ISSN 2321 – 9149 **IJAEES (2014) Vol.2, No.2, 39-45**
Research Article

IROSSS
Advancing Sciences and Social Sciences for Mankind

International Journal of Advancement in Earth and Environmental Sciences

PROVENANCE, TECTONIC SETTING AND PALEOCLIMATE OF UPPER BHANDER SANDSTONE IN PARTS OF RAISEN DISTRICT MADHYA PRADESH (INDIA)

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ABSTRACT: The Upper Bhander Sandstone (Late Neoproterozoic) of Raisen district of Madhya Pradesh, central India has been analyzed to understand provenance, tectonic setting and paleoclimate of the Vindhyan basin. Upper Bhander Sandstone is the uppermost unit of Vindhyan Supergroup. Qt-F-L and Qm-F-Lt triangular diagrams of twenty representative samples of Bhander sandstones of study area were examined. The result shows that majority of the sands were mainly derived from continental block (cratonic) with small amount of sediments was contributed by recycled orogen with uplifted basement. The bivarient log-log plot of ratio of polycrystalline quartz to feldspar plus rock fragments (Qp/F+R) against the ratio of total quartz to feldspar plus rock fragments (Qt/F+R) suggests that the paleoclimate at the time of deposition of Upper Bhander Sandstone was humid.

KEYWORDS: Vindhyan Supergroup, Upper Bhander Sandstone, Raisen, Provenance, Paleoclimate, Tectonic-setting.

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1. INTRODUCTION: The rocks of Vindhyan Supergroup were deposited in a sickle-shaped NE trending intracratonic basin. It is one of the largest Proterozoic sedimentary basins of the world (1). The Vindhyan basin is located in the central part of peninsular India, extending from Dehri-On-Son in Sasaram to Dholpur in Rajasthan passing through the Son Valley, Bhopal, Dhar forest and Chitoorgarh and Swai Madhupur [(2), (3)]. This huge basin wraps round the batholithic mass of Bundelkhand Granite (Fig. I). Vindhyan Supergroup covers an area of more than 1,04000 square kilometer with extensive, voluminous, unmetamorphosed and largely undeformed sandstones, shales, limestones, dolomites with subordinate amount of conglomerates and volcanics [(2),(4)-(5)]. A large part of Vindhyan rocks is lying underneath the Deccan traps and Indo-Gangetic alluvium [(3)-(4)]. The thick pile (~ 4000 m) of Proterozoic Vindhyans has been divided into Lower and Upper divisions. The lower Vindhyan consists of Semri Group and Upper Vindhyan consists of Kaimur, Rewa and Bhander groups in ascending order [(1)-(6)]. Provenance is an important tool to understand the geological history, tectonic setting and crustal evolution during the deposition of sediments (7). During the past few decades sedimentologists have successfully utilized the composition of sandstones to interpret the nature and tectonic setting of provenance and paleoclimate prevailing at the time of deposition [(8)-(14)]. The present study mainly deals with upper Bhander Sandstone found exposed in parts of Raisen district of Madhya Pradesh state, India. The main objective of present paper is to evaluate provenance and its tectonic setting and paleoclimatic condition in the study area during deposition of Upper Bhander Sandstone.

2. GEOLOGICAL SETTING: The study area is situated in north eastern part of Raisen district of Madhya Pradesh (Fig. I), falls in Survey of India toposheets No. 55 E/11 and 55 E/15. The area of investigations lies between the cartesian coordinates 23°15′ to 23° 30′ N and 77° 35′ to 77 °50′ E. The Vindhyan rocks show excellent preservation of sedimentary structures and are considered as being deposits of beach, shallow marine littoral environment with fluctuating condition [(3),(15)].

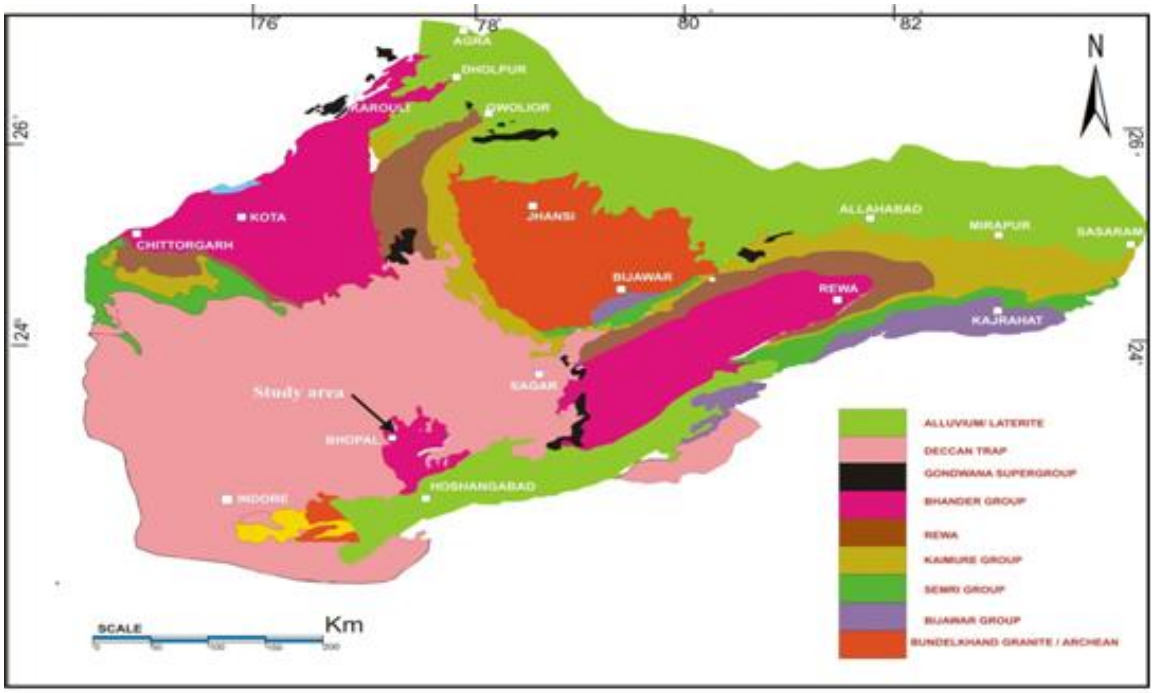

Fig. I: Regional geological map of the Vindhyan basin (Simplified after Soni et.al 1987)

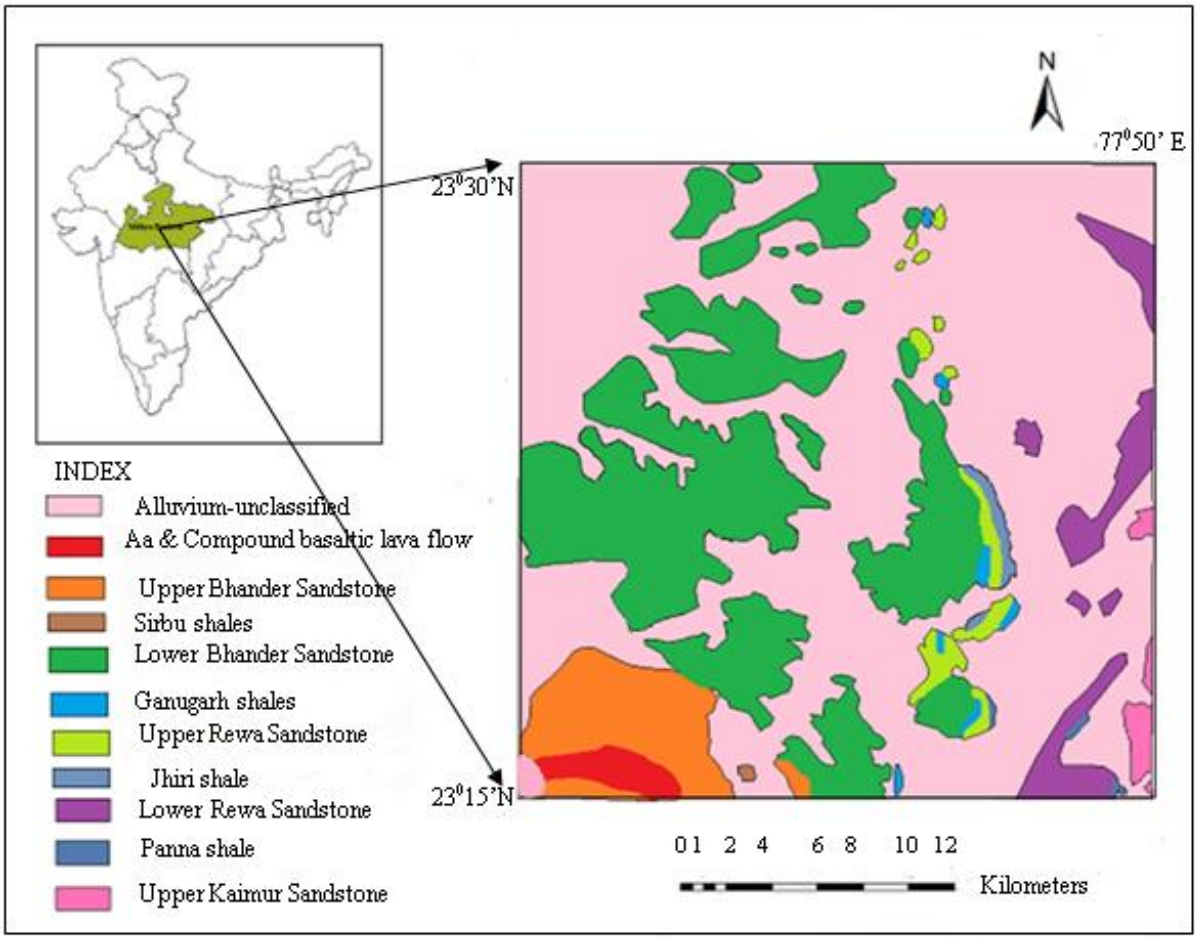

Fig. II: Geological Setup of the study area

In the investigated area, the Bhander sediments are found exposed along the scarp faces and in road and nala cuttings like Kuhu nala, Bangawan, Ratanpur, Richan nala, Raisen, Khanpur etc. These rocks are occasionally overlapped by Deccan trap (Cretaceous to Palaeocene) (16) and Alluvium of Quaternary age (4). The Bhander Group is arenaceous to argillaceous in nature and is divided into four formations as Ganugarh Shale, Lower Bhander Sandstone, Sirbu Shale and Upper Bhander Sandstone in ascending order (Fig. II), as displayed in geological map of the area. Ganugarh/ Sanchi shale is green coloured, occasionally calcareous in nature found exposed in and around Raisen fort. Lower Bhander Sandstone is fine grained, pink to pinkish brown, hard and compact in nature. Sirbu shale is found in small, isolated exposures with chocolate brown to pale yellow colour. Fine to coarse grained Upper Bhander Sandstone is pink in colour and found mainly in south-western part of the study area.

3. MATERIALS AND METHODOLOGY: In the present investigation, the detrital components of Upper Bhander sandstone are studied to interpret the provenance, tectonic setting, and paleoclimatic condition. To achieve this aim Dickinson, 1985 (9) scheme of classification is followed. Out of 50 collected sandstone samples, 20 representative samples are cut into thin sections for petrographic study.250 to 300 framework grains per thin sections are counted using Gazzi-Dickinson point counting method (17). For provenance and tectonic setting, the detrital modes were recalculated to 100 percent by summing up of Qt, Qm, F, L and Lt (Table I). Log-log plot of Suttner and Dutta (18) is adopted to interpret the paleoclimatic condition prevailing at the time of deposition.

S.N	QtFL			QmFLt			Qp/(F+R)	Qt/(F+R)
	Qt	F	L	Qm	F	Lt		
BH-01	97	1	2	96	1	3	2	32.3
BH-02	97	2	1	97	2	1	1.7	32.3
BH-03	96	2	2	95	2	3	0.67	32
BH-04	98	0	2	98	0	2	1	49
BH-05	95	4	1	95	4	1	0.4	19
BH-06	97	1	2	97	1	2	1.3	32
BH-07	99	0	1	98	0	2	2	3
BH-08	97	2	1	96	2	2	1	99
BH-09	98	0	2	98	0	2	1	32
BH-10	96	3	1	93	3	4	1.5	3
BH-11	98	0	2	96	0	4	1.5	49
BH-12	98	0	2	97	0	3	0.5	49
BH-13	94	4	3	92	4	4	0.3	15.67
BH-14	96	1	3	96	1	3	1	24
BH-15	95	2	1	94	2	4	0.4	19
BH-16	99	0	2	98	0	2	7	99
BH-17	96	2	2	94	2	4	1	24
BH-18	98	1	1	97	1	2	1.5	49

BH-19	95	3	2	94	3	3	0.6	19
BH-20	98	1	1	98	1	1	3.5	49
AVERAGE	96.85	1.45	1.7	95.95	1.45	2.6	1.5	36.5

Table I: The recalculated detrital composition of Upper Bhander Sandstone of Raisen District (Based on Dickinson 1985 sheme). Qt=Total quartz, F= Total feldspar, L= Total lithic fragments, Qm= Monocrystalline quartz, Lt= Total rock fragments including polycrystalline quartz, Qp= Polycrystalline quartz.

4. PETROGRAPHY: The thin section study under the microscope of Upper Bhander Sandstones shows that they are medium to fine grained and moderately to well sorted with sub-angular to subrounded grains with low to medium sphericity. Quartz is the most dominant mineral in these sandstones followed by feldspars, rock fragments, micas, chert and heavy minerals. The average composition of detrital minerals is as follows: monocrystalline quartz 91 percent, polycrystalline quartz 4 percent, fresh and altered feldspar about 2 percent, rock fragments up to 2 percent whereas micas, chert and heavy minerals are noted in very minor number. Quartz with varities of common, recrystallized and stretched metamorphic is present. Chert grains are represented by clear, cloudy and altered varieties. Both muscovite and biotite are present as laths and flakes. The heavy minerals in these sandstone samples are represented by tourmaline, zircon, biotite, garnet, hornblende and opaque.

5. PROVENANCE AND TECTONIC SETTING:

5.1. PROVENANCE: The study shows, common quartz is the most abundant mineral. It is mainly derived from granitic batholiths or granite-gneisses, whereas recrystallized quartz has a variety of sources like metaquartzites, highly metamorphosed granites and gneissic rocks. The stretched quartz is generally derived from granites, schists or quartz veins. Flakes of muscovite and biotite flakes are usually supplied by pegmatites, shists or granites. Microcline is the most dominant variety of feldspar indicating the presence of either pegmatite or some metamorphic rock in the source area [(18)-(20)]. The modal composition of under discussion Upper Bhander sandstones reveals that they have been derived from an area with a variety of rocks such as batholiths, granites, metasediments, genisses and schists. The suite of heavy minerals including biotite, hornblend, tourmaline and zircon indicate acid igneous source for these sediments. On the other hand the presence of garnet and opaques reflect metamorphic source for these sediments. The mineralogical composition and heavy mineral assemblage of the Upper Bhander sandstone reflect that their source had mixture of different rock types in the provenance. Such mixed population of rocks is found exposed in Archean Bundelkhand Gneissic complex, Aravalli range and granites-gneisses of Mahakoshal Group which lie in the vicinity of Vindhyan basin.

5.2. TECTONIC SETTING: Qt-F-L and Qm-F-Lt triangular diagram Dickinson, 1985 (10) has been adopted to interprate the tectonic setting of the provenance of the Upper Bhander Sandstone of Raisen area. The triangular diagram for plotting point counts of sandstones is subdivided into fields, which are the characteristics of sandstone provenance terrains which is controlled by plate tectonics (11).The Qt-F-L diagram is the reflection of all factors which are controlled by provenance, relief, weathering conditions and transport history and mechanism. This diagram is based on the total amount of quartose, feldspathic and lithic modes. The present investigation reveals that source of the most of the studied samples is continental block and a few samples indicate their origin from recycled orogen provenance [Fig. III (a)]. The ternary plot suggests the maturity of the provenance which lies in craton interior orogen and recycled orogeny provenance with basement uplift. The Qm-F-Lt diagram exhibits that all samples have their provenance in craton interior [Fig. III (b)]. Bivariant log/log plot of the ratio of polycrystalline quartz to feldspar plus rock fragments (Qp/F+R) against the ratio of total quartz to feldspar plus rock fragments (Qt/F+R) following Suttner and Dutta [21] has been used to interpret the paleoclimatic condition of these sandstones of Raisen area. The plot suggests that the humid paleoclimatic condition prevailed at time of deposition of these sediments.

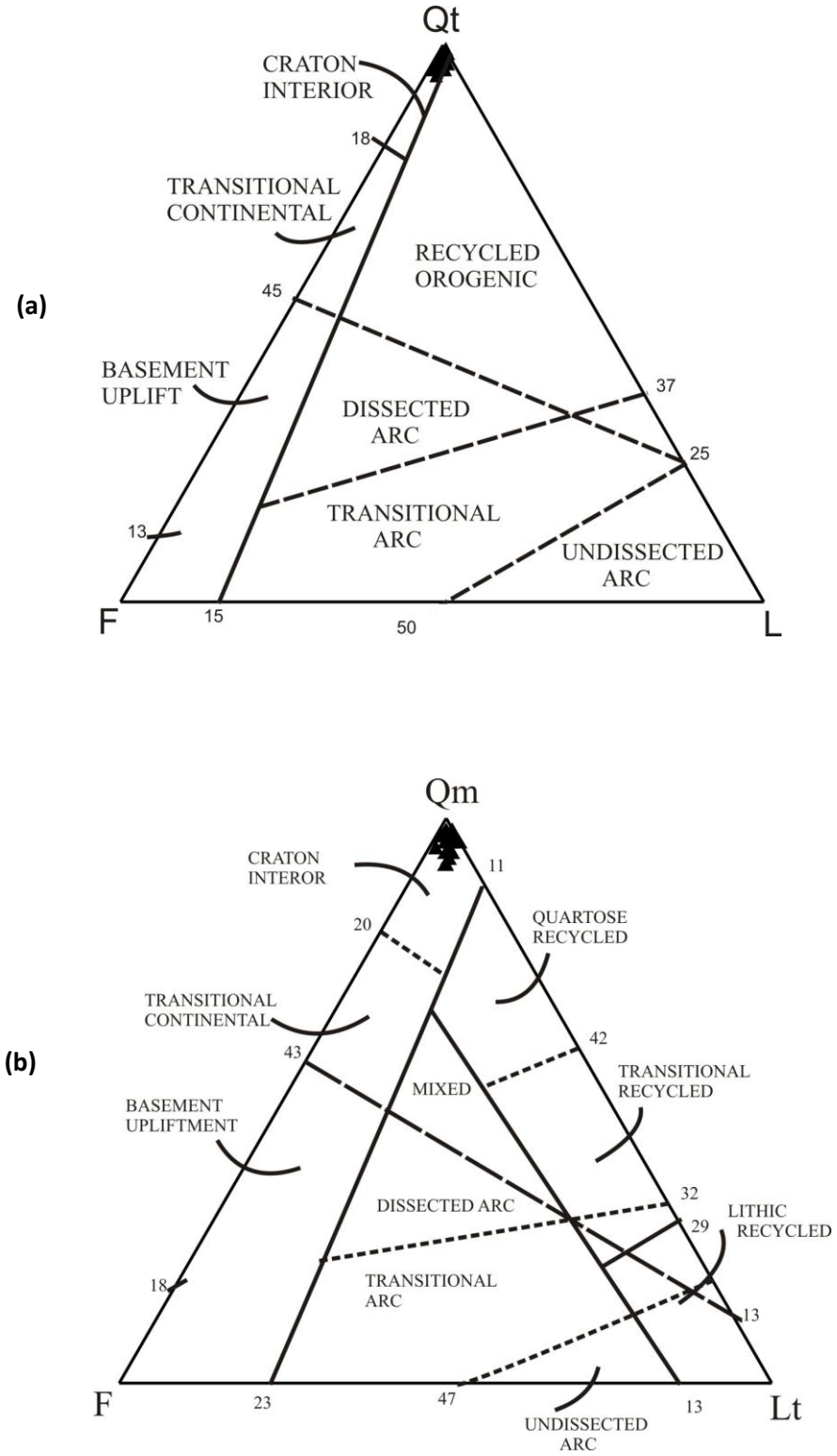

Fig. III: Triangular diagrams (a) QtFL and (b) QmFLt of Upper Bhander Sandstone of Raisen district for provenance (after Dickinson et.al. 1985)

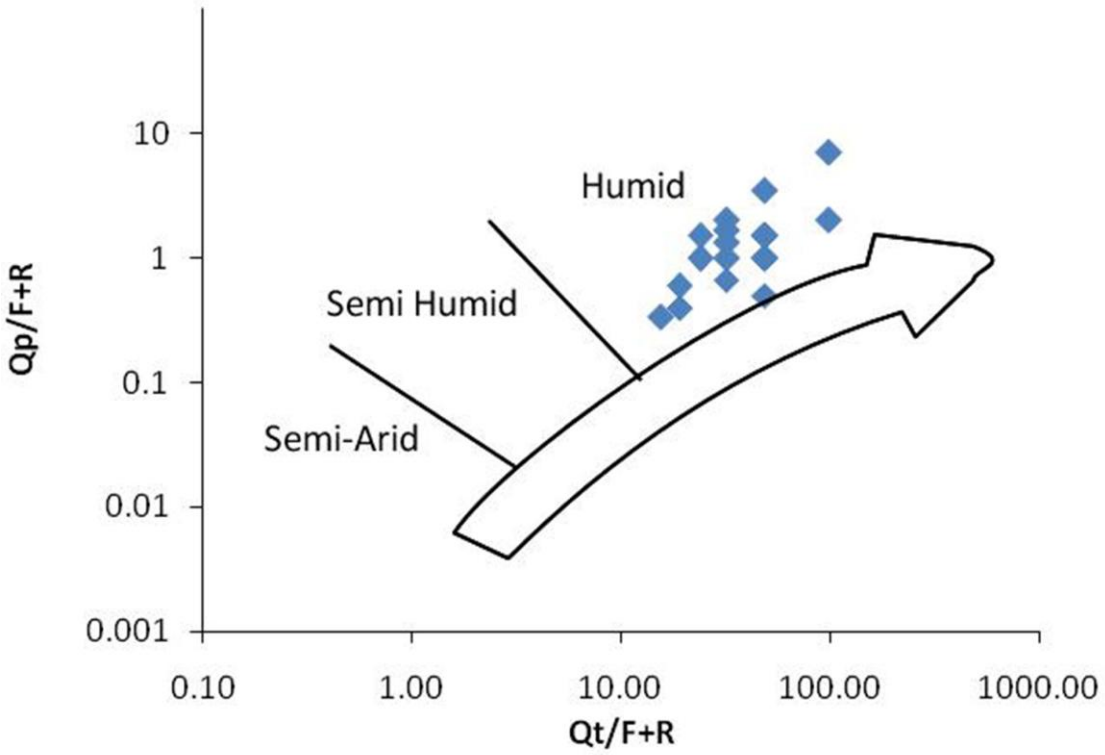

Fig. IV: Bivarient log/log plot of ratio of Qt/F+R and Qp/F+R of Upper Bhander sandstone of Raisen district

6. CONCLUSIONS: Thin section study of Upper Bhander Sandstone suggests fine to medium grained and moderately to moderately well sorted nature. Mineralogically sandstones are dominated by quartz and followed by feldspar, rock fragments, micas, chert and heavy minerals. This composition suggests source with mixed rocks e.g. plutonic, sedimentary and metamorphic. Triangular diagrams (Dickinson, 1985) indicate that, detrital modes of sandstones have been derived from the craton interiors and medium to high grade metamorphic supracrustals, forming recycled orogenic provenance. Bivariant plot, suggests humid paleoclimatic condition during the deposition of this Upper Bhander Sandstone.

ACKNOWLEDGEMENT: The authors are thankful to the Chairman, Prof. Mahshar Raza for providing facility to carry out the study and to Prof. A.H.M. Ahmad, Department of Geology, Aligarh Muslim University, Aligarh for help. Chief author Nazrana Mohammadi is also thankful to UGC, New Delhi for providing financial assistance to compile the work..

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