robust directional constraint for sediment transport within the Shri Balaji sector. Measurements compiled from 141 individual observations across fifteen ripple-bearing horizons reveal a concentrated directional trend, yielding a mean resultant paleocurrent vector of 295.5° (WNW). The tight clustering of azimuths around the WNW sector indicates that the ripple bedforms were generated by a persistent, coherent directional flow system. While localized azimuthal variations occur between individual beds, they operate within a unified transport framework. This directional consistency demonstrates that local bedform generation was governed by a broader regional sediment dispersal trend.

5.4 Integrated Interpretation of Hydrodynamic Regime

Synthesizing granulometric data with primary bedforms points to a fluctuating yet predominantly current-influenced hydrodynamic regime. The unimodal fine-sand population reflects persistent sediment reworking, while cross-bedding and asymmetrical ripples chronicle active tractional transport under unidirectional currents. Periodic reductions in flow energy are recorded by flaser and lenticular bedding, and subaerial exposure is substantiated by desiccation features. This coexistence of tractional bedforms, transitional bedding styles, and emergence marks is consistent with a shallow-water depositional system subject to cyclical changes in energy and water depth.

5.5 Depositional Environment

The integrated sedimentological evidence strongly supports a shallow-water to intertidal-marginal-marine setting for the Nagaur Sandstone at Shri Balaji. This interpretation is anchored by multiple lines of evidence: (i) tractional current structures, including cross-bedding and asymmetric ripples; (ii) rhythmic flaser and lenticular bedding reflecting fluctuating flow conditions; (iii) desiccation features indicating periodic emergence; and (iv) a coherent, unidirectional WNW paleocurrent dispersal pattern. Rather than representing a strictly terrestrial or deep-marine milieu, the succession records a transitional shallow-marine or coastal setup governed by active current transport, water-level fluctuations, and periodic subaerial exposure.

5.6 Implications for Local Basin Dynamics

The granulometric and directional datasets provide key insights into the local sedimentary dynamics of the Shri Balaji sector. The uniform fine-sand population indicates persistent sediment reworking, while the WNW-directed paleocurrent points to a steady transport vector. Vertical alternations between laminated intervals and thicker sandstone beds in the measured stratigraphic section reflect temporal shifts in sediment influx and hydraulic energy. Local basin dynamics were primarily controlled by the interplay between sediment supply, hydraulic energy variations, and accommodation space, with regional WNW transport maintaining a stable dispersal vector across the stable cratonic floor.

5.7 Integrated Depositional Model

The synthesized data define a current-influenced shallow-water to intertidal depositional architecture. Fine- to very-fine-grained sand was continuously transported and reworked by predominantly unidirectional currents, generating asymmetric ripples and cross-bedding. Energy fluctuations modulated bedform development, while lower-energy intervals facilitated fine-grained accumulation and flaser/lenticular bedding. Periodic drops in water level caused localized desiccation, with overall sediment dispersal directed toward the WNW (295.5°).

6. Integrated Depositional Model and Basin Dynamics

The integration of grain-size statistics, sedimentary structures, and paleocurrent data provides a comprehensive framework for reconstructing the depositional dynamics of the Nagaur Sandstone in the Shri Balaji sector. The dominance of fine- to very-fine-grained sand, coupled with broadly unimodal frequency distributions, indicates repeated sediment transport and active reworking within a persistent sandy depositional system. Bed-scale variations in medium, fine, and very fine sand proportions reflect localized fluctuations in hydraulic energy and sediment availability. Primary sedimentary structures furnish direct evidence of changing depositional mechanisms, where cross-bedding and asymmetric ripples record tractional transport under unidirectional currents, and flaser/lenticular bedding denotes alternating phases of sand traction and suspension settling. Localized desiccation structures further highlight episodic subaerial exposure.

The paleocurrent data introduce a robust directional constraint to this model, with a mean transport vector of 295.5° (WNW) demonstrating that local sediment dispersal was predominantly oriented toward the west-northwest. Consequently, the depositional model for the Shri Balaji Nagaur Sandstone defines a current-influenced shallow-water sedimentary system characterized by directional sediment routing, energy fluctuations, and periodic emergence.

Conclusions

The integrated analysis of grain-size statistics, sedimentary structures, and paleocurrent data from the Nagaur Sandstone exposed in the Shri Balaji area yields the following principal conclusions:

- Granulometric profiling indicates that the analyzed sandstone samples (SBL-1 to SBL-10) are overwhelmingly dominated by fine- to very-fine-sand fractions, featuring a unimodal distribution with a primary modal concentration around 2.5 Φ .
- Textural variations among individual samples—specifically medium-sand enrichment in SBL-4 and SBL-9 versus fine-sand concentration in SBL-7, SBL-8, and SBL-10—reflect bed-scale changes in hydraulic energy and reworking intensity.
- Primary sedimentary structures, including planar stratification, cross-bedding, asymmetric ripples, flaser-lenticular bedding, and desiccation marks, record recurring fluctuations in flow energy, tractional transport, and episodic emergence.
- Paleocurrent analysis derived from 141 measurements across fifteen ripple-bearing horizons establishes a strongly preferred transport direction with a mean vector of 295.5° (WNW).
- The synthesis of granulometric and structural data confirms that the Nagaur Sandstone accumulated under fluctuating hydraulic conditions within a current-

influenced shallow-water to intertidal-marginal-marine environment.

- The consistent paleocurrent orientation and persistent fine-sand population indicate that directional transport and sediment reworking were core components of the local depositional system.
- Overall, the Shri Balaji succession preserves a dynamic shallow-water sedimentary archive defined by unidirectional WNW-directed transport, active reworking, and periodic subaerial exposure.

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