



Limestone Deposits of Khanmouh Syncline (KS) Srinagar, Kashmir, India

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Abstract

This study presents the results of a 1:50,000 scale geological field mapping and geochemical evaluation of the Zawora-Sangari limestone belt within the Khanmouh Syncline, District Srinagar. The research, conducted across a 50 km² area in the interior Dun valley, aimed to delineate limestone lithologies and assess their grade and potential industrial suitability. The stratigraphy of the area comprises Triassic limestone and shale, underlain by the Permo-Carboniferous Panjal Volcanic Group. A detailed investigation, including systematic channel sampling, was undertaken on a 5-hectare, lease-free block near Sangari village, where limestone is interbedded with shale and dips at approximately 45° NE. Geochemical analysis of the representative surface samples from the Sangari deposit reveals an average composition of 29.02% CaO, 22.77% SiO₂, and 2.14% MgO. A comparative evaluation against the Bureau of Indian Standards (BIS) specifications for cement-grade limestone indicates that the deposit is substandard for conventional Portland cement manufacturing. The key limiting factors are a significantly elevated silica (SiO₂) content and a corresponding deficit in calcium oxide (CaO), despite magnesium levels being within tolerance. Consequently, the Sangari limestone is deemed unsuitable for cement production, necessitating the consideration of alternative industrial applications or further beneficiation studies. This assessment provides critical data for resource planning and highlights the need for region-specific industrial grading criteria.

Keywords: Surface Outcrop Mapping, Geochemical Analysis, Limestone, Industrial Grade, Resource Assessment, Cement Suitability, Zaskar Himalaya.

Introduction

The study area is located in the north-eastern part of the Zabarwan Mountain Range, bounded by the geographical coordinates between latitudes 34°00'00" to 34°05'00" North and longitudes 74°55'00" to 75°00'00" East, covered by Survey of India (SOI) topographic map bearing reference no 43 J/16 (Scale 1:50000). The study area is approachable by means of 15kilometerlong Srinagar-Khanmouh metallic road from district headquarters Srinagar¹⁻³.

The nearest airport is located at a distance of 15 kms from the area under investigation, while as the railway station at Nowgam is at a distance of about 10 kilometers. At Zewan and Guryal ravine areas, the Panjal Traps are much altered and weathered but their hard and tough nature is maintained, they are essentially non-porphyrific, dark grey to greenish grey and fine grained⁴.

Located in the interior of the elongate Dun valley (approximately 6 km long and 1.5 km wide), the Sangri Limestone Block is exposed across two prominent north-south ridges. These ridges are subsidiary to the main east-west topographic trend and are demarcated by the Sangari Stream. The bedrock is dominated by Triassic-aged limestone, which exhibits intercalations of siliceous, argillaceous, and magnesium limestone facies, alongside shale units. The topography of the area is extremely rugged and is characterized by high peaks and

precipitous slopes. The elevation ranges from 1640 meters to 2500 meters above mean sea level. The area is drained by Sangari nalla on the northeastern side while as northwestern side is drained by Guryal Ravine nalla⁵⁻⁶.

Many seasonal nallas emerging from the snow fed Zabarwan Mountain Range gush forth fresh surface water during summers as a part of snow melt. The Sangri nalla, flows in the south-east direction and has a total longitudinal distance of 3 kilometers while as the Guryal Ravine nalla originating from 2838 m, flows in the north-south directions with a total longitudinal distance of 5 kilometers before entering the valley⁷⁻⁸.

The upper reaches are surrounded by lofty snow fed mountains which form dendritic pattern of drainage system in the area. The temperature ranges from – 5°C to 30°C. The main precipitation of the area is in the form of snow during the winter and rains during spring and summer. The fauna of the area includes bears, monkeys, rat snakes and Himalayan Pit Vipers (*Gloydius himalayanus*) a deadly venomous snake, produces cytotoxic and hemotoxic effects. The area is densely forested, vegetation is generally supported on slopes comprising mainly conifers and other plants, including Cedres Deodar (*Deodar*), Pine (*Pinus excels*), Juglans regia (*Walnut*), etc. There are numerous orchards of apples, apricots and walnuts in the study area⁹.

Previous work: The geology of Khanmouh Syncline has been extensively studied and documented by various researchers.

Notable contributions include works by C.S. Middlemiss¹, D.N. Wadia², Kapoor, H.M.³, J. Gregory Shellnutt et al.⁴ and Singh V et al.⁵. A number of investigations have been carried out by officers of the Department of Geology and Mining, Srinagar and their work appears in several published and unpublished reports. Mujoo, C.L. from Department of Geology and Mining, Srinagar, investigated the eastern side of the study area in connection with leasing of limestone block to M/S Khyber Industries Pvt. Ltd. for their Cement Plant⁶.

Subsequently Chowdry, G. N.⁷ from Department of Geology and Mining, Srinagar mapped the Tul-Pow and Saman-Hardalaw Section for occurrences of limestone deposits and established six high grade to cement grade blocks in the area which were later leased out to M/S Khyber Industries Pvt. Ltd. and Saman Mines, Srinagar. Recent studies include those by Mohsin Noor^{8,9} and Nadeem Ahmad Bhat and Riyaz Ahmad Mir¹⁰.

The Guryal Ravine, fossil park, comprising the western slope of the study area running in North Northwest to South Southeast direction has been mapped by a team of geologists from Department of Geology and Mining, Srinagar, identified and subsequently demarcated the boundaries of Guryal Ravine fossiliferous zone with the help of Global Positioning Satellites (G.P.S) and Theodolite. The Surface Plan was cross checked by the team many times in the field for accuracy before submitting the proposal to the Government for declaration of protected fossiliferous zone. Accordingly, an area of 983337 square meters was reserved by the Government of Jammu and Kashmir (UT) vide Govt. Order No 94 IND of 2017 dated 03.04.2017 for maintaining and persevering of fossiliferous zone with a face length of 1413 meters, amidst picturesque exposures of Zabarwan Mountain Range. The study area comprising the central and northeastern part of the Dun valley is housing three (03) major mineral mining leases of limestone.

Present Work: This investigation involved 1:50,000 scale outcrop mapping of the 50 km² Zawora-Sangari limestone belt (Khanmouh, District Srinagar) during summer⁸. The study aimed to systematically delineate all limestone bands—including any previously unmapped units—to determine their resource grade and tonnage, thereby informing their potential suitability for various industrial uses. In order to carry out surface geological mapping of Sangri Limestone block, the author first consulted Survey of India topographic map bearing reference no. 43J/16(Scale 1:50000 to finalize the amount of work. Subsequently, the author used imaginary from Google Earth and ASTER30 digital elevation model (D.E.M.) together with the Global Mapper software version (22) for generation of various map attributes⁹.

Geochemical characterization of the Sangri Limestone block was performed to ascertain its industrial-grade potential. Field methods included detailed lithological examination with a hand lens and bed thickness measurement. Geochemical data were obtained from 31 channel samples, collected systematically

along the dip direction from distinct lithological units. Standard laboratory assays were conducted to determine the concentrations of CaO, MgO, SiO₂, Al₂O₃, Fe₂O₃, and Loss on Ignition (LOI). The Kashmir Basin (KB) representing a complete tectono-stratigraphic sequence of marine Phanerozoic Aeon which is bounded by two linear mountain ranges - the Pir Panjal Range (PPR) and the Zanaskar Range (KR) trending northwest-southeast in direction. It contains one of the finest developments of the stratigraphic succession right from Proterozoic to Recent.

The summer capital, Srinagar forms the northeastern part of Kashmir Basin wherein Paleozoic to Quaternary rocks of diverse origin are exposed. The main geological Formations/ Members constituting the bedrock, and the surrounding mountains ranges include the Panjal Volcanics (Late Carboniferous), non-marine Mamal Formation, Risin Member (Early Permian) marine Zewan Formation (Late Permian) and Khanmouh Formation (Early Triassic) are exposed eastwardly all along the hilly tract. The Panjal Volcanics, Zewan Formation and Khanmouh Formation constitutes the western slope of the study area running in North Northwest to South Southeast direction and dipping gently to North Northeast.

The Khanmouh Formation (Early Triassic) is unconformably overlain by the alluvium (Recent to Sub-Recent) lies in terraces at various levels comprising of typical chocolate brown clays with kankar concretions, liberally distributed through them¹⁰.

Sangri Limestone Block

This study focuses on the Sangri Limestone Block (Figure-1), situated in the interior Dun valley (approx. 6 x 1.5 km) within the Khanmouh region, District Srinagar. As part of a district-wide reappraisal of limestone resources, surface outcrop mapping of the broader 50 km² Zawora-Sangari belt was conducted at a 1:50,000 scale (Figure-1). The specific Sangri block, a 260 x 250 m lease- and license-free area, is located in the northeastern Zabarwan Mountain Range (Lat. 34°05'07.23"N, Long. 74°59'05.72"E; SOI Toposheet 43 J/16) at an elevation of 1950 m AMSL. It is exposed on two north-south trending ridges, subsidiary to the main east-west ridge and separated by the Sangri Stream. The lithology comprises Triassic limestone interbedded with siliceous, argillaceous, and magnesium limestone, as well as shale^{9,10}.

The Sangri limestone deposit is characterized by a dominant structural trend, striking NNW-SSE and dipping at 45° (degree) towards the northeast. A detailed lithological description of the Sangri Limestone Block is presented as follows (Table-1).

Geochemistry of Limestone blocks

To assess the industrial quality of the Sangri Limestone block, 31 channel samples were collected from various lithological units along the dip direction for geochemical analysis. The results, represented in a CaO-MgO-SiO₂ ternary diagram

(Figure-2), show the average weight percentages of these major oxides. Most samples plot within a compositional field defined by average values of 53.81% CaO, 3.96% MgO, and 42.22% SiO₂. This CaO-MgO-SiO₂ plot confirms the dominance of calcite as the primary carbonate mineral. However, the overall geochemical data (Table-2) indicate the limestone is of substandard quality and unsuitable for direct use as a raw material in clinker manufacturing.

Table-1: Lithological description of the Sangri Limestone Block.

Age	Formation	Lithology	Average Thickness
Triassic	Limestone	Greyish colour thickly bedded medium to fine grained limestone interbedded with thin calcareous shales.	30
		Greyish colour thickly bedded fine grained limestone interbedded with thin bands of siliceous and argillaceous limestone.	70

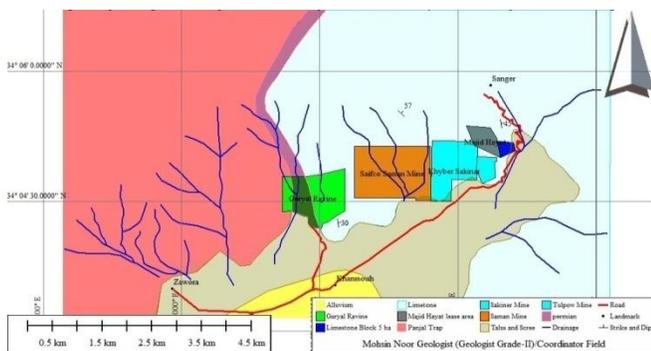


Figure-1: Geological Map of Limestone Deposits of Khanmouh Syncline (KS) Srinagar, Kashmir, India.

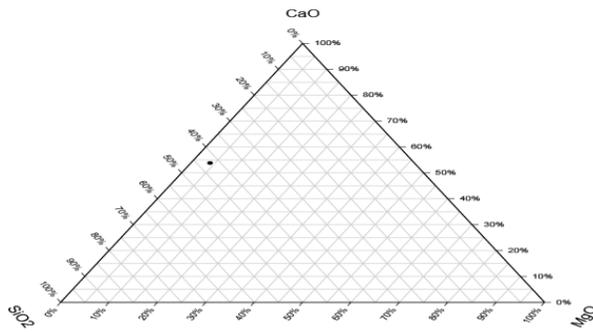


Figure-2: CaO-MgO-SiO₂ ternary diagram.

Also, the Broad chemical specifications of Cement Grade Limestone (Run-on-Mine) for cement manufacturing suggested by the National Council for Cement and Building Material, New Delhi doesn't confirm the suitability of the Sangri Limestone Block for its use in cement industry (Table-3)¹¹.

Table-2: Chemical analyses of the channel samples of Sangri Limestone Block.

Channel Sample	CaO	MgO	SiO ₂	Density
B1/Sr/01/Sg	45.05	1.60	8.25	2.61
B2/Sr/02/Sg	46.08	0.80	7.90	2.54
B3/Sr/03/Sg	52.08	1.68	1.90	2.59
B4/Sr/04/Sg	35.44	1.78	20.01	2.66
B5/Sr/05/Sg	39.02	1.60	14.96	2.73
B6/Sr/06/Sg	47.60	0.80	7.35	2.53
B7/Sr/07/Sg	49.28	1.60	5.70	2.74
B8/Sr/08/Sg	49.84	1.20	5.61	2.73
B9/Sr/09/Sg	29.96	1.60	23.80	2.70
B10/Sr/10/Sg	43.12	0.80	11.24	2.71
B11/Sr/11/Sg	7.84	1.20	58.94	2.65
B12/Sr/12/Sg	41.44	0.80	13.80	2.68
B13/Sr/13/Sg	10.92	1.60	49.08	2.51
B14/Sr/14/Sg	41.44	1.20	11.61	2.61
B15/Sr/15/Sg	19.60	2.40	34.95	2.64
B16/Sr/16/Sg	5.04	3.60	50.97	2.68
B17/Sr/17/Sg	42.18	2.00	11.03	2.55
B18/Sr/18/Sg	29.08	1.20	28.82	2.66
B19/Sr/19/Sg	47.87	1.60	6.98	2.53
B20/Sr/20/Sg	7.12	2.13	60.50	2.51
B21/Sr/21/Sg	27.12	2.14	32.38	2.73
B22/Sr/22/Sg	14.56	2.00	46.79	2.70
B23/Sr/23/Sg	19.60	2.80	37.21	2.68
B24/Sr/24/Sg	5.92	2.62	54.22	2.64
B25/Sr/25/Sg	51.00	1.20	5.69	2.76
B26/Sr/26/Sg	37.49	1.76	23.11	2.70
B27/Sr/27/Sg	42.56	1.60	12.79	2.54
B28/Sr/28/Sg	40.88	2.00	13.05	2.54
B29/Sr/29/Sg	20.72	2.80	35.59	2.66
B30/Sr/30/Sg	15.12	2.40	44.65	2.68
B31/Sr/31/Sg	18.48	2.80	33.08	2.67
AVGERAGE	29.02	2.14	22.77	2.65

Table-3: Broad chemical specifications of Cement Grade Limestone (Run-on-Mine).

Oxide component	Acceptable range for manufacturing of cement (%)	Limiting values, scope of Beneficiation and blending (%)
CaO	44-52	40(min)
MgO	3.5(min)	5.0(max)
SiO ₂	To satisfy LSF, Silica	-
Al ₂ O ₃	Modules and alumina	-
Fe ₂ O ₃	Modules	-
Free Silica	<8	<10
TiO ₂	<0.5	<1.0
Alkalies	<0.6	<1.0
Total S as SO ₃	<0.6	<1.0
Mn ₂ O ₃	<0.5	<1.0

Conclusion

From the perusal of geochemical analysis of channel samples of Sangri Limestone Block, it is revealed that the limestone deposit of Sangri contain high silica SiO₂ 22.77, and low calcium oxide CaO 29.02 which is not suitable for cement manufacture as per the threshold value Cao 34 % and SiO₂< 5 % for cement manufacture suggested by the Indian Bureau of Mines (I.B.M), India, vide notification No. C-284/3/CMG/2017 dated 25th of April 2018 and the Broad chemical specifications of Cement Grade Limestone (Run-on-Mine) for cement manufacturing suggested by the National Council for Cement and Building Material, New Delhi, India¹¹.

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