STRATIGRAPHY OF QUATERNARY DEPOSITS OF NARMADA VALLEYCENTRAL INDIA

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ABSTRACT ijser.editor@ijser.org

The SONATA LINEAMENT ZONE embodies the two Quaternary basins of tectonic origin on the two margins of Sapura Crustal Block. The Satpura block traversed by enechelon system of faults and lineaments is characterized by thinner crust (33-38 km deep, basement depth >2.5 km) with series of ENE-WSW trending gravity high (viz. Sendwa, Khandwa, Chicholi, Tikaria etc.) with amplitudes of 10-35 mgal. The chain of gravity high indicates extensive magmatic and emplacement of derivatives at shallow crustal levels. The associated Narmada South (Satpura North) fault and Satpura South Fault marking the two hinges of the Satpura block are fundamental in nature and extend to Moho level. The Narmada Quaternary basin in the north and Tapti-Purna basin in the south are two Graben which formed prominent loci of sedimentation in lineament zone. The area of lineament zone studied tectonically encompasses two crustal provinces of Central India Shield, namely, the Northern Crustal Province (NCP) and the Southern Crustal Province (SCP). The two provinces are separated by a crustal level shear zone, referred as Central Indian Suture. The zone has been a major locus of episodic tectonism with evidences of reactivation.

The Narmada Rift valley forms an ENE-WSW lineament where Quaternary deposits are confined in a trough like basin on unstable platform which forms a prominent lineament with profound geomorphologic and geological asymmetry between the northern and southern valley walls, giving it a tectonic significance. The alluvial deposits of the Narmada valley represent the thickest Quaternary deposits in peninsular India. These sediments were deposited in faulted and sinking platform under structural riparian rift trench remained silent and unrevealed. The quaternary blanket of Narmada consists of sediments of various domains which were deposited in different environment in vertical chronology in faulted trough in time and space.

The Quaternary sedimentation in Narmada Rift valley incepting from glacial activity, followed by fluvio-glacial, lacustrine and fluvial phase within the rinsing and sinking environment, block faulting and linear displacement and dislocation, uplifting and isolated domal up- lift, Neogene rifting and Quaternary sedimentation. The rift-bound Pliocene–Pleistocene rifting and volcanic activities specifically during glacial and fluvio-glacial phase are major component of the Quaternary period and tectonic processes of the Rift System which form the base of quaternary deposits. The Narmada rift system basin platform provided a unique setting for dynamic ecosystems that were characterized by Rift-related subsidence and coeval sedimentation and environment for the accumulation of sediments volcanic fabrics sediments, burial, digenesis, and preservation of organic remains.

The present disposition of Narmada blanket of Narmada, in SONATA LINEAMENT ZONE revealed that the rift occurred after widespread Quaternary sedimentation and accumulation of sediments in the linear trench by glacial activity in late Pleistocenc.The Fluvio-glacial phase is represents by boulder conglomerate which has formed the persistent horizon in the valley. The

Narmada has in the area under study has sculptured the alluvial tract into stepped sequence forming four alluvial terraces along its course. These are designated as NT0 to NT3, NT0 being the youngest terrace and NT-3 the oldest terrace where the sub terraces are designated NT2-A is NT2-B, NT2 B, besides NT2-C, NT3-A & NT3-B in increasing order of antiquity. These are both erosional and depositional terraces and confined at an elevation of, between 280 to 380 are separated by the scarp both of curvilinear and linear in nature facing towards river side. These are abandoned flood plains represent the level of former valley floor in the area, and were formed by cumulative climato-tectonic changes in the watershed of Narmada in the Quaternary times Khan et.al (2016)

The Jabalpur- Bharuch Harda section of Narmada possess the complete sequence of all three domain of sediments in increasing antiquity from the bottom of the rift trench, Boulder bed (glacial), Boulder conglomerate (fluvial-glacial) sediments of paleo-domain of Narmada (fluvial). The intense tectonic activities within the basins of the Narmada Rift System during the Neogene and Quaternary periods have destroyed fossil record except the fossiferous horizons exposed in river sections. The erosional-sedimentary cycle has persisted in the rift valley environment for millions of years as a result of the interplay between depositional and erosional forces driven by tectonic processes; there are numerous gaps in the fossil record, particularly in the important time period between Mio-Pliocene Pleistocene times. It is pertinent to the understand the origin of Hominid during the late Miocene, but it is difficult to disclose mysteries of human evolution in Narmada due to concealed nature of these deposits in rift system, however the complementary part of Tapti-Purna Quaternary blanket may be potential and possessive of human remain and should be studied to trace further the imprints of fossil man taking in to account of SONATA LINEAMENT ZONE as single ecosystem for evolution of man in Indian subcontinent. However, evidence of the effects of tectonics on fauna and flora are distinct and its signatures on dislocation and concealing of fossiliferous horizons are uncontrolled and ill-defined in the ecosystem in the valley during the Pliocene–Pleistocene periods. The boulder conglomerate which yielded the skull cap of *Homo eructs* in Narmada rift from Hathnora Sonakia (1984) remained only discovery of hominid fossil in last two and half decade due to concealed and hidden nature of Mio-Pliocene Pleistocene deposits in rift system and inconsistency in exposure of fosiliferous horizon due faulting, dislocation ad subsidence of Quaternary blanket of Narmada rift system.

The Narmada rock basin of Narmada is occupied by the Quaternary sediments of three domains viz. glacial, fluvio- glacial and fluvial which were deposited in distinct environments during Quaternary time. The glacial deposit comprised of thick pile of sediments occupied base of rock basin and was deposited by glacial activities in dry and cold climatic condition during early Pleistocene time. The study of these concealed sediments, their sedimentary environments and sedimentation and correlation both in vertical and horizontal columns indicates that the lower most units, Boulder bed (20 to 260 m. below ground level) is of glacial origin, where as the fossiliferous bed Boulder conglomerate (260 to 278m. above m.s.l.) is of fluvio-glacial and top four formations in increasing antiquity Sohagpur, Shahganj, Hoshangabad and Janwasa (278 to 350m. above m.s.l.) are of fluvial origin and represent the complete sequence of Quaternary sedimentation in Central India Khan & Sonakia (1992).). The boulder conglomerate is a marker horizon of Quaternary sedimentation in Narmada Valley and as well in Central India, its disposition and relation with other deposits in the valley, indicates a significant change in regional climate from cold dry to warm and humid, during which the sediment were re-worked from glacial front intermittently and deposited in the valley over a very long time. The skull cap of *Homo erectus* (Narmada Man) and other fauna recorded along with calc- nodules within the boulder conglomerate; suggest that warm climatic phase prevailed for very long time.

The Boulder Conglomerate which is of fluvio-glacial origin and has yielded human skull from Sonakia (1982) Khan &Sonakia (1992) is exposed impersistently in scarp section of Narmada at few places only. The type section of Boulder Bed and Boulder *Conglomerate* which are

potential sediments of human remains of Pliocene Pleistocene time are hidden and concealed under sediments of present and paleo- domain of Narmada in the valley.

The skull cap of *Home erectus*(Sonakia1984) and other fauna recorded along with calc- nodules near village Hathnora (22 ° 52" N; 77 ° 52" E) in fossiliferous boulder conglomerate; named as Hathnora formation Khan & Sonakia (1992). It is found to be associated with volcanic Ash bed of Quaternary age in the area around Hathnora, and upstream Khan et.at. (1991). The two levels of horizons of Ash bed identified are designated as NAB-I and NAB-II in ascending antiquity in the valley. The Ash bed NAB-1 is associated lower litho units of boulder conglomerate which is well preserved and persistent where as NAB-II is associated with younger deposits. The NAB-1 contains three micro layer (L-1 to -L3) and NB-II two micro layers (L-4 to L-5) in increasing antiquity Khan et.at. (1991).

In Narmada valley the association of Ash bed NAB-I with Hathnora formation at the depth of 78 m in Quaternary column and occurrences skull cape *of Homo erectus* at the depth of 83 m in decreasing antiquity from the top assumed that Toba eruption have taken place later than existence of *Homo erectus* which appeared and resided in the valley for long time before the fall of Toba ash. The association of Ash is NAB-II at the depth of 72 m with the younger deposit revealed the second cyclic fall of Toba ash which certainly have had influenced on hominines and had collective and cumulative impact on *Homo erectus* (Sonakia1984) *Homo sapiens* (Thobold 1860, 81), in Narmada valley and Indian sub-continent. Oppenheimer (2003) argues that *Homo. Sapiens*occupied India before ~74 ka and may have undergone "mass extinction" as a result of the Toba eruption. The argument of Oppenheimer (2003) is in strong conformity with the present observation of authors. As sediment & Ash bed sequence of Quaternary column of Narmada (325 m) and occurrences of fossil of skull cape *of Homo erectus* (Sonakia1984) at 83 m & human cranium *Homo sapiens* (Thebold 1960, 1981) transported have existed prior to fall of Toba ash and they are among the few who inspite of massextinction causedby mega dislocation in ecology and environment related with volcanic eruption survived in Narmada Valley. It is further documented by the rarest occurrences of these fossils in subcontinent which also confirm the intensive impact of volcanic ash fall on these hominines and their consequential mass extinction.

The skull cap of Narmada Man *Homo erectus* was found in Narmada Valley near village Hathnora (22 ° 52" N; 77 ° 52" E) in fossiliferous boulder conglomerate, in district Sehore, M.P., India. The skull cap is completely fossilized undistorted, renal vault nearly complete except few left Supra-orbital and statures are nicely preserved. The various morphological features and robust form of skull and excessive thickness of the bones indicate that it belongs to adult male individual (Sonakia, 1984). The discovery of skull cap of *Homo erectus* in fossiliferous boulder conglomerate in association of other mammalian fossil is recorded in stratigrphic column of Quaternary deposits at the depth of 83 m , where estimated total thickness of deposits is about (325 m).This blanket consist of sediments of three domain viz. glacial, fluvio-glacial and fluvial, which were deposited in distinct environment during Pleistocene to Holocene time (Khan & Sonakia (1992), (Khan et.al. in press).The statistical analysis of sediments form these different domain in vertical column has been conducted to ascertain the environment of sedimentation and trace the breaks in climate (Khan et.al. in press). An attempt has been made for the first time Khan et.al (2013) to correlate the various stratigraphic columns of associated hominid fossils of Narmada valley (325 m) India and that of Luochuan sequence,(90-120 m) Chenjiawoe (50m) and Congwanling sequence (36 m) of China on unified Quaternary platform tied up and developed at mean sea level. The study revealed that the depth of occurrence of Narmada skull cap on unified Quaternary platform is about (83 m) as compared to with that of Chenjiawo and Gongwangling of China which occur at very shallow depth of 38 and 26 m respectively. The estimated age of Narmada Man based on these parameters is about 1.38 m.y. (+), which is greater than *Homo erectus* of Chenjiawo 0.65 m.y. and Gongwangling 1.15 m.y. of China An Zhisheng and Ho Chuan Kun (1989). On the merits of

correlation of startigraphic columns of Quaternary of Narmada, accumulation of sediment, rate of sedimentation, palaeo- environments, lithostratigraphy and biostratigraphic position of boulder conglomerate in unified Quaternary Platform, author consider it as one of the earliest and oldest *Homo erectus* in Asia. Khan et.al (2013) Khan2016).
The area around Hominid locality of Hathnora area is occupied by thick Quaternary sediments which represent various domain of sedimentation. Based on sedimentological characters, depositional environments, and erosional processess and their correlation with depositional / erosional terraces revealed that quaternary blanket is consisting of three domains of sediments viz glacial, fluvio-glacial and fluvial. The lower most units (Boulder bed) is or glacial origin, the boulder conglomerate of glacio-fluvial (Khan *el. al* 1991) and fluvial terraces are of fluvial paleo- domain of Narmada. The top four formations Sohagpur, Shahganj, Hoshangabad and Janwasa are designated as (NT_o-NT_3). Boulder conglomerate is assigned an independent formational status based on distinct lithology and fossil assemblage. The sequence of Quaternary events and the history of sedimentation of Narmada indicate that the upper 70m top 90m of the Narmada alluvium was deposited in two distinct aggradations episode with a distinct and well defined break in sedimentation in rift system. The dissection of the quaternary blanket resulted two terraces (NT_3-NT_2), after break in sedimentation.The sediments of this aggradations episode constitute three lithostratigraphy units Sohagpur, Shahganj, Hoshangabad formation. The sediments of the alluvial phase are underlain by a boulder bed of glacio-fluvial origin. Thus, the fossiliferous boulder conglomerate, the basal unit of alluvium marks a disconformity between the lower glacial-boulder layer and upper fluvial sediments. The fossiliferous basal boulder conglomerate is being of middle Pleistocene age (Khan 1992).

In India Narmada basin considering the one of a main loci of Quaternary sedimentation, and assuming the uniform accumulation rate of sediment in the basin in the line of Ma. et. al. (1978) Yobin Sun & Zhisheng, An (2005) and comparing the Narmada sequence of Quaternary deposit (325 m.) with those of Luochuan standard sequence of Chenjiawo and Congwangling sequence of China. The skull cap of *Homo erectus* (Narmada Man) recovered from the boulder conglomerate of fluvio-glacial origin in middle part of Quaternary column from deep level of Narmada, at the depth of 83 m. above glacial deposits, in association of ash bed, as compared to Chenjiawo Hominid from inter bedded sequence of paleo sols loess and silty loess at the depth of 38 m. and Congwangling 26 m. from paleo sols which are younger than Narmada deposits.

The Narmada skull cap of *Homo erectu*s which is recovered from the vom of basal unit of boulder conglomerate at the depth of 83 m. (278 m. above m.s.l.) is estimated to be of upper segment of lower Pleistocene age. It is older than the *Homo erectu*s of Chenjiawo, Congwangling of China which were recovered from paleo-sole and loess deposit at the depth of 38 and 26 m. The Quaternary sequence of Narmada (325 m.) as compared to Louchuan (136 m.) sections of China on unified Quaternary platform is older and represents the complete and type sequence of Quaternary sedimentation in Narmada Rift System in Central India. The occurrence of skull cap of early man at the depth of 83 m. in basal unit of boulder conglomerate of fluvio-glacial origin in Narmada Valley is one of the earliest and oldest *Homo erectu*s in Asia.

The skull cap of Narmada Man *Homo erectus* was found in Narmada Valley near village Hathnora (22 ° 52" N; 77 ° 52" E) in fossiliferous boulder conglomerate, in district Sehore, M.P., India. The skull cap is completely fossilized undistorted, renal vault nearly complete except few left Supra-orbital and statures are nicely preserved. The various morphological features and robust form of skull and excessive thickness of the bones indicate that it belongs to adult male individual (Sonakia, 1984). The discovery of skull cap of *Homo erectus* in fossiliferous boulder conglomerate in association of other mammalian fossil is recorded in stratigrphic column of Quaternary deposits at the depth of 83 m , where estimated total thickness of deposits is about (325 m).This blanket consist of sediments of three domain viz. glacial, fluvio-glacial and fluvial, which were deposited in distinct environment during Pleistocene to Holocene time (Khan & Sonakia (1992), (Khan et.al. in press).The statistical analysis of sediments form these different domain in vertical column has been conducted to ascertain the environment of

sedimentation and trace the breaks in climate (Khan et.al. in press). An attempt has been made for the first time Khan et.al (2013) to correlate the various stratigraphic columns of associated hominid fossils of Narmada valley (325 m) India and that of Luochuan sequence,(90-120 m) Chenjiawoe (50m) and Congwanling sequence (36 m) of China on unified Quaternary platform tied up and developed at mean sea level. The study revealed that the depth of occurrence of Narmada skull cap on unified Quaternary platform is about (83 m) as compared to with that of Chenjiawo and Gongwangling of China which occur at very shallow depth of 38 and 26 m respectively. The estimated age of Narmada Man based on these parameters is about 1.38 m.y. (+), which is greater than *Homo erectus* of Chenjiawo 0.65 m.y. and Gongwangling 1.15 m.y. of China An Zhisheng and Ho Chuan Kun (1989).

The time-stratigraphic data obtained from tephra interbedded with fossiliferous Quaternary sedimentary deposits provided an important framework for the study of hominid origins, evolution, adaptations, and cultural changes. The paleoantoological Paleoanthropological information from these localities is remained closely associated with Quaternary sedimentary deposits boulder conglomerate and boulder bed often related to the trench Quaternary sedimentation , formation and development of rift and linear basin caused by repeated uplift, and the development of rift basins that began in the middle to late Pliocene and Pleistocene period. The unfortunate part of theses deposits is that due repeated tectonic dislocation and faulting they are dislocated ad distorted ad at present are concealed under the thick pile of sediments of present and paleo domain of Narmada of late Pleistocene and Holocene time. These deposits do not provide adequate opportunity to researcher to study the human remain as postulated, except in limited section where they are exposed.

In Narmada valley the most of the hominid remains and associated artifacts in the would have been found associated with Miocene Pliocene– Pleistocene sediments of boulder bed and boulder conglomerate in increasing antiquity, unfortunately same are not exposed due rift system and tectonic setting. In the rift system the type development of Quaternary blanket is confined between Jabalpur _Harda section, and Tilakwarda _Bharouch which posses the complete sequence of all three domain in increasing antiquity in chronology in vertical coloumn from the bottom of the rift trench viz Boulder bed (glacial), Boulder conglomerate (fluvio-glacial) sediments of paleo-domain of Narmada (fluvial). The intense tectonic activities within the basins of the Narmada Rift System during the Neogene and Quaternary periods have destroyed fossil record except the fossiferous horizons exposed in river sections. The erosional-sedimentary cycle has persisted in the rift valley environment for millions of years as a result of the interplay between depositional and erosional forces driven by tectonic processes; there are numerous gaps in the fossil record, particularly in the important time period between Mio-Pliocene Pleistocene times. It is pertinent to the understand the origin of Hominid during the late Miocene, but it is difficult to disclose mysteries of human evolution in Narmada due to concealed nature of these deposits in rift system, however the complementary part of Tapti-Purna Quaternary blanket may be potential and possessive of human remain and should be studied to trace further the imprints of fossil man taking in to account of SONATA LINEAMAN ZONE as single ecosystem for evolution of man in Indian subcontinent.

The Hominids skull cap of Sonakia (1984), including other fossil assemblage suggest that the Narmada Rift System created productive ecosystems during Pliocene–Pleistocene time. The volcanic rocks within the fossiliferous sediments provide temporal information for calibrating and sequencing hominid and other faunal evolution. The detailed study geological, sedimentological, geochemical, aspects of interbedded tephra quartz grain morphology of sediments of quaternary strata paleo-sole and geochronological studies of different localities for establishing accurate biostratigraphic and lithostratigraphic data, sedimentation rates pale environmental and tectonic histories of different sediment columns in area along of the rift system, Interbedded volcanic rocks allow determination of the time of rifting, the beginning of sedimentation, sedimentation rates, and the oscillation of rift platform from glacial, fluvio-

glacial lacustrine to fluvial environments. The cyclic environmental transitions recorded in the sedimentary sequences of the rift basins are caused by tectonic activities (uplift and subsidence), changes in relief, and climatic variations. The climatic changes in uplift, topographic and landscape features, coupled with block faulting, rinsing and sinking platform, created basins for the accumulations of thick lacustrine and fluvial sediments sequences with terrestrial and aquatic fossils. The sequential change in the sediment fancies from finely bedded lacustrine deposits to fluvial sediments are commonly noted in the sedimentary sequences and reflect environmental and tectonic changes that can be temporally determined. Moreover, regional correlation based on the chemistry and geochronology of interbedded tephra has made it possible to establish accurate stratigraphic relations that are useful for pale- environment reconstruction and evolutionary studies of fossil remains in the Narmada rift valley Khan et.al. (2013). Regional tephra correlation is being used increasingly to link sites together, and has already established that similar tephra layers are known from other parts of rift valley, as well as from other basin and peninsular India Basu, Biswas, and Acharyya, S.K. (1987): Achariya,(1993), Khan, (1992) Khan et.al. (2013).There is a great potential for further correlation of tephra in the rift system and marine sediments in the Arabian Sea. The Arabian Sea has a continuous record of deposition that extends to at least 7 million years. The Quaternary sediments interbedded with tephra with within the age range of the ODP Ocean Drilling Program 721/722 stratigraphic sections of the Arabian Sea are also present within the rift floor and the western rift margin of the region. The chemical and chronological correlations of ash beds within the rift sequences of have been made with ashes described in marine sections. Detailed correlations based on orbitally calibrated time scales of pale magnetic stratigraphy Rao (1985) within Quaternary sediments of rift deposits will provide ties to establish global climate changes based on the terrestrial and marine sediments of the rift system.

The rift system and platforms of sedimentation bear the imprints of and evidence of the effects of tectonics on fauna and flora are distinct, however the signatures of subsidence dislocation and concealing of fossiliferous horizons are uncontrolled and ill defined in the ecosystem in the valley during the Pliocene–Pleistocene periods. The boulder conglomerate which yielded the skull cap of *Homo eructs* in Narmada rift from Hathnora Sonakia (1984) remained only discovery of hominid fossil in last two and half decade due to concealed and hidden nature of Mio-Pliocene Pleistocene deposits in rift system and inconsistency in exposure of fosilifrous horizon of Narmada rift system which is the handicapp in search of further human remains in Narmada valley after Sonakia (1984).

The Miocene -Pliocene–Pleistocene lake deposit of Katni on the eastern rift shoulder was created by faulting, topographic control, or isostatic depression similar to that of other Rift system. The Narmada flows along seismic tectonically active NSF which forms a fault controlled basin of a huge thickness of Tertiary and Quaternary sediments. The thick blanket of Quaternary sediments occurs in the central part of valley in Jabalpur –Harda section and in Gurudeshwar – Bharouche section in lower of valley; where as in the other part in Harda –Mandleshwar section thin and isolated caps and strips of quaternary sediments are noticed on rock cut terraces and rock benches of country rocks. In Mandleshwar-Barwani, Dhadgaon- Tilakwarda the quaternary deposits are shallow to moderate in thickness and thin out to wards east. The isolated loci of accumulation and sedimentation along the entire length of 1300 kms of Narmada area controlled by the tectonics and structural frame work and sinking and uplift of fault bounded blocks and lineaments. It is well illustrated by neoseismic signatures and imprints on quaternary deposits and landscapes in the valley. The critical analysis of landscape profile evolution of drainage, quaternary terraces, river morphology and analysis of bore hole data of basement configuration of rock and quaternary deposits revealed that Jabalpur-Harda section valley segment suffered mega dislocation and sink to level of about 1150 m as compared to the adjoining blocks and created and has formed open rock basin and platform of quaternary sedimentation. This section display complete record of quaternary deposits of glacial, fluvio- glacial and fluvial sediments in increasing antiquity from the base.

I. Introduction

The Narmada river originates from the Amarkantak plateau of Satpura Ranges in Rewa at an elevation of about 1057 m (220 40' -810 45') flows westerly course for about 1284 kms length across the middle of Indian subcontinent before entering Gulf of Cambay in the Arabian sea near Baroda in Gujarat state. It enters the fertile alluvial plain and passes through the gorge of about 19 kms long consisting of Marble rocks near Jabalpur.It then takes westerly turn through the alluvial tract, situated between the Satpura and Vindhyan hills. The river course of Narmada conspicuously straight and is controlled by ENE_WSW to E_W lineament, is bounded by Vindhyan in the north and Satpura in the south. The valley has maximum width of about 32 kms.

The Quaternary Blanket of Narmada basin covers an area of abut 12950 sq. km starting from west of Jabalpur ($23^0 07^0 790530$) to Bharouch (22^0 29'; 76^0 58') in Gujarat state for a distance of about 1300 km. It is found to be ideal locus of Quaternary sedimentation in Central India as witness by multi-cyclic sequence of Quaternary terraces in the valley. The general elevation of Narmada alluvial plain varies between 265.7 and 274.3 m above the sea level. The general gradient of this plain in this stretch is about 1m /Km towards West.

The Quaternary deposits of the Narmada valley contain the richest vertebrate fossil assemblage including only known Hominid fossil from the Indian sub-continent (Sonakia 1984) The boulder bed which yielded Hominid fossil from boulder conglomerate reported to be of glacial & fluvial origin for first time(Khan & Sonakia 1992). Beside occurrences of association of ash beds with fossileferous boulder conglomerate (Khan & Rahate 1991) Achariya 1993 indicates volcanic source. It appears that close to the completion of cycle of deposition of the boulder bed there was vilolent volcanic eruption in around Middle to uper Pleistocen time and subsequent settled down across the globe and in the pennisular India during the quaternary sedimentation. The occurrences of association of two marked horizons at different levels further revealed the cyclic eruption and settling of volcanic matrix during sedimentation. Khan and Sonakia (1992) reported for the first time glacial and interglacial deposit in the Narmada valley, Central India which is represented by arid and humid cycles. The lithostratigraphy of Narmada valley described by Khan (1984), Khan & Benarjee (1984), Khan & Rahate (1990-91), Khan & Sonakia (1992), Khan *et al* (1991), Rahate & Khan (1985), Khan (1991), Khan & Sonakia (*1992*), Yadav & Khan (1996).

The Quaternary lithostratigraphy and sedimentological aspects were studied and in the Narmada valley (Khan 1984, Khan & Benarjee 1984, Khan & Rahate 1990-91-90 Khan & Sonakia 1992, Khan &*et al* 1991, Rahate & Khan 1985, Khan *et al.* 1991, Khan 1991, Khan *et al.* 1992, Yadav & Khan 1996. The Narmada valley embodied complete sequence of Quaternary deposits from lower Pleistocene to Holocene (Khan & Sonakia (1992). Khan, et.al (1912), Khan (2012) et.al Khan (in press) , Khan (in press),.The results of sedimentological studies Khan (2015), quartz grain morphology, Khan (2014), quartz grain morphology,Palesole Quaternary column section in Hominid locality in central sector of Narmada revealed the presence of complete sequence of quaternary sediments in Narmada rock basin viz Glacial, fluvio-glacial and fluvial domain whereas the boulder conglomerate which has yielded human skull is of fluvio-glacial origin from Khan & Sonakia (1991)

The Quartz grain morphology of sediment column Khan (2014) Quartz grain morphology of different pale- sole, , Khan (2014), Ash bed Khan & Maria (2012) Khan & Maria (1912) Heavy mineral assemblage Khan (2016) tephra stratigraphy, Khan et.al (1991) Acharya, S.K. and Basu, P.K. (1993) Khan etal (2014) Khan & Maria (2015) Ash fall and its impects (2015) Khan (2016) magnetostratigraphy, and bio-stratigraphy and correlation of sediment columns intra valley wise , inter valley wise and on unified Quaternary Platform Khan et.al (2012) focusing on hominid localities of China have been studied on quaternary platformwhich have given new insight on the age of the Narmada *Homo erectus.*

The present an integrated analysis of the stratigraphy of the Quaternary deposits of the Narmada Valley; is based on multiple criteria of morphostratigraphy, soil stratigraphy, tephra stratigraphy, lithological assemblage, biostratigraphy volcanic ash bed and polarity. Based on critical data analysis the stratetigraphy of quaternary deposit of Narmada Valley has been attempted for the first time. The Quaternary alluvial sequence of the Narmada Valley is well known for its rich and diverse mammalian fossil content and Paleolithic tools (Princep, 1833; Splisburry, 1837, 1844, 1883; Falconer, 1859; Theobold, 1860, Lydekker, 1880, 1882, 1884; DeTerra and Patterson, 1939; Khatri, 1961 & 1966; Dassarma, 1979; Badam, 1979; Biswas and Dassarma, 1981; Khan and Sonakia, 1992). It further gained prominence with the find of skull cap of Homo erectus (Sonakia 1984) and volcanic ash beds (Khan et.al 1984 & Khan et.al 1992, Basu et. al. 1987).Based on analysis of multiple thematic data the stratigraphic classifications are summarized in (Table No QGT_3,6,& 7).(Plate No_1,2,3)

Previous Work

The Narmada valley received adequate attention of Earth scientist after recovery of Human skull from Quaternary deposits of Hathnora sonakia (1984) accordingly Quaternary deposits and its geomorphological aspects have been studied in detailed in last three decade and data base of various aspects has been updated (Khan 1984, Khan & Benarjee 1984, Khan & Rahate 1990-91-90 Khan & Sonakia 1992, Khan &*et al* 1991, Rahate & Khan 1985, Khan *et al.* 1991, Khan 1991, Khan *et al.* 1992, Yadav & Khan 1996. The Narmada valley embodied almost complete sequaence of Quaternary deposits in time span from the lower Pleistocene to Holocene (Khan & Sonakia (1992). Khan (1912), Khan (2012), Khan et.al (2013) Khan et.al (2014), Khan (2015), Khan et.al (2015) Khan .etal. (2015) .The results of sedimentological studies Khan (2015), in recent years, Quatenary tectonics & sedimentation, geomorphphic evolution have also been attemepted of Narmada Valley Khan et.al (1916), Khan et.al (1916). The study of geomorphology of Quaternary column and area of Hominid locality Hathnora has further supplemented data on evolution of the area Khan et.al (1916) in central sector of Narmada.The sediment statistics and sedimentology of in vertical coloumn (320) , revealed the presence of complete sequence of quaternary sediments in Narmada rock basin which comprise of sediments of viz Glacial, fluvio-glacial ad fluvial domain wheras the boulder conglomerate which has yielded human skull which is of fluvio-glacial origin Khan & Sonakia (1991) Khan et.al (2016) Khan et.al (1991) Khan & Maria (1912) bio-stratigraphy aspects and correlatied sediment of Quaternary columns of hominid locality on unified Quaternary Platform Khan et.al (2012) focusing on hominid localities of China these deposits have thrown new light on the age of the Narmada *Homo erectus*.

Present work

The present work is telefocus on study the varios aspsects of geomorphology and geomorphic veolution, Quaternary tectonics and sedimentation of Narmada valley in Jabalpur _ Bharouch Section with special reference to Hominid locality Hathnora and occurrence fossil man.The Narmada valley embodies two prominent Quaternary landscape viz in Jabalpur_Harda section in central Sector and Gurudeshwar_Bharouch Section in lower Sector which was found to be ideal locus of sediment accumulation and Quaternary sedimentation as witnessed by multi-cyclic sequence of Quaternary terraces in the valley. The study of Quaternary landscape revealed that it has been posed to the repeated post erosional & depositional activities and subjected to anisotropic and asymmetric tectonic dislocation which has culminated diversified manifestation, it is further undergone to process of tectonic evolution and chiseling of rift valley by dynamic erosional and depositional activity resulting in reshaping of the terrain into various multi morphogenetic illustration. The delineation and reorganization of different units and land form element, sequential and renewed configuration of drainage, topography, physiography,plantation surfaces, denudation ridges, structural linear valleys, strike hills, valley gapes, escarpments and river terraces

revealed that area has uudergone multicylic erosion and deposition unerfrequential change tectonic set up in recent past.. The cumulative and cyclic deviation of concealed dynamics and structural deformation of unstable platform of Narmada further added with hidden cyclic mechanism of tectonics, geothermic, seismicity has chiseled surface and subsurface both quaternary & pre-quaternary landscape in to present composit expression which defines evolution of basin by imprints of neotectonisam identified by various signatures on landscape profile in the valley.In present paper the quaternary & pre-quaternary landscape its architech expression tectonics & noetectonics subsidence and uplift of fault bound blocks, platform of sedimentation, morphotectonics, impact of tectonics, channel morphology and river terraces have been studied and correlated with erosional cycles & geomorphic eventsin Narmada valley (Plate No _2 &_3).

II. Geology

The Narmada basin is occupied by different of geological formations. The geological succession of these rocks is incorporated in table.

Table No_1

Age	Group	Rock formation
Recent Quaternary	Alluvial Plains (Older and Newer Alluvium)	Unconsolidated sand, silt, clay.
Eocene Cretaceous	Deccan Trap Bagh and Lameta beds	Basalt Sandstone, Cherty Limestone
CretaceousPaleozoic	Gondwana Super Group : Jabalpur, Mahadeva	Boulder beds Sandstone, Shale, Clay, Limestone,CoalSeams
Pre Cambrian (Proterozoic)	Vindhyan Super Group : Bhander, Rewa, Kaimur, Semri. Bijawar Group Mahakoshal Group	Shale, Sandstone, Limestone porphyrtic granite , Quartz veain, and basic dykes Gneisses, phyllites, Chert and mete basics
Archaeans		Quartzites, Granites, Phyllites, Schists

III. Pleistocene sedimentation

The Narmada Rift valley formed a linear trench in the middle of Indian subcontinent was an ideal loci for accumulation of sediments .The rift trench is intruded by the dolerite and other mafic and siliceous dykes and sills along lineaments in different phases of tectonic deformation. The Quaternary sedimentation incepting from glacial activity, followed by fluvio-glacial, lacustrine and fluvial phase within the rinsing and sinking environment, block faulting and segmental and linear displacement and dislocation, uplifting and isolated domal up- lift, Neogene rifting and Quaternary sedimentation and rift-bound Pliocene–Pleistocene rifting and volcanic activity specifically during glacial and fluvio-glacial phase are major component of the Quaternary period and tectonic processes of the Narmada Rift System and form the base of quaternary deposits . The conspicuous ENE-WSW to E-W rift basin zone is filled with Pliocene–Pleistocene sediments, whereas some of them contain Miocene sedimentary deposits. The Narmada Rift System, bounded by adjacent plateaus rising 300–700 m above the rift floor, consists of number symmetrical and symmetrical faulted blocks, escarpment, rock cut terraces, rock floors and segments of micro half grabben. Although rift-related basins started to form during the late Oligocene to early Miocene times, the Narmada Rifts were fully defined by middle to late Miocene time.

The Miocene -Pliocene–Pleistocene lake deposit of Katni on the eastern rift shoulder was created by faulting, topographic control, or isostatic depression similar to that of other Rift system. The skull cap of *homo-eructus* Sonakia (1984), suggest that the Narmada Rift System created productive ecosystems during Pliocene–Pleistocene time. The volcanic rocks within the fossiliferous sediments provide temporal information for calibrating and sequencing hominid and other faunal evolution. The detailed geological sedimentological geochemical of interbedded tephra ,Quartz grain morphology of sediments of quaternary strata and palo-sole of and geochronological studies of from the different localities for establishing accurate biostratigraphic and lithostratigraphic data, sedimentation rates, and paleoenvironmental and tectonic histories of different sediment columns in area along the rift system. Interbedded volcanic rocks allow determination of the time of rifting, the beginning of sedimentation, sedimentation rates, and the oscillation from glacial, fluvio-glacial lacustrine to fluvial environments. The cyclic environmental transitions recorded in the sedimentary sequences of the rift basins are caused by tectonic activities (uplift and subsidence), changes in relief, and climatic variations. The climatic changes in uplift, topographic and landscape features, coupled with block faulting, rinsing and sinking platform, created basins for the accumulations of thick lacustrine and fluvial sediments sequences with terrestrial and aquatic fossils. The sequential change in the sediment fancies from finely bedded lacustrine deposits to fluvial sediments are commonly noted in the sedimentary sequences and reflect environmental and tectonic changes that can be temporally determined. Moreover, regional correlation based on the chemistry and geochronology of interbedded tephra has made it possible to establish accurate stratigraphic relations that are useful for pale- environment reconstruction and evolutionary studies of fossil remains in the Narmada rift valley Khan et.al. (2012). Regional tephra correlation is being used increasingly to link sites together, and has already established that similar tephra layers are known from other parts of rift valley, as well as from other basin and peninsular India Achariya,(1995), Khan (1992) Khan et.al. (2012) Tiwari (1996). There is a great potential for further correlation of tephra in the Rift System and marine sediments in the Arabian Sea. The Arabian Sea has a continuous record of deposition that extends to at least 7 million years. The Quaternary sediments interbedded with tephra with within the age range of the ODP Ocean Drilling Program 721/722 stratigraphic sections of the Arabian Sea are also present within the rift floor and the western rift margin of the region. The chemical and chronological correlations of ash beds within the rift sequences of have been made with ashes described in marine sections. Detailed correlations based on orbitally calibrated time scales of pale magnetic stratigraphy Rao (1996) within Quaternary sediments of rift deposits will provide ties to establish global climate changes based on the terrestrial and marine sediments of the rift system.

Moreover, because of tephra layers in sedimentary basins of different geologic periods, processes such as faulting, rifting, sedimentation and digenesis, impact of climatic changes, age of fossils, nature and acquisition of archeological implements, and the origin, distribution, and functional significance of early hominid artifact assemblages can be deciphered. However, evidence of the effects of tectonics on fauna and flora are distinct and its signatures on dislocation and concealing of fossiliferous horizons are uncontrolled and ill defined in the ecosystem in the valley during the Pliocene–Pleistocene periods. The boulder conglomerate which yielded the skull cap of *Homo erectus* in Narmada rift from Hathnora Sonakia (1984) remained only discovery of hominid fossil in last two and half decade due inconsistency concealed nature of fosilifrous horizon due faulting, dislocation and subsidence of Quaternary blanket of Narmada rift system as such researcher and scientist failed to add any further knowledge to hominid discovery any further.

Moreover, because of tephra layers in sedimentary basins of different geologic periods, processes such as faulting, rifting, sedimentation and diagenesis, impact of climatic changes, age of fossils, nature and acquisition of archeological implements, and

the origin, distribution, and functional significance of early hominid artifact assemblages can be deciphered. However, evidence of the effects of tectonics o fauna and flora are distinct and its signatures o dislocation and concealing of fossiliferous horizons are uncontrolled ad ill defined and the ecosystem in the rift system during the Pliocene–Pleistocene periods is not clear.The boulder conglomerate which yielded the skull cap of *Homo eructs* in Narmada rift from Hathnora remained only discovery of hominid fossil in last two and half decade due inconsistency concealed nature of fosilifrous horizon in Narmada valley. Historical or modern analogs illustrate the potential of the regional and sometimes global effects of such major silicic eruptions in the geologic past of sedimentation, sedimentation rates, and the oscillation from lacustrine to fluvial environments. The cyclic environmental transitions recorded in the sedimentary sequences of the rift basins are caused by tectonic activities (uplift and subsidence), changes in relief, and climatic variations. Changes in topographic features, coupled with volcanic damming, created basins for the accumulations of thick glacial, fluvio-glacial lacustrine and fluvial sequences with terrestrial and aquatic fossils. Changes from finely bedded lacustrine deposits to fluvial sediments are commonly noted in the sedimentary sequences and reflect environmental and tectonic changes that can be temporally determined. Moreover, regional correlation based on the chemistry and geochronology of interbedded tephra has made it possible to establish accurate stratigraphic relations that are useful for pale environment reconstruction and evolutionary studies of fossil remains in the rift valleys across India sub continent Regional tephra correlation is being used increasingly to link sites together, and has already established that similar tephra layers fro known area in Rift system.

The Boulder Bed and Boulder conglomerate which form the base of Quaternary sediments in Central sector of armada Rift Valley are not exposed in the lower Narmada valley. These deposits are concealed under the sediments of lacustrine and fluvial deposits in the valley. The presence of these deposits is confirmed by study of bore hole data and logs of State ad Federal agencies drill in lower Narmada valley under various projects.The boulder bed is diffrentiated in Hominid locality by extensive an intensive statistical analysis of sediment collected from bore hole logs for grain size parameters heavy mineral study quartz grain morphology of sediments and plaosole which have assited in identifying the sedimentological breaks in increasing antiquity in vertical coloumns and their correlation in other sections of Narmada Rift valley.

Early to Late Pleistocene phase

In the Narmada valley the River terraces (NT-1 NT-2) which represents sediments of Bharuch ad Tilakarda formation date back to the Late Pleistocene. The sedimentation commenced with the deposition of the marine basal clays during the last interglacial high sea level at f125 ka, which is presumed to be about + 7 m as revealed by the studies Regression of this sea led to the initiation of fluvial sedimentation. The fluvial sediments were deposited in to two phases of sedimentation with a sharp break marked by tectonic changes and related climatic changes. The fluvial flood plain deposit of Bharuch formation overlies the marine clays followed by the fluvial flood plain deposit of Tilakwarda formation. The sequence of these to formation is exposed in the cliff section which represents different sediment facies typical of fluvial environments .The sequence of sediments display imprints of compressive tectonic regimes of sedimentation. The southern margin of lower Narmada is marked by Narmada–Son Fault, the transformation of this geofracture in Tertiary to reverse fault in Quaternary is implicit in the seismic studies of the area (Roy, 1990). Additional evidence for prevalence of compressive stress regime in the lower Narmada basin is provided by numerous reverse faults (Fig. 2B) in the Neogene sediments exposed immediately to the south of Narmada–Son Fault (Agarwal, 1986). These evidences suggest that the sediments of both the formation were formed in a compressive tectonic environment. There are evidences of subsidence of basin which has been documented on landscape of basin which are authenticated by other studies exist from adjacent area of

synsedimentary subsidence on alluvial plain sedimentation (Shuster and Steidtmann, 1987; Brown and Plint, 1994; Kraus and Middleton, 1987; Kraus, 1992; Jordan, 1981; Hagen et al., 1985).

Absence of soil profiles in the thick blanket of Quaternary sediments of the study area is indicative of synsedimentary subsidence of the basin.. It is unlikely that a high sinuosity channel will produce stacked system of fluvial deposits showing these aracteristics (Shuster and Steidtmann, 1987). Deformations in these sediments of the types described above are the direct manifestations of this subsidence. Strong similarity of the structural orientations of the deformation structures suggests subsidence in a thrusting environment along the NSF which is consistent with the subsurface studies. It is inferred a low sinuosity and relatively fixed river system in a slowly subsiding basin for the deposition of these sediments.Synsedimentary subsidence of the basin due to differential movement along the NSF is indicated by entrenched meander thick overbank sediments and the deformation structures. Folding and faults with reverse movement in the overbank sediments suggest a compressive stress regime along the NSF. A brief period of tectonic stability followed as suggested by the 4–5-m thick palaeosol (red soil), which is stratigraphically correlatable with the red soil exposed in the Mahi and Sabarmati river basins of Gujarat alluvial plains.

The physiographic set up and drainage configuration of the Narmada the area of study demonstrate strong influence of tectonic and structure on development ad evolution of drainage. The Narmada enters in the area around Garudeshwar descends NW –SE direction cutting across NSA entering the quaternary tract. It further down stream of Tilakarda swing towards west and suddenly become slow and sluggish and sinuous to meandering in channel pattern long the northern edge of upland ad ultimately debouches in the Gulf of Cambay. The disposition and convergence of drainage net in conformity of disposition of quaternary landscape demonstrates is anomalous further imprints and neosiesmic signatures on landscape profile reveled persistent instability of basin during sedimentation.

The tectonic uplift of the lower Narmada valley during the Early and Late Holocene suggests inversion of an earlier subsiding basin. Such inversions of the basin have been common in the Tertiary times and are well recorded in the sediments of that age (Roy, 1990). A symmetric convergence of the NT-1,NT-2 terraces , diagonal disposition of paired equivalent of terraces across the channel , divergent and linear disposition of cliff of NT-3 terrace in conformity of NSF constant subsidence of basin and in response to frequential movement and geotectonic activity along the NSF. The displaced Late Pleistocene sediments across NSF in the Narmada and Orsang Heran and Madhumati & Karjan valleys, the NNW tilting of the NT-1, NT-2 sediments litho units consisting of the Late Pleistocene sequence, the anomalous topographic slope in the same direction and the incised cliffs up to 25–30 m in the streams that flow along this slope in the area between NSF and the Narmada River ,indicate unsynchronized neoseismic movements along the NSF during the Early Holocene. The displacement of sediments of NT-1 surface across the NSF indicates differential movement of about 35 m along the NSF during Early Holocene. The block between the Narmada and Karjan rivers bounded by the NSF and the two other cross-faults suffered subsidence leading to the formation of a series, linear and curvilinear cuts of on terraces and flood plains. The 5–8-m incised cliffs of the streams also suggest that this block escaped the uplift induced large scale incision going on simultaneously in other areas of the lower Narmada valley. The occurrence of ravines and association of deep gullies with the river terraces is morph-tectonic manifestation caused by the sudden vertical movement and block adjustment due subsidence resulting to sudden collapse of water table and ground water regime in the area. The strongest supporting evidence for the Early Holocene tectonic uplift of the area comes from the sea-level curves of the west coast of India which suggest a tectonic component of about 40 m at this time (Rao et al., 1996).

Middle Holocene - Recent phase

In the Lower Narmada valley the Mid–Late Holocene Quaternary valley deposits is the

product of a Holocene high sea-level-induced deposition in a deeply incised valley trench trough highly influenced by NSF. The Mid–Late Holocene which resulted in both estuarine ad fluvial sedimentation in the lower reaches. A significant slowing down of tectonic uplift facilitated the encroachment of the sea into the valley and the creation of a depositional wedge, which extended up to the deep in land foothills. The 5–10-m exposed thickness of the valley-fill sediments reveals tide dominated estuarine deposition in the lower reaches and fluvial deposition upstream of the tide reach. The pre-existing quaternary platform of NT-3 of middle Pleistocene prior to induced sedimentation of tidal transgression was strongly induced by tectonic impulses of NSF. The relative disposition of terraces,(NT-2 NT-3 cliff alluvial bluff and scarp , reveals that the present mouth of the Narmada river has retained roughly the originally funnel shape of the estuary formed during the Mid–Late Holocene. However, the size of the estuary is now considerably reduced in space and time with sedimentation and t compressive tectonic environment.

The incursion and transgression of tides, present estuarine reach contains several islands, which are coeval with the terrace surface above the present tidal range. Hence, they are the products of estuarine processes of the Mid–Late Holocene and not those of the present day. Funnel shaped morphology and increasing tidal energy landward are characteristics of tide-dominated estuaries (Wright et al., 1973). Existing data suggest that the Mid–Late Holocene sea level has remained at the same level up to the present with minor fluctuations (Chappel and Shackleton, 1986; Hashimi et al., 1995). The Mid–Late Holocene sediments show tilting of 10–20j which is more pronounced in the vicinity of the NSF suggesting that the incision and uplift of the valley-fill terraces well above the present day tidal limits is related to the continued differential uplift along NSF. Evidence of tectonic uplift has been reported from the coast also in the form of raised mudflats occurring 2–4 m above present sea level (Merh, 1993). Currently, the river occupies the northern margin of the Early Holocene channel belt and is clearly more sinuous. It exhibits a narrow channel with wide meanders inside wide belts of Mid–Late Holocene terraces (NT-3) a typical pattern of under fit streams (Dury, 1970).

In the Narmada valley the River terraces (NT-3) has occupied large area on the both bank of Narmada. It extends from Orsang river in the north east to Mahi river in the west from Baroda in the north to Bharuch – Aliabet in the southwest. In the southern bank of Narmada it is developed alround Ankleshwar and Rajpipla and further south. The average elevation of this surface is about 75 m above m.s.l, separated by both linear and curvilinear scarp from NT-2. The average height of cliff is about 40 m. The sediments comprised of this terrace are exposed in the cliff section. The oldest deposit of the exposed sediment successions a highly pedogenised mottled clay horizon showing vertisolic characters like extensive fracturing giving rise to blocky aggregates, seudo anticlines and hydro plastic slickenside along the fracture surfaces. .The sediments of this terrace are associated with a rich assemblage of shallow marine foraminifers. The basal unit consisting of rock pebbles with clays is overlain by thick fluvial sediments, which comprise alluvial plain facies. The pebbly unit which contains rock fragments of quartzite, granite basalt, and limestone sandstone is about 5.5.m thick, it is a persistent horizon and exposed in the cliff section. It is marker horizon, represent distinct phase of sedimentation in the valley. In the Narmada valley the River terraces (NT-3) which represent sediments of Ankleshwar formation. The fluvial sediments indicate deposition in single phase of fluvial sedimentation with a sharp break marked by tectonic changes and related climatic changes. The sequence of this formation is exposed in the cliff section, is marked by the major break in sedimtation as witnessed by the occurrence of persist pebble horizon at the base .This formation represent different sediment facies typical of fluvial environments .The sequence of sediments display imprints of compressive tectonic regimes on sedimentation. In the lower Narmada Valley alluvial fan as identified between Tilakwarda and Rajpipla within the loop of Narmada is mono

illustration of morphogenetic process ad morph tectonic =manifestation associated with neotectonic event. The disposition of Quaternary blanket, fan deposit and other quaternary land forms are controlled and restricted by SONATA LINEAMENT. The convergence of fan deposits and its apex is not in persistence and in conformity of piedmont sedimentation further it is devoid of torrential stream net work and environment which firmly rule out to be endogenetic genetics of fan deposits The present study of these deposits its disposition its composition indicate that these deposits are older deposits and brought to the present position by tectonic activity along SONATA LINEAMENT.

The boulder bed is diffrentiated in Hominid locality by extensive an intensive statistical analysis of sediment collected from bore hole logs for grain size parameters heavy mineral study quartz grain morphology of sediments and plaosole which have assited in identifying the sedimentological breaks in increasing antiquity in vertical coloumns and their correlation in other sections of Narmada Rift valley. The sediments of paleo-domain of Narmada conformably overlie the boulder conglomerate and represent the flood-plain fluvial facies of the Narmada. The sediments of the fancies predominantly consist of clay silt and sand, discontinuous nodules and plates. The beds are horizontal, exhibit upward fining sequence typical of fluviatile deposits .This domain may be divided into three formations based on lithology, sediment assemblage, shape and size of rock clastics, relative disposition and diagnostic sedimentary characteristics. These formations are, viz. (i) Shohagpur, (ii) Shahganj, and (iii) Hoshangabad Formations respectively. These formations represent the sediments the complete sequence of Narmad\a deposited in channel and flood plin environments during Upper Pleistocene time. (Plate No _4_9 to_17)

IV. Geological Sequence of Quaternary Deposits of Narmada Valley

Quaternary Geology

The Narmada Rift valley formed a linear trench in the middle of Indian subcontinent was an ideal locus for accumulation of sediments. The rift trench is intruded by the dolerite and other mafic and siliceous dykes and sills along lineaments in different phases of tectonic deformation. The Quaternary sedimentation incepting from glacial activity, followed by fluvial-glacial, lacustrine and fluvial phase within the rinsing and sinking environment, block faulting and segmental and linear displacement. The instability of turmoil sedimentation platform, dislocation, uplifting and isolated domal up- lift, Neogene rifting, sedimentation and rift-bound Pliocene–Pleistocene rifting and volcanic activity specifically during glacial and fluvial-glacial phase are major component of the Quaternary period and tectonic processes of the Narmada Rift System which form the base of quaternary deposits. The rift system and basin platform provided a unique setting for dynamic ecosystems that were characterized by rift-related subsidence and coeval sedimentation created an ideal ecology and loci of Quaternary sedimentation and environment for the accumulation of sediments. The disposition of quaternary deposits, drainage configuration basin boundary and geotectonic of the area revealed that rifts was formed after widespread Quaternary sedimentation occurred and voluminous sediments in the rift basins were accumulated by glacial activity, it is also witnessed by present disposition of quaternary blankets of SONATA LINEAMENT ZONE.

The Narmada valley consists of sediments of three domains viz glacial, fluvio-glacial and sediment of paleo-domain of Narmada.

The glacial and fluvio-glacial deposits of Narmada unconformable overly the Vindhyan and the basaltic Deccan Trap rocks. The sediments consist of a Hetero-heterogeneous assemblage of sub-angular to angular, sub-rounded, unsorted, stratifiedrock fragments ranging from boulders to small pebbles, predominantly of quartzite, gneiss, sandstone, basalt, jasper, chart, gneiss, sandstone, basalt, chart, altered feldspar, ferruginous nodules, in a matrix of very coarse to very fine-sand, silt and clay. These clastics are highly angular, generally poorly sorted and isotropically imprecated. Fine sediments comprise of reddish grayish

and greenish sand with appreciable amount of mica flaks, altered feldspar, brick-red and buff silt, greenish-brown silt and clay, and greenish, reddish and dark maroon hard and plastic clay. These fine sediments contain fairly good amount of ferruginous material, quartz, mica flakes and altered feldspar grain. Through these sediments are similar in composition to the other deposits of Narmada Valley, exhibit entirely different sedimentary pattern, sediment characters and mineral composition. These rock clastics are largely angular, very poorly sorted and demonstrate isotropic imbrications pattern in the valley. The sediments of glacial domain of Narmada occur between and average elevation of about 20-265 m above m.s.l. and were deposited in glacial environments during Pleistocene time. These deposits are concealed under boulder conglomerate in the valley.

The Fluvio-glacial deposits are represented by conglomerate bed that constituted the fossiliferous horizon of Narmada is sandwiched between older Alluvium and the glacio-fluvial bounder bed. This conglomerate bed is a very persistent marked horizon indicating a distance phase of sedimentation in the Narmada Valley. The boulder conglomerate predominantly consists of sub-rounded to well rounded boulder, cobble and pebble of quartzite, gneiss, sandstone, basalt, agate, jasper, chert, chalcedony tightly cemented in a matrix of sand and silt. The finer sediments include different grade of sand and silt, brown and maroon in color often laminated and cross laminated. The boulder conglomerate is fossil and skull cap of early man *Homo erectus* (Sonakia, 1984)

The boulder conglomerate consists of three sub-litho units; each sub-unit characterized by distinct rock fragment shape, size, lithological abundance and allied sediment characters. The sub-units are composed of variable assemblage of quartzite, gneiss, basalt, sandstone, agate, jasper, chalcedony, chart, sand and silt (Khan1992) These sub-litho units display fancies variation in the valley and upper units grades into gritty sandstone upstream of Hathnora

The Fluvial sediments of paleo-domain of Narmada conformably overlie the boulder conglomerate and represent the flood-plain fluvial facies of the Narmada. The sediments of the fancies predominantly consist of clay silt and sand, discontinuous nodules and plates. The beds are horizontal, exhibit upward fining sequence typical of fluviatile deposits .This domain may be divided divided into three formations based on lithology, sediment assemblage, shape and size of rock clastics, relative disposition and diagnostic sedimentary characteristics. These formations are, viz. (i) Shohagpur, (ii) Shahganj, and (iii) Hoshangabad Formations respectively. These formations represent the sediments the complete sequence of Narmada deposited in channel and flood plain environments during Upper Pleistocene times.It consists of sediments of paleo-domain of Narmada. It is represented by a thick sequence of clay, silt-sand and rock gravels. The unit is divisible into three sub litho unit. The basal sub-unit is chiefly red and brownish sand, silt, clay containing appreciable amount of cal matrix. The average measured thickness of this sub-unit is about 6.25m. The middle sub-unit consists of yellow and brownish silt, clay with subordinate sand and occasional rock gravel lenses. The average measured thickness of this sub-unit is about 5.50m. The upper sub-units predominantly consist of compact yellow clay, silt and calcareous concretion. The average measured thickness of this sub-unit is about 3.25m.

The sediments of fluvial domain of Narmada identified between an elevations of 268 to 350 m above m.s.l. and were deposited in channel and flood plain environments during upper Pleistocene lime. The sequence of Quaternary events and the history of sedimentation of Narmada indicate that the upper 70m top 90m of the Narmada alluvium was deposited in a single aggradations episode with minor pauses when dissection of the alluvium produced two terraces (NT_3-NT_2). The sediments of this aggradations episode constitute three lithostratigraphy units viz. Boulder conglomerate, Sohagpur and Shahganj formation. The sediments of the alluvial phase are underlain by a boulder bed of glaciao-fluvial origin. Thus, the fossiliferous boulder conglomerate, the basal

unit of alluvium marks a disconformity between the lower glacial-boulder layer and upper fluvial sediments. The fossiliferous basal boulder conglomerate is being of middle Pleistocene age (Khan 1992)

The sediments of present domain of Narmada is represented by sediments of active flood plain, point bar and sand bar facies of present domain and consist of unconsolidated imbricated, stratified, polygonal sorted rock-gravel supported by very coarse to very fine-sand and is named as Janwasa formation, after the village Janwasa where is it best developed. The measured thickness in the valley is about 5m.

i. Boulder Bed (Glacial/Fluvial-glacial deposits)

The glacial and fluvio-glacial deposits of Narmada unconformable overly the Vindhyan and the basaltic Deccan Trap rocks. The sediments consist of a Hetero-heterogeneous assemblage of sub-angular to angular, sub-rounded, unsorted, stratifiedrock fragments ranging from boulders to small pebbles, predominantly of quartzite, gneiss, sandstone, basalt, jasper, chart, gneiss, sandstone, basalt, chart, altered feldspar, ferruginous nodules, in a matrix of very coarse to very fine-sand, silt and clay. These clastics are highly angular, generally poorly sorted and isotropically imprecated. Fine sediments comprise of reddish grayish and greenish sand with appreciable amount of mica flaks, altered feldspar, brick-red and buff silt, greenish-brown silt and clay, and greenish, reddish and dark maroon hard and plastic clay. These fine sediments contain fairly good amount of ferruginous material, quartz, mica flakes and altered feldspar grain. Through these sediments are similar in composition to the other deposits of Narmada Valley, exhibit entirely different sedimentary pattern, sediment characters and mineral composition. These rock clastics are largely angular, very poorly sorted and demonstrate isotropic imbrications pattern in the valley. The sediments of glacial domain of Narmada occur between and average elevation of about 20-265 m above m.s.l. and were deposited in glacial environments during Pleistocene time. These deposits are concealed under boulder conglomerate in the valley.

ii. Boulder Conglomerate (Fluvio-glacial deposits)

The Vindhyan Group of rocks and Deccan Trap in the Central sector of the Narmada Valley form the basement for the Quaternary deposits. The conglomerate bed that constituted the fossiliferous horizon of Narmada is sandwiched between older Alluvium and the glacio-fluvial bounder bed. This conglomerate bed is a very persistent marked horizon indicating a distance phase of sedimentation in the Narmada Valley. It is exposed in the bluff/scrap of Narmada around Sardar Nager, Hathnora, Surajgarh, Budhni, Hoshangabad, Khoksa, Tigharia, Demawar and Bhariya-Ghat at the base of terraces NT_2 (Khan, 1984). The measured thickness of the exposed boulder conglomerate varies from 1.5 to 6.5m but average 5m.

The boulder conglomerate predominantly consists of sub-rounded to well rounded boulder, cobble and pebble of quartzite, gneiss, sandstone, basalt, agate, jasper, chert, chalcedony tightly cemented in a matrix of sand and silt. The finer sediments include different grade of sand and silt, brown and maroon in color often laminated and cross laminated. The boulder conglomerate is fossil and skull cap of early man *Homo erectus* (Sonakia, 1984)

The boulder conglomerate consists of three sub-litho units; each sub-unit characterized by distinct rock fragment shape, size, lithological abundance and allied sediment characters. The sub-units are composed of variable assemblage of quartzite, gneiss, basalt, sandstone, agate, jasper, chalcedony, chart, sand and silt (Khan1992) These sub-litho units display fancies variation in the valley and upper units grades into gritty sandstone upstream of Hathnora

The basal unit of boulder conglomerate and is characterized by sub-rounded to rounded boulders cobbles, pebble of quartzite (38.50%), gneiss (18.50%) sandstone (14.50%), basalt (6.50%), agate and other rock fragments (3.50%). These clastic are

tightly cemented in a reddish brown and maroon sand and silt which exhibit lamination, cross-lamination and cut and fill feature. It is capped by a pebbly layer containing vertebrate fossils and a human skull of early man (Sonakia, 1984). The average measured thickness of this layer is about 2.25m.

The middle sub-unit of boulder conglomerate characterized by an abundance of spherical, discoidal and bladed cobbles, pebbles of quartzite (31.50%), gneiss (14.00%), jasper (8.50%), sandstone (15.00%), basalt (10.50%), agate (12.50%), chart (6.50%) and other rock fragments chart (1.50%). These coarse clasitic are tightly cemented by a deep brown and maroon sand, silt and clay. The finer clastics display sedimentary feature like lamination, cross-bedding load structure, small ripples and, cut and fill feature. Out of this sedimentary structure the cross bed units of boulder conglomerate vary from 5.15^{o} and average about is 8.5^{o}. The cross-beds average is often truncated by a pebbly layer at the top. This sub-unit contents mammalian fossil and some stone implements. The average measured thickness of these sub-units is about.

The upper sub-units of the boulder conglomerate. It consists of sub-rounded to well-rounded pebble of quartz (23.50%), gneiss (11.50%), sandstone (14.50%), basalt (13.50%), agate (15.50%), jasper (11.50%), chart (8.00%) and other rock fragments (2.00%). These clastics are commented by grey and brownish sand and silt containing appreciable amount of calcareous matrix.

These deposits identified between an average elevations of 245 to 300 m above m.s.l. the basal unit of boulder conglomerate identified is marked at an elevation of about 268 m above m.s.l, exposed on the northern bank of Narmada around Hathnora (22° 52" N - 77° 52" E) at the depth of about 83 m in stratigraphic column of Quaternary sediments of Narmada.

The boulder conglomerate is of middle Pleistocene age equivalent to Siwalik boulder conglomerate (India), Trinil bed of Java (Indonesia) and boulder conglomerate of Tapti (Khan. These deposits have yielded skull cap of early man, Homo erectus Narmadensis along with other mammalian fossils (Sonakia, 1984). The Ash bed of Quaternary age is recorded associated with these deposits around Timrawan upstream of Hathnora is of aeolian nature and perhaps indicates volcanic activity during middle Pleistocene time.

iii. Fluvial deposits
(Flood plain deposit of paleo domain of Narmada

The sediments of paleo-domain of Narmada conformably overlie the boulder conglomerate and represent the flood-plain fluvial facies of the Narmada. The sediments of the fancies predominantly consist of clay silt and sand, discontinuous nodules and plates. The beds are horizontal, exhibit upward fining sequence typical of fluviatile deposits .This domain may be divided divided into three formations based on lithology, sediment assemblage, shape and size of rock clastics, relative disposition and diagnostic sedimentary characteristics. These formations are, viz. (i) Shohagpur, (ii) Shahganj, and (iii) Hoshangabad Formations respectively. These formations represent the sediments the complete sequence of Narmada deposited in channel and flood plain environments during Upper Pleistocene times. The lowest Sohagpur Formation is named after Sohagpur town. The unit occurs along the outer flanks of Narmada Valley bounded by Vindhyachal range to the north and Satpura to the south. It consists of sediments of paleo-domain of Narmada. It is represented by a thick sequence of clay, silt-sand and rock gravels. The unit is divisible into three sub litho unit. The basal sub-unit is chiefly red and brownish sand, silt, clay containing appreciable amount of cal matrix. The average measured thickness of this sub-unit is about 6.25m. The middle sub-unit consists of yellow and brownish silt, clay with subordinate sand and occasional rock gravel lenses. The average measured thickness of this sub-unit is about 5.50m. The upper sub-units predominantly consist of compact yellow clay, silt and calcareous concretion. The average measured thickness of this sub-unit is about 3.25m.

The Sohagpur formation is often association with discontinues and persistent pebbly horizon containing well sorted polymodal gravel of quartzite, gneiss, basalt, agate, jasper and chart in the matrix of course to fine-sand. The gravel is general discoidal, spherical and exhibits higher indices of sphericity and roundness indicating their derivation from distance and mixed provenance during sedimentation.

The Shahganj formation is forms litho-stratigraphic unit overlying boulder conglomerate and occupies large area in the central part of the valley. It is exposed in the bluff section of Narmada around Narayanpur, Sardarnagar, Hathnora, Shahganj and Hoshangabad. This formation is equivalent to the Shivpur formation described by Khan (1984) from the down stream of Hoshangabad. It consists of sediments of palaeo-domain of Narmada. It is represented by clay, silt, sand accompanied by inconsistent pebbliferous bed containing quartzite, gneiss, basalt, chart, agate. The average measured thickness of this formation is about 15m. These sediments constitution three units each characterized by distinct lithology, rock classics and diagnostic sediment characters.
The Hoshangabad is the younger formation of the Narmada and is represented by the flood plain fancies. It forms a distinct morphostratigraphy unit; above the present day flood plain of Narmada. It is crescent-shaped and is confined within the meander looped of the Narmada. This formation comprises three units. The basal unit predominantly consists of rock gravels of quartzite, gneiss, basalt and agate imbricated in the grayish sand and silt. The middle unit is represented by unconsolidated imbricated matrix of sand and silt supported by bimodal sorted gravel of quartzite, basalt, agate and chart. The upper unit contains yellowish and brownish silt and clay with occasional calcium concretion. It is capped by black soil. The measured thickness of the units is 6.5m, 5.00m and 3.5m respectively. The sediments of fluvial domain of Narmada identified between an elevation of 268 to 350 m above m.s.l. and were deposited in channel and flood plain environments during upper Pleistocene lime.

The sequence of Quaternary events and the history of sedimentation of Narmada indicate that the upper 70m top 90m of the Narmada alluvium was deposited in a single aggradations episode with minor pauses when dissection of the alluvium produced two terraces (NT_3-NT_2). The sediments of this aggradations episode constitute three lithostratigraphy units viz. Boulder conglomerate, Sohagpur and Shahganj formation. The sediments of the alluvial phase are underlain by a boulder bed of glaciao-fluvial origin. Thus, the fossiliferous boulder conglomerate, the basal unit of alluvium marks a disconformity between the lower glacial-boulder layer and upper fluvial sediments. The fossiliferous basal boulder conglomerate is being of middle Pleistocene age (Khan1992).

The sediments of present domain of Narmada is represented by sediments of active flood plain, point bar and sand bar facies of present domain and consist of unconsolidated imbricated, stratified, polygonal sorted rock-gravel supported by very coarse to very fine-sand and is named as Janwasa formation, after the village Janwasa where is it best developed. The measured thickness in the valley is about 5m. (Table No_2, 3,6& 7) (Plate No _4_9 to_16)

Table No_2 Geological sequence of Quaternarydeposits of Narmada Valley

Age	Quaternary formations	Lithe constituents	Environments of Deposition	Associated geomorphic Phenomena
1	2.	3.	4.	5.
Recent	Younger Alluvium Fluvial terraces / fluvial deposit of	Reworked sediments, mostly rock gravel consisting boulder, cobble, pebble of	Channel & flood plain environments	Point bars, channel bars, present day active flood

	present domain of Narmada	quartzite, gneiss, granite, schist, basics, slate, phyllite, limestone & shale in a matrix of coarse to fine sand		plane and channel braids: Fluvial terrace: NT-0. (Fluvial deposits)
Holocene	Fluvial terraces fluvial deposits / older alluvium 9 Sediment of paleo-domian of Narmada	Coarse gravel consisting of boulder, cobble, pebble, of quartzite gneiss granite, schist, phyllite, state, fossiliferous lime stone, shale & basic rocks in a matrin of coarse to fine sand.	Channel & flood plain environments.	Fluvial terraces of Narmada NT-0_1 to NT-3 . (Fluvial deposits)
Late Pleistocene	Fluvio- glacial deposits	Sub-angular to sub rounded boulder, cobble, pebble of quartzite, gneiss, granite schist with subordinate amount of limestone, slate, phyllite& basic rocks with coarse to fine sand & silt.	Fluvio glacial environments	Fluvio-glacial deposts "FGD"
Pleistecene	Glacial deposit	A heterogeneous mix of sub- angular to angular boulder and cobble of predominately gneiss, granite, schist, & quartzite with subordinate an amount of slate phyllite and shale together with very fine sand, silt & clays.	Glacial environment	Glacial deposits “GD".

V. Geological Sequence of Quaternary Deposits of Hathnora

The Quaternary deposits of the Narmada valley represent the thickest Quaternary deposits in peninsular India which were deposited in a tectonic trench of SONATA LINEAMENT ZONE., the sedimentation has been controlled and synchronised by mechnisam of tectonisam during entire span of sedimentation from Lower Pleistocene to Holocene time. The association of fossils and stone implements with Quaternary deposits of Narmada are well described, quarries on various aspects on geology geomorphology, sedimentolgy, provenance of sediments, stream kinetics, stratigraphy, chronology ,tectonics, neotectonic, subsurface geometry, and overall model of Quaternary sedimentation of Narmada in faulted and oscillating rift trench remained silent and disclosed and unrevealed hidden miseries needed attention.

The Hominid locality Hathnora is located on tectonic depressin associated with a linear trench in the middle of valley, it was an ideal locus for accumulation of sediments. The rift trench is intruded by the dolerite and other mafic and siliceous dykes and sills along lineaments in different phases of tectonic deformation. The Quaternary sedimentation incepting from glacial activity, followed by fluvio-glacial, lacustrine and fluvial phase within the rinsing and sinking environment, block, faulting, uplifting, Neogene rifting, Quaternary sedimentation, rift-bound Pliocene–Pleistocene rifting and volcanic activity specifically during glacial and fluvio-glacial phase are major component of the Quaternary period and tectonic processes

of the Narmada Rift System which forms the base of quaternary deposits. The quaternary landscape in this segment is confined in trough like basin which embraces the stepped sequence of Narmada terraces (NT1 to NT3), where Boulder conglomerate exposed at the base of these deposits. The Boulder conglomerate is persistent horizon and represent distinct fluvial-glacial phase of sedimentation. It is underlian by Boulder bed which is concealed under younger sediments in the valley.The Quaternary landscape embodies imprints of tectontonisam which revealed that sedimentation had been controlled by mechanics of SONATA LINEAMENT ZONE.

The Narmada rock basin of Narmada is occupied by the Quaternary sediments of three domains viz. glacial, fluvio- glacial and fluvial which were deposited in distinct environments during Quaternary time. The glacial deposit comprised of thick pile of sediments occupied base of rock basin and was deposited by glacial activities in dry and cold climatic condition during early Pleistocene time. The study of these concealed sediments, their sedimentary environments and sedimentation and correlation both in vertical and horizontal columns indicates that the lower most units, Boulder bed (20 to 260 m. below ground level) is of glacial origin, where as the fossiliferous bed Boulder conglomerate (260 to 278m. above m.s.l.) is of fluvio-glacial and top four formations in increasing antiquity Sohagpur, Shahganj, Hoshangabad and Janwasa (278 to 350m. above m.s.l.) are of fluvial origin and represent the complete sequence of Quaternary sedimentation in Central India Khan & Sonakia (1992).). The boulder conglomerate is a marker horizon of Quaternary sedimentation in Narmada Valley and as well in Central India, its disposition and relation with other deposits in the valley, indicates a significant change in regional climate from cold dry to warm and humid, during which the sediment were re-worked from glacial front intermittently and deposited in the valley over a very long time. The skull cap of *Homo erectus* (Narmada Man) and other fauna recorded along with calc- nodules within the boulder conglomerate; suggest that warm climatic phase prevailed for very long time. (Table No AB- 1-3 & Plate No AB-1)

In Homnid locality Hathnora in Narmada valley is occupied by thick Quaternary sediments which are classified on the basis of statistical parameters.quartz grain morphology of sediments, quartz grain morphology of quartz grain of paleosole, heavy mineral assemblage, and ash bed sedimentary features and environments of sedimentation. The lowermost units (Boulder bed) is or glacio-fluvial origin (Khan *el al* 1991) whereas the rest of fluvial origin. The top four formations (Sohagpur, Shahganj, Hoshangabad and Janwasa) are classified based on morphostratigraphic state (NT_o-NT_3), degree of oxidation, calcification and compaction. Janwasa formation comprises of sediments of active channel deposition and is the older three (Sohagpur, Shahganj, Hoshangabad formation) are related to older flood plains deposits of paleo-do-main of Narmada and are grouped under older alluvium. Boulder conglomerate of fluvio-glacial origin is assigned an independent formational status based on distinct lithology and fossil assemblage. The sequence of Quaternary events and the history of sedimentation of Narmada indicate that the upper 70m top 90m of the Narmada alluvium was deposited in a single aggradations episode with minor pauses when dissection of the alluvium produced two terraces (NT_3-NT_2). The sediments of this aggradations episode constitute three lithostratigraphy units viz. Boulder conglomerate, Sohagpur and Shahganj formation. The sediments of the alluvial phase are underlain by a boulder bed of glacio-fluvial origin. Thus, the fossiliferous boulder conglomerate, the basal unit of alluvium marks a disconformity between the lower glacial-boulder layer and upper fluvial sediments. The fossiliferous basal boulder conglomerate is being of middle Pleistocene age (Khan 1992)

The boulder bed which yielded Hominid fossil from boulder conglomerate reported to be of fluvio-glacial origin for first time (Khan & Sonakia 1992). Beside occurrences of associated of ash beds with fossileferous boulder conglomerate (Khan & Rahate 1991) Achariya 1993 indicates volcanic source. It appears that close to the completion of cycle

of deposition of the boulder bed there was vilolent volcanic eruption in around Middle to uper Pleistocen time which was subsequently settled down across the globe and in the pennisular India during the quaternary sedimentation. The occurrences of association of two marked horizons at different levels further revealed the cyclic eruption and settling of volcanic matrix was occurred with a pause during sedimentation. Khan et.al. (1991). Khan and Sonakia (1992) reported for the first time glacial and interglacial deposit in the Narmada valley, Central India which is represented by arid and humid cycles. The lithostratigraphy of Narmada valley described by Khan (1984), Khan & Benarjee (1984), Khan & Rahate (1990-91), Khan & Sonakia (1992), Khan *et al* (1991), Rahate & Khan (1985), Khan (1991), Khan & Sonakia (*1992*), Yadav & Khan (1996).

The Quaternary lithostratigraphy and sedimentological aspects were studied and in the Narmada valley (Khan 1984, Khan & Benarjee 1984, Khan & Rahate 1990-91-90 Khan & Sonakia 1992, Khan &*et al* 1991, Rahate & Khan 1985, Khan *et al.* 1991, Khan 1991, Khan *et al*. 1992, Yadav & Khan 1996. The Narmada valley embodied complete sequence of Quaternary deposits from lower Pleistocene to Holocene (Khan & Sonakia (1992). Khan, et.al (1912), Khan (2012) et.al Khan (in press) , Khan (in press),.The results of sedimentological studies Khan (2015), quartz grain morphology, Khan (2014), quartz grain morphology,Palesole Quaternary column section in Hominid locality in central sector of Narmada revealed the presence of complete sequence of quaternary sediments in Narmada rock basin viz Glacial, fluvio-glacial and fluvial domain whereas the boulder conglomerate which has yielded human skull is of fluvio-glacial origin from Khan & Sonakia (1991).The Quartz grain morphology of sediment column Khan (2014) Quartz grain morphology of different paleo- sole, , Khan (2014), Ash bed Khan & Maria (2012) Khan & Maria (1912) Heavy mineral assemblage Khan (2016) tephra stratigraphy, Khan et.al (1991) Acharya, S.K. and Basu, P.K. (1993) Khan etal (2014) Khan et.al.(2015) Ash fall and its impects (2015) Khan (2016) magnetostratigraphy, and bio-stratigraphy and correlation of sediment columns intra valley wise , inter valley wise and on unified Quaternary Platform Khan et.al (2012) focusing on hominid localities of China have been studied on quaternary platform which have given new insight on the age of the Narmada *Homo erectus.*

The Hathnora section section of Narmada possess the complete sequence of all three domain of sediments in increasing antiquity from the bottom of the rift trench Boulder bed (glacial), Boulder conglomerate (fluvial-glacial) sediments of paleo-domain of Narmada (fluvial). The intense tectonic activities within the basins of the Narmada Rift System during the Neogene and Quaternary periods have destroyed fossil record except the fossiferous horizons exposed in river sections. The erosional-sedimentary cycle has persisted in the rift valley environment for millions of years as a result of the interplay between depositional and erosional forces driven by tectonic processes; there are numerous gaps in the fossil record, particularly in the important time period between Mio-Pliocene Pleistocene times. It is pertinent to the understand the origin of Hominid during the late Miocene, but it is difficult to disclose mysteries of human evolution in Narmada due to concealed nature of these deposits in rift system, however the complementary part of Tapti-Purna Quaternary blanket may be potential and possessive of human remain and should be studied to trace further the imprints of fossil man taking in to account of SONATA LINEAMENT ZONE as single ecosystem for evolution of man in Indian subcontinent. However, evidence of the effects of tectonics on fauna and flora are distinct and its signatures on dislocation and concealing of fossiliferous horizons are uncontrolled and ill-defined in the ecosystem in the valley during the Pliocene–Pleistocene periods.

The boulder conglomerate which yielded the skull cap of *Homo eructs* in Narmada rift from Hathnora Sonakia (1984) remained only discovery of hominid fossil in last two and half decade due to concealed and hidden nature of Mio-Pliocene Pleistocene deposits in rift system and inconsistency in exposure

of fosiliferous horizon due faulting, dislocation ad subsidence of Quaternary blanket of Narmada rift system.

The Boulder Conglomerate which is of fluvio-glacial origin and has yielded human skull from Sonakia (1982) Khan &Sonakia (1992) is exposed persistently in scarp section of Narmada at few places only. The type section of Boulder Bed and Boulder *Conglomerate* which are potential sediments of human remains of Pliocene Pleistocene time are hidden and concealedunder sediments of present and paleo- domain of Narmada in the valley.(Table No_3, 4,6,7 &_4)(Plate No _8 to_17)

VI. Geological Sequence of Quaternary Deposits of Vom Of Indian Fossil Man & China Man On Unified Quaternary Platform A Correlation

The Quaternary sequence of Hominid locality of Hathnora represents multiple sequences of sediments. Based on study of statistical parameters of sediment their deviation and breaks in vertical stratigrphic column between 00.00 to 260 m below the ground level indicate that the sediments consist of three domains viz. glacial, fluvio-glacial and fluvial.(Khan et.al 2016. The study of these concealed sediments, their sedimentary environments and sedimentation and correlation both in vertical and horizontal columns indicates that the lower most units, Boulder bed (20 to 260 m. below ground level) is of glacial origin, where as the fossiliferous bed Boulder conglomerate (260 to 278m. above m.s.l.) is of fluvio-glacial and top four formations in increasing antiquity Sohagpur, Shahganj, Hoshangabad and Janwasa(278 to 350m. above m.s.l.) are of fluvial origin and represent the complete sequence of Quaternary sedimentation in Central India. The Janwasa formation comprises of sediments of active channel deposit where as the older three (Sohagpur, Shahganj, Hoshangabad formation) are related to older flood plains deposits of paleo-do-main of Narmada and are grouped under older alluvium. Boulder conglomerate of fluvio-glacial origin is assigned an independent formational status. Khan & Sonakia (1992).

The skull cap of Narmada man *Homo erectus* Narmadanesis was found in near village Hathnora (22 ° 52” N; 77 ° 52” E) in fossiliferous boulder conglomerate, (Sonakia, 1984) at an elevation of about 268m above the m.s.l. and at the depth of about 83m in Central Narmada Valley. These deposits are underlain by glacial deposits and overlain by fluvial deposits of palaeo-domain of Narmada. The Quaternary sequence of Hathnora is described by Khan & Sonakia (1992).

The boulder conglomerate at Hominid locality Hathnora consist of stratified hard compact basal unit comprising of rook fragments of different shape and size of granite, quartzite, sandstone, agate, chalcedony, chart, basalt and calcareous nodules tightly cemented in the matrix of brown, red and grayish sand and silt. These rock clastics constitute various sub-litho units and are supported by grey and brownish, cross bedded sand. The sub-litho units consists of mostly pebble supported horizons which contains vertebrate fossils, stone implements, like chopper, scraper hand axes and core flakes mostly of quartzite, flint, chalcedony and quartzite.

A mandible of Lantian hominid at Chenjiawo (China) was found in paleosole (S6) and at the depth of 38 m in the loess deposits A Zhisehng et. al. (1989). Assumingly a roughly uniform accumulation rate of sedimentation in the line of Ma. et.al. (1978) estimation of age, the date of the Lantian mandible at Chanjiawo is computed to be about 0.65 m. m.y.r. Ho-chuan at the depth of 26m which were deposited in typical fluvial environments. In view of recovery of skull cap of *Homo erectus* (Narmada Man) from older deposits and from deeper level (83m.) as compared to Chinese Hominid, the claim of Lantian Hominid of Congwangling (1.15 m.y.r.) after A Zhisehng et. al. (1989)\ needs re-evaluation of reassessment of its age.

The rock basin of Narmada is occupied by the Quaternary sediments of three domains viz. glacial, fluvio- glacial and fluvial which were deposited in distinct environments during Quaternary time. The glacial deposit comprised of thick pile of sediments

occupied base of rock basin and was deposited by glacial activities in dry and cold climatic condition during early Pleistocene time. The boulder conglomerate constitute fossiliferous horizon of Narmada, deposited in fluvio-glacial environments (interglacial). It is a marker horizon of Quaternary sedimentation in Narmada Valley and as well in Central India its disposition and relation with other deposits in the valley, indicates a significant change in regional climate from cold dry to warm and humid, during which the sediment were re-worked from glacial front intermittently and deposited in the valley over a very long time. The skull cap of *Home erectus* (Narmada Man) and other fauna recorded along with calc- nodules within the boulder conglomerate; suggest that warm climatic phase prevailed long time. The Lantian hominid cranium at Gongwangiling was found in silty loess at the depth of about 26 m. and it Luochuan standard sequence the fossil bearing stratum un-doubted to the middle part of silty loess L-15 which at Luochuan was dated to be 1.09 to 1.20 m.y.r. The hominid fossil and associated faunas were discovered in the middle part of silty layer; the age of the fossils at Gongwanling can be pinpointed narrowly to 1.15 m.y.r. This dates differs from the earliest (0.75-0-80 m.y.r.) of Ma. et. al. (1978) and from 1 m.y.r. estimate of Cheng et. al. (1978). The Lantian fossil hominid at Gondwangling is considered as earliest *Homo erectus* in China. Ho Chuan Kun (1986).

In India Narmada basin considering the one of a main loci of Quaternary sedimentation, and assuming the uniform accumulation rate of sediment in the basin in the line of Ma. et. al. (1978) Yobin Sun & Zhisheng, An (2005) and comparing the Narmada sequence of Quaternary deposit (325 m.) with those of Luochuan standard sequence of Chenjiawo and Congwangling sequence of China. The skull cap of *Homo erectus* (Narmada Man) recovered from the boulder conglomerate of fluvio-glacial origin in middle part of Quaternary column from deep level of Narmada, at the depth of 83 m. above glacial deposits, in association of ash bed, as compared to Chenjiawo Hominid from inter bedded sequence of paleo sols loess and silty loess at the depth of 38 m. and Congwangling 26 m. from paleo sols which are younger than Narmada deposits.

The Narmada skull cap of *Homo erectu*s which is recovered from the vom of basal unit of boulder conglomerate at the depth of 83 m. (278 m. above m.s.l.) is estimated to be of upper segment of lower Pleistocene age. It is older than the *Homo erectu*s of Chenjiawo, Congwangling of China which were recovered from paleosole and loess deposit at the depth of 38 and 26 m. The Quaternary sequence of Narmada (325 m.) as compared to Louchuan (136 m.) sections of China on unified Quaternary platform is older and represents the complete and type sequence of Quaternary sedimentation in Central India. The occurrence of skull cap of early man at the depth of 83 m. in basal unit of boulder conglomerate of fluvio-glacial origin in Narmada Valley is one of the earliest and oldest *Homo erectu*s in Asia. (Plate No _8_ to_12 16, 17)

The Boulder bed and Boulder Conglomerate in Son Narmada Tapti and Purna with similar rock assemblages and suites of rock fabrics, heavy mineral assemblages, and quartz grain morphology in critical and crucial sections across the SONATA LINEAMENT ZONE Khan (2013) Khan (2014) strongly support tearing and rifting of quaternary blanket during late Pleistocene time. The presence of thick boulder bed in Harda inliers area, such as at Chandgarh and north east of Barwaha, boulder bed in confluence are of Tapti and waghur around Khadgaon in Tapti valley Khan et.al (1984) Khan et.al (2015) Khan et.al (2016) Khan (2016) supports this assumption.

The sequence of quaternary dposits in this segment of rift system was deposited on uneven platform of valley floor of turmoil nature in tight and narrow basin which depicts cyclic transitional environmental of the rift basins are caused by tectonic activities (uplift and subsidence), changes in relief, and climatic variations. The climatic changes in uplift, coupled with block faulting, rinsing and sinking platform, created basins unstable platform for the accumulations of thick lacustrine and fluvial sediments sequences with terrestrial and aquatic fossils.The evidence of the effects of

tectonics on fauna and flora are distinct and its signatures on dislocation and concealing of fossiliferous horizons are uncontrolled and ill defined in the ecosystem in the valley during the Pliocene–Pleistocene periods. The boulder conglomerate which yielded the skull cap of *Homo eructs* in Narmada rift from Hathnora Sonakia (1984) remained only discovery of hominid fossil in last two and half decade due inconsistency and concealed nature of fosilifrous horizon due faulting, and subsidence of Quaternary blanket of Narmada rift system as such researcher and scientist failed to add any further knowledge to hominid discovery.in Narmada valley.(Table No _3 &_9)

VII. Geological Sequence of Quaternary Deposits of Jabalpur _Harda Section

In Narmada valley Jabalpur _ Harda section is occupied by thick quaternary deposits which have been chisealled to three prominent terraces (NT1 to NT3) besides sub terraces NT2-A is NT2-B, NT2 B, tese terraces are seprated by linear and curvilinear scarps, show convergence and divergence in their relative position and cyclic & non cyclic in nature. In some section of valley rock cut terraces, rock cut platform and benches are notices which at many places over lie by caps and strips quaternary deposits representing the former level of valley floor of Narmada. The rock cut terraces and rock cut benches are time equivalent to NT1 to NT3 which have developed in Nasrullahganj &Harda .Khan et.al (2016). The Quaternary events of the Narmada portys three prominent terraces and two sub terraces in these sections which are designated NT1 to NT3 and sub terraces NT2-A is NT2-B, NT2 B, besides NT2-C, NT3-A & NT3-B besides NT-0 in the valley. They have been designed NT_O to NT3, (280 to 400 m), NT_O being the low level terrace above the present-day course of the river, NT_1-the younger terrace both of cyclic ad o cyclic nature. The NT_3 terrace occurs as elongated strip and isolated caps and lenses along the margin of valley flanks has divergent relative disposition. These land forms indicate vigorous and abrupt incision of valley floor due to relatively & repaid uplift of watershed area during Upper Pleistocene time. The NT1to NT_2 is the major depositional terrace and have both convergent & divergent mutual disposition with other terrace. These terraces further downstream have matched equivalents along the valley flanks, whereas in the up stream section the matched equivalents are rare. The conspicuous divergent relation of these terraces the valley reveals successive uplift of catchments area and consequential incision of valley floor and adjustment of base level of Narmada during Upper Pleistocene time.

In Hoshangabad Harda Section section the Vindhayan group of rocks is overlain uncomfortably by the Quaternary Formations. The basal conglomerate bed is exposed at Dimawar, Bhilariyaghat, Kund, Hathnora etc. It consists of rounded to sub-rounded pebbles, cobbles of quartz, jasper, agata, chert, calcareous matrix or siliceous matrix with coarse of fine sand, silt and little of clay. Recently Sri A. Sonkia has found fossilized human skull known as the Narmada man, in association with extinct Pleistocene mammals at Hathnora associated with the conglomerate horizon. The fossils assemblage indicates that it belongs to middle Pleistocene. This unit is overlain by the older Alluvium Group-Varying in thickness viz 25m at Dimawar, 36m at Mardhanpur 18m. at Hathnora etc. it broadly comprises of two litho units. The basal member of which consists chiefly of light yellow to brown silt with clay and fine sand whereas the upper horizon consists of hard and compact clay, brown to red in colour with sub-ordinate amount of silt. At the base coarse sand is observed approximately 1.5m thick showing current bedding, cross bedding and other sedimentary structures. The entire section is associated with horizons of pebbles, cobble bed having composition of green to black quartzite, sandstone, jasper, agate, and chert. The thickness of this horizon varies form 1m to 5m. These units are horizontally bedded at places show prominent bedding. The upper horizon of this unit are pre-dominently clayey and is hard and compact whereas the lower horizon are less compact and silty in composition containing layers of sand and calcareous concretions. The older alluvium is represented by Demawar, Shivpur and

Nasrullahganj Formations.The sequence of Quaternary deposits is given in the (Table No QGT_3 & _4.)

Fluvial Deposit (flood plain deposit of paleo domain of Narmada)

a. Nasrullahganj Formation

The Nasrullahganj formation is the oldest Quaternary formation of the Narmada and it derives its name after Nasrullahganj where it is best developed. The formation overlies the Vindhayan group of rocks unconformable. It occupied an extensive area both in the north and south bank of the Narmada river. It comprises sediments of plaeodomain of the Narmada river and forms morphostratigraphic unit comparable with Nasrullahaganj geomorphic surface. The formation is represented by a thick sequence of brown to pink colored hard and compact clay, thin layer of light yellow to brown silt and coarse to fine sand and associated with sub-rounded to well rounded boulder, pebble and cobble to quartzite, basalt, gneiss, sandstone, agate, chert jasper.

b. Shivepur Formation

It is younger than the Nasrullahganj Formation and overlies it with a erosional scarp. It derives its name after ShivpurMain Township located on this formation and also best developed here. This Quaternary formation has a large l extent on either side of the Narmada river. It comprises sediments of palaeo-domain of the Narmada river and forms morphostratigraphic unit referable to the Shivpur geomorphic surface. It consists of yellowish clay, subordinate amount of silt and coarse to fine sand accompanied by pebble and cobble horizon of quartzite, gneisses, basalt, sandstone, agate, chert, jasper.

c. Demawar formation

This forms the youngest unit of older alluvium group of the Narmada. It is younger than the Shivpur and older than the Amba formations. It assumes its name after Demawar village which forms the type aread of the formation. In comparison to other Quaternary formations described above, Demawar occupies smaller area and is concentrated in the meandering loops of the Narmada on either side of the Narmada river. It represents sediments of the palaeodomain of the Narmada and forms morphostratigraphic unit comparable to the Demewar geomorphic surface.

i. Fluvial Deposit (flood plain deposit of paleo domain of Narmada)

This represents the active flood plain deposits of the Narmada and its tributaries. These deposits are restricted to the present day course of the channel and surrounding low lying areas. It consists chiefly of fine grey sand (showing various sedimentary structures as current bedding, graded bedding etc.) with pebbles, cobbles, boulders of quartzite, gneiss, sandstones, agate and jaspers. This unit is represented by Ambar, Indra, Kolar and Amba formations.

a. Amba Formation

This forms the youngest formation of the Narmada and represents the sediments of the Recent Flood Plain facies of the Narmada river. This is a morphostratigraphic unit referable to Amabs geomorphic surface. It comprises fine to coarse sand, silt and subordinate clay. This occurs in the meander loops of the Narmada and is found around Amba, Kund, South of Nilkanth, Jalha etc. This section, as observed in around the village Kund shows the following units. A zone of cobbles and pebbles of quartz, jasper, agate, chert is strewn over the surface and it is succeeded upwards by a thick sequence of (about 4m) of conglomerate showing gradual fineness upwards and dipping 5’ to 10’ away from the river. This is followed upwards by inter layered sequence of sand and clay exhibiting cross-bedding.

b. Kolar Formation

These represent sediments of the Recent Flood Plain facies of the Kolar and Ganjal rivers. The Kolar is on the north bank whereas the Ganjal is on the southern. Bank of the Narmada. These form morphostratigraphic unit comparable with the Kolar/Ganjal geomorphic surface. Kolar is deeply entrenched river. It has restricted

flood plain and even show poor development of Point Bar due to the deep entrenchment of the river. The river is probably controlled by fault trending NNW-SSE as evident from the pattern of the riverc course. The Ganjal river is also found to have restricted flood plain and is entrenched. The flood plain facies of both river comprises sediments dominated by coarse to fine sand silt and lesser amount of clay. The thickness of sediment is about 5m.

c. Indra Formation

This represents the sediments of the Recent Flood Plain from of the Indra river a tributary to the Narmada on the southern bank. The formation assumes its name after the indra river. It forms morphostratigraphic unit comparable with the Indra geomorphic surface. The restricted flood plain of the river comprise sediments consisting of coarse to fine grey coloured sand silt and little amount of clay and associated with rock gravels comprise quartzite, quartz, Jaspar, chert, agate, etc. Thickness of sediments is about 3m.

d. Ambar Formation

This formation is developed along the Ambar river a tributary of the Narmada on the northern bank and derives its name ager the Ambar river. It represents the sediments of the Recent Flood Plain facies of the Amba river and forms morphostratigraphic unit referable to the Ambar Geomorphic surface. The flood plain of the river comprises sediments similar to that of the other tributaries of the Narmada viz. coarse to fine sand silt and clay. (Table No QGT_3 &_4_5,6) (Plate No _4 to _8_13 14& 17).

TABLE_5 GEOLOGICAL ESQUENCE OF QUATERNAR DEPSITS OF JABALPUR _HARDA SECTION

Terrace	Elevation above MSL	Nature of its Origin	Morphostatigraphy
NT_o	260-280 m	Depositional	Light grey to dark grey sand and silt
NT_{-1}	280-300- m	Erosional / Depositionalwith rock pebble sand and silt	Light grey to dark grey sand and silt
$NT_{-2}A$	300-320 m	Depositional	Grey & brown sand and silt.
$NT_{-2}B$	320-340m	Depositional Erosional /	Yellow brownish clay with silt
NT_2C	340-360 m	Depositional	Yellow brownish clay with silt with Dark brown oxidized clay silt
$NT_{-3}A$	360-380 m	Depositional Erosional/	Dark brown, dark yellow clay silt Brownish red clay and silt with Calc - matrix.
NT_{-3B}	400 m	Depositional	Dark brown, dark yellow clay silt Brownish red clay and silt with Calc-matrix
Boulder Conglomerate pebble		Fluvio-glacial	sub rounded to rounded cobble inthe matrix coarse to fine sand & silt
Boulder Bed cobble sand,		Glacial	sub angular to sub rounded boulder pebble in the matrix coarse to fine silt and clay

VIII. Geological Sequence of Quaternary Deposits of Gurudeshwar- Bharouche Section

The Narmada river in Grudeshwar and Bharouche section of Narmada bounded by latitude 21 30 to 22 31 North 72 50 to 74 15 East in parts of of Gujarat state negotiatiates in lower part of valley before debouching in Gulf of Cambay in Arabian Sea in Gujarat state. This segment is about 90 km in length and forms the southern margin of the N–S extending Gujarat alluvial plains .A significant feature of the lower Narmada valley is the deposition of a huge thickness of Tertiary and Quaternary sediments in a fault controlled rift trench. To the south of the ENE–WSW-trending Narmada–Son Fault (NSF), the Tertiary rocks and basaltic flows of Deccan Trap Formation occur on the surface while to the north they lie in the subsurface and are overlain by Quaternary sediments. The Quaternary tract of lowerNarmada basin covers an area of about 10830 sq. km starting from Gurudeshwar to Bharouch for a distance of about 130 km. It is found to be ideal locus of Quaternary sedimentation in western India as witness by multi-cyclic sequence of Quaternary terraces in the valley. The general elevation of Narmada alluvial plain varies between 65.00 m to 95.00 m above the sea level. The general gradient of this plain in this stretch is about 1m /km towards West (Plate No QG-42-52 Table No QG 34 to _53)It is occupied by thick Quaternary deposits of about 800 m which represent various domain of sedimentation. Based on sedimentlogical characters, depositional environments, erosional processes and their relation with depositional activity revealed that it comprised of four domains of sediments viz glacial, fluvio-glacial fluvial and tidal flats. The lower most units (Boulder bed) is, of glacial origin, followed by the boulder conglomerate of glacio-fluvial and subsequently by fluvial of paleo- domain of Narmada and tidal flats . The top Quaternary landscape is chisealed into three terraces NT1 to NT3 besides presentday flood plain NT0 which is represented by four formations Ankleshwar, Tilakwarda & Bharuch and Aliabat respectively.(Table NoQGT_9) The Boulder conglomerate is assigned an independent formational status based on distinct lithology and fossil assemblage. The sequence of Quaternary events and the history of sedimentation of Narmada indicate which is exposed at the base of NT2. The upper 180 of the Narmada alluvium was deposited in two distinct aggradations episode with a distinct, well defined break in sedimentation in rift system. The dissection of the quaternary blanket resulted in to two terraces (NT_3-NT_2), after break in sedimentation. The sediments of this aggradations episode constitute three lithostratigraphy units viz Ankhleshwar, Tilakwarda and Bharuch formation. The sediments of the alluvial phase is underlain by a boulder bed of glacio-fluvial origin. Thus, the fossiliferous boulder conglomerate, the basal unit of alluvium marks a disconformity between the lower glacial-boulder layer and upper fluvial sediments. The fossiliferous basal boulder conglomerate is being of middle Pleistocene age.

The area of study is located in the western extremity of Narmada basin at the mouth of Gulf of Cambay. It is bounded by latitude 21 30 to 22 31 North 72 50 to 74 15 East in parts of Barouche of Gujarat state. The area is main segment of tectonic disconformities it encompasses two crustal provinces of Central India Shield, namely, the Northern Crustal Province (NCP) and the Southern Crustal Province SCP (Acharyya and Roy, 1998; Roy, 1988). The two provinces are separated by a crustal level shear zone, referred as Central Indian Suture (CIS Jain et al. 1995). The southern part of the NCP, containing the Sapura and son Narmada (SONA) valley geographic domain, is known as Central Indian Tectonic Zone (CITZ; Radhakrishna and the CITZ are marked by Narmada North Fault (NNF) in the north and CIS in the south (Acharyya, 1999). The Jabalpur earthquake affected area lies in SONA lineament zone which forms the northern units of CITZ. The SONA zone is about 1600 km long and 150 km-200km wide, extending from the southern margin of Kathiawar peninsula in the west to the margin of Vindhyan basin in the east .The zone has been a major locus of episodic tectonisam with evidences of reactivation. The E-W to ENE-WSW trending Narmada and Tapti lineament from a prominent

tectonic belt (SONATA) in midplate continental India.

The Narmada in area on the western extremity of basin in between Garudeshwar and Bharouch in lower part of valley, descends in sinuous to meandering pattern, it is strongly influenced and guided by the SONATA Lineament the major geofracture known as the Narmada-Son fault,

The area in western sector of Narmada between Grudeshwar and Barouche is occupied by thick Quaternary deposits of about 800 m which represent various domain of sedimentation. Based on sedimentlogical characters, depositional environments, and erosional processes and their correlation with depositional activity revealed that it comprised of four domains of sediments viz glacial, fluvio-glacial fluvial and tidal flats. The lower most units (Boulder bed) is, of glacial origin, the boulder conglomerate of glacio-fluvial, fluvial of paleo- domain of Narmada and tidal flats. The top four formations Ankleshwar, Tilakwarda & Bharouch and Aliabat are designated as (NT_o-NT_3). Boulder conglomerate is assigned an independent formational status based on distinct lithology and fossil assemblage. The sequence of Quaternary events and the history of sedimentation of Narmada indicate that the upper 180 of the Narmada alluvium was deposited in two distinct aggradations episode with a distinct, well defined break in sedimentation in rift system. The dissection of the quaternary blanket resulted in to two terraces (NT_3-NT_2), after break in sedimentation. The sediments of this aggradations episode constitute three lithostratigraphy units Ankhleshwar, Tilakwarda and Barouche formation. The sediments of the alluvial phase are underlain by a boulder bed of glacio-fluvial origin. Thus, the fossiliferous boulder conglomerate, the basal unit of alluvium marks a disconformity between the lower glacial-boulder layer and upper fluvial sediments. The fossiliferous basal boulder conglomerate is being of middle Pleistocene age.

The Quaternary deposits contained in the western asymmetric trench consist of sediments of various domains viz glacial, fluvio-glacial, fluvial, lacustrine and tidal flats influenced by incursion of marine transgression and regression on tectonically active platform. It is evidenced by bore hole data and subsurface statistical analysis of sediments, quartz grain morphology of sediments, pale sole geometry and configuration of quaternary deposits in western segments of Narmada rift valley and SONATA TECTONIC ZONE.

The Quaternary deposits and river terraces (NT1to NT3) entrapped in tectonic zone with rock cut equivalence and scare is significant signature of euestatic change / climatic changes in the western coast and Gulf sedimentation. The alluvial fan in between Tilakwarda and Rajpipla within the loop of Narmada Chamyal (2002) is mono illustration of morphogenetic process associated with neotectonic event. The disposition of Quaternary blanket, fan deposit and other quaternary land forms are controlled and restricted by SONATA LINEAMENT towards north. The convergence of fan deposits and its apex is not persistence and in conformity of piedmont sedimentation and devoid of torrential stream net work which firmly rule out to be endogenetic fan deposits and appears to be older quaternary deposits which have been moved from basement and have been pasted along SONATA LINEAMENT.

The Narmada in area on the western extremity of basin in between Garudeshwar and Bharouch in lower part of valley, descends in sinuous to meandering pattern, it is strongly influenced and guided by the SONATA Lineament the major geofracture known as the Narmada-Son fault, which causes the river to flow westwards, opposite to the regional slope.

The Narmada graben controlled accumulation of the 800 m thick alluvial sediments through synsedimentary subsidence (Ravi Shanker, 1991) which consist of four distinct groups of deposits viz. glacial, fluvio- glacial and fluvia / lacustrine l and tidal flats which were deposited in distinct environment in Pleistocene to Late Holocene times. Khan (1992) Khan (2014). The blanket comprised

of various pale sole at different levels which marks significant micro change in climate during Quaternary times.

The area is situated at the mouth of Gulf of Cambey at terminus point of basin which forms a oval depression which elongated and starched E-W direction ad truncated by crossed structural lineaments trending NW –SE, NE-SW direction. The quaternary blanket exposed to post deposition activity which subsequently chiseled by cumulative geostatic ad climatic changes resulting into various terraces, pre-quaternary and quaternary surfaces and landform elements of various domain and plantation surface. In the area Narmada channel course is both obstructed & guided and controlled by the cross lineament trending transverse to strongly dominated ENE-WSW to E-W SONATA LINEAMENT resulting in the channel dynamics to suddenly open out which at short range became sluggish as evident by the disposition of quaternary terraces and various landform elements. Based on morphologenetic expression, elevation, slope characteristics, drainage density, erosional pattern, pedagogical characters and diagnostic land form elements, the area in lower Narmadavalley is broadly three Quaternary terraces (NT1 to NT3) which are time equivalent to three terraces of central sector of Narmada Khan et.al (1982) Khan 1984, Khan 1992 & khan 2014.

The complete account of Quaternary lithostratigraphy has been up dated in the Narmada valley (Khan 1984, Khan & Benarjee 1984, Khan & Rahate 1990-91-90 Khan & Sonakia 1992, Khan &*et al* 1991, Rahate & Khan 1985, Khan *et al.* 1991, Khan 1991, Khan *et al.* 1992, Yadav & Khan 1996. The Narmada valley embodied almost whole of the Quaternary deposits time span from the lower Pleistocene to Holocene (Khan & Sonakia (1992). Khan (1912), Khan (2012), Khan (in press) , Khan (in press),.The results of sedimentological studies Khan (2014), quartz grain morphology, Khan (2014) paleo study of type Quaternary column section in Hominid locality in central sector of Narmada revealed the presence of complete sequence of quaternary sediments in Narmada rock basin viz glacial, fluvio-glacial ad fluvial domain whereas the boulder conglomerate which has yielded human skull is of fluvio-glacial origin from Khan & Sonakia (1992) The results of analysis of sedimentary structures Khan (in Press) Quartz grain morphology of sediment column, Khan (in Press) Quartz grain morphology of different pale- sole, , Khan (2014) heavy mineral assemblage Khan (in Press) tephra stratigraphy, , Khan et.al (1991) Khan & Maria (1912) magneto-stratigraphy, and bio-stratigraphy and correlation of sediment columns intra valley wise , inter valley wise and on unified Quaternary Platform Khan et.al (2012) focusing on hominid localities of China these deposits have thrown fresh light on the age of the Narmada *Homo erectus*. Discoveries of volcanic ash beds and palaeomagnetic reversal in these deposits for the first time for peninsular India are breakthroughs in fixing the chronologic position of the skull. Fresh data on the age of the Narmada *Homo erectus* are also available by additional finds of fossil mammals and a detailed taxonomic study along with a thorough review of some families of mammals.

The western Narmada basin on the terminal segment, it is expressed as a single deep-seated fault (NSF) confirmed by the deep seismic sounding studies (Kaila et al., 1981). The seismic reflection studies have firmly established that the NSF is a normal fault in the subsurface and becomes markedly reverse near the surface (Roy, 1990). Reactivation of the fault in Late Cretaceous led to the formation of a depositional basin in which marine Bagh beds were deposited (Biswas, 1987). The NSF remained tectonically active since then with continuous subsidence of the northern block, designated as the Broach block, which accommodated6–7-km thick Cenozoic sediments (Biswas, 1987). The total displacement along the NSF exceeds 1 kmwithin the Cenozoic section (Roy, 1990). However, the movements along this fault have not been unidirectional throughout. The general tendency of the basin to subside has been punctuated by phases of structural and tectonic inversion (Roy, 1990). The N–S-directed compressive stresses during the Early Quaternary, folded the Tertiary

sediments into a broad syncline, the Bharouch syncline, in the rapidly subsiding northern block (Roy, 1990). The Bharouch syncline extends from the NSF to the Mahi river in the north. The E–W trending axis of this syncline lies to the north of the Narmada river corresponding anticlinal structures are found in the Tertiary rocks exposed in the southern up thrown block. Historical and instrumental records indicate that the compressive stresses still continue to accumulate along the NSF due to continued northward movement of the Indian plate. This is evidenced by the fault solution studies of the earthquakes at Bharouch (23 March 1970) and Jabalpur (22 May 1997), which suggest a thrusting movement (Gupta et al., 1972, 1997; Chandra, 1977; Acharyya et al., 1998). However, the underlying cause of the seismicity in the NSF zone is not yet understood (Quittmeyer and Jacob, 1979) extending Gujarat alluvial plains. A significant feature of the lower Narmada valley is the deposition of a huge thickness of Tertiary and Quaternary sediments in a fault controlled basin. To the south of the ENE–WSW-trending Narmada–Son Fault (NSF), the Tertiary rocks and basaltic flows of Deccan Trap Formation occur on the surface while to the north they lie in the subsurface and are overlain by Quaternary sediments. However, the overlying Quaternary sediments having a maximum thickness of 800 m (Maurya et al., 1995) .The correlation of subsurface data of CGWB and other agencies on Quaternary Platform Khan (2012) and Khan (2014) indicate presence of glacial fluvio-glacial deposits at the base of rock basin. Drill data from some of the deepest wells in the basin have revealed occurrence of Deccan Trap at depths of 6000 m followed by an Archaean basement (Roy, 1990). The Tertiary sediments, outcropping to the south of the NSF, represent the full sequence from Eocene to Pliocene overlying the Deccan Trap and show extensive deformation in the form of several ENE–WSW-trending anticline highs and ENE–WSW and E–W-trending reverse faults. Profuse occurrences of E–W-trending dykes suggest that the zone formed the main centre of eruptive activity (Bhattacharji et al., 1996). The entire zone is presently characterized by high gravity anomalies, high-temperature gradient and heat flow and anomalous geothermal regime (Ravishankar, 1991) suggesting that the zone is thermo mechanically and seismically vulnerable in the framework of contemporary tectonism (Bhattacharji et al., 1996). The westward extension of this zone into the lower Narmada valley exhibits a less complex structural setting.In the lower Narmada basin, it is expressed as a single deep-seated fault (NSF) confirmed by the Deep Seismic Sounding studies (Kaila et al., 1981). Seismic reflection studies have firmly established that the NSF is a normal fault in the subsurface and becomes markedly reverse near the surface (Roy, 1990). Reactivation of the fault in Late Cretaceous led to the formation of a depositional basin in which marine Bagh beds were deposited (Biswas, 1987). The NSF remained tectonically active since then with continuous subsidence of the northern block, designated as the Bharouch block, which accommodated 6–7-km thick Cenozoic sediments (Biswas, 1987). The total displacement along the NSF exceeds 1 km within the Cenozoic section (Roy, 1990). However, the movements along this fault have not been unidirectional throughout. The general tendency of the basin to subside has been punctuated by phases of structural and tectonic inversion (Roy, 1990). The N–S-directed compressive stresses during the Early Quaternary, folded the Tertiary sediments into a broad syncline, the Bharouch syncline, in the rapidly subsiding northern block (Roy, 1990). The Broach syncline extends from the NSF to the Mahi river in the north. The E–W trending axis of this syncline lies to the north of the Narmada river. Corresponding anticline structures are found in the Tertiary rocks exposed in the southern up thrown block. (Historical and instrumental records indicate that the compressive stresses still continue to accumulate along the NSF due to continued northward movement of the Indian plate. This is evidenced by the fault solution studies of the earthquakes at Bharouch roach (23 March 1970) and Jabalpur (22 May 1997), which suggest a thrusting movement (Gupta et al., 1972, 1997; Chandra, 1977; Acharyya et al., 1998). However, the underlying cause of the seismicity in the NSF zone is not yet understood (Quittmeyer and Jacob, 1979).

i. Quaternary Geology

The area in western segment of Narmada rift valley is occupied by Quaternary blanket of about 800 m which represent different domain of sedimentation. Based on sedimentlogical characters, depositional environments, and erosional processes and their correlation with depositional erosional activity revealed that it comprised of four distinct domains of sediments viz glacial, fluvio-glacial fluvial / lacutrine and tidal flats. The lower most units (Boulder bed) is of glacial origin, the boulder conglomerate which seprates glacial and fluvial deposit is persistent horizon and is of of glacio-fluvial (Khan *el. al* 1991) fluvial terraces are of paleo- domain of Narmada and tidal flats over top the fluvial deposits and confined along the coast line on the margin of gulf of Cambay.The top three formations Ankleshwar, Tilakwarda , Bharouche, and Aliabat are designated as (NTo-NT_3) represent thick and multiple sequences of Quaternary sediments.

Based on study of statistical parameters of sediment their deviation and breaks in vertical stratigrphic column between 00.00 to 260 m below the ground level indicate that the sediments consist of three domains viz glacial, fluvio-glacial and fluvial.(Khan et.al in press) The study of these concealed sediments, their sedimentary environments and sedimentation and correlation both in vertical and horizontal columns indicates that the lower most units, Boulder bed (20 to 260 m. below ground level) is of glacial origin, whereas the fossiliferous bed Boulder conglomerate (260 to 278m. above m.s.l.) is fluvio-glacial and top three formations in increasing antiquity are of fluvial origin. Boulder bed, Boulder Conglomerate, Ankleshwar, and Tilakwarda Bharouch & Aliabat (65 to 90 m. above m.s.l.) are fluvial origin and represent the complete sequence of Quaternary sedimentation in Central India (Khan *el al* 1991). The Alibat formation comprises of sediments of active channel deposit where as the older three Ankleshwar, Tilakwarda Bharouch formation are related to older flood plains deposits of paleo-do-main of Narmada and are grouped under older alluvium. Boulder conglomerate of fluvio-glacial origin is assigned an independent formational status based on distinct lithology and fossil assemblage. Boulder conglomerate is assigned an independent formational status based on distinct lithology and fossil assemblage. The sequence of Quaternary events and the history of sedimentation of Narmada indicate that the upper 180 of the Narmada alluvium was deposited in two distinct aggradations episode with a distinct and well defined break in sedimentation in rift system. The dissection of the quaternary blanket resulted two terraces (NT_3-NT_2), after break in sedimentation. The sediments of this aggradations episode constitute tour lithostratigraphy units Ankleshwar and Bharouch & Aliabat formation. The sediments of the alluvial phase are underlain by a boulder bed of glacio-fluvial origin. Thus, the boulder conglomerate, the basal unit of alluvium marks disconformities between the lower glacial-boulder layer and upper fluvial sediments. The fossiliferous basal boulder conglomerate is being of middle Pleistocene age (Khan 1992)..

The stratigraphic succession of Quaternary sediments in lower Narmada valley comprise of four distinct groups of deposits viz. glacial, fluvio- glacial and fluvial ad tidal flats ; their age, litho constituents, environments of deposition and associated geomorphic elements are given in tables.(Table No QGT-9)Khan et.al. (2015),Khan et.al.(2016) Khan et.al.(2016)

ii. Glacial/Fluvio-glacial deposit

The glacial fluvio-glacial deposits of Narmada unconformably overly the Vindhyan and Deccan Trap rocks. The sediments consist of a heterogeneous assemblage of sub-angular to angular, sub-rounded, unsorted, unstratifiedrock fragments ranging from boulders to small pebbles, predominantly of quartzite, gneiss, sandstone, basalt, jasper, chart, gneiss, sandstone, basalt, chart, altered feldspar, ferruginous nodules, in a matrix of very coarse to very fine-sand, silt and clay. These clastics are highly angular, generally poorly sorted and imbricated in fine matrix. The fine sediments comprise of reddish grayish and greenish sand with appreciable amount of mica flaks, altered feldspar, brick-red and

buff silt, greenish-brown silt and clay, and greenish, reddish and dark maroon hard and plastic clay. These fine sediments contain fairly good amount of ferruginous material, quartz, mica flakes and altered feldspar grain. Thouough these sediments are similar in composition to the other deposits of Narmada but exhibit entirely different sedimentary pattern, sediment characters and mineral composition. These rock clastics are largely angular, very poorly sorted and demonstrate isotropic pattern in the valley. The sediments of glacial domain of Narmada were deposited in glacial environments during Pleistocene time. These deposits are concealed under boulder conglomerate in the valley.

iii. Fluvio-glacial deposits (Boulder Conglomerate)

The conglomerate bed which constituted the fossiliferous horizon of Narmada is sandwiched between older fluvial sediment of paleo -domain and the glacio-fluvial boulder bed. This conglomerate bed is a very persistent horizon indicating a distinct phase of sedimentation in the valley. It is exposed in the bluff/scrap of Narmada around at the base of terraces NT_2 (Khan, 1984). The measured exposed thickness of the boulder conglomerate in western sector of Narmada is about 16.5 m and average thickness is 12.00 m.

The boulder conglomerate predominantly consists of sub-rounded to well rounded boulder, cobble and pebble of quartzite, gneiss, sandstone, basalt, agate, jasper, chert, chalcedony tightly cemented in a matrix of sand and silt. The finer sediments include different grade of sand and silt, brown and maroon in color often laminated and cross laminated. The skull cap of early man *Homo erectus* is recovered from boulder conglomerate (Sonakia, 1984).

It consists of three sub-litho units; each sub-unit characterized by distinct rock fragment shape, size, lithological abundance and allied sediment characters. The sub-units are composed of variable assemblage of quartzite, gneiss, basalt, sandstone, agate, jasper, chalcedony, chart, sand and silt (Khan1992) These sub-litho units display facies variation in the valley and upper units grades into gritty sandstone upstream of Tilakwarda Hathnora. The rock clastics of boulder conglomerate are tightly cemented in deep brown and maroon sand, silt and clay. The finer clastics display sedimentary feature like lamination, cross-bedding load structure, small ripples and, cut and fill feature. The cross-bedded units are often truncated by a pebbly layer at the top. The average measured thickness of these sub-units is about 2m.

The boulder conglomerate is of middle Pleistocene age equivalent to Siwalik boulder conglomerate (India), Trini bed of Java (Indonesia) and boulder conglomerate of Tapti (Khan.1982) These deposits have yielded skull cap of early man, *Homo erectus* Narmadensis along with other mammalian fossils Sonakia, (1984). (Khan 1991) has identified and recorded Ash bed of Quaternary age associated with these deposits around Timrawan upstream of Hathnora is of Aeolian nature and perhaps indicates volcanic activity during middle Pleistocene time.

iv. Fluvial deposit of paleo domain of Narmada

The Fluvial deposit of conformably overlies the boulder conglomerate and represents the flood-plain fancies of palaeo -domain of Narmada. The sediments facies predominantly consist of clay silt and sand, calc nodules and calc matrix. The sediments are horizontal disposed and exhibit upward fining sequence typical of fluviatile deposits. The Fluvial deposit of paleo-domain of Narmada can be divided into three formations based on lithology, sediment assemblage, shape and size of rock clastics, relative disposition and diagnostic sedimentary characteristics. These formations are, viz. where as the older three Ankleshwar, Tilakwarda Bharouch formation Aliabat are related to older flood plains deposits of paleo-do-main of Narmada respectively. These formations represent the sediments of the palaeodomain of Narmada deposited in channel and flood plain environments during Upper Pleistocene times Khan & Sonakia (1992).

The younger alluvium is represented by sediments of active flood plain, point bar and sand bar facies of present domain of Narmada and consist of unconsolidated imprecated, stratified, polymodal sorted rock-gravel supported by very coarse to very fine-sand and is named as Aliabat formation. (Table No QGT-9).

In Narmada Rift system taking as single ecological unit for Quaternary sedimentation & tectonics and presence of the Katni Formation in central sector with angiosperm flora suggests that sedimentation continued during Mio-Pliocene in localized lakes. The relative disposition of such lakes and subsequent deformation and structural dislocation on oscillating valley platform clubbed with rifting and faulting during Quaternary period has shifted the site of the lakes towards the present alluvium-covered area between Harda -Jabalpur, Garudeshwar and Bharuch as presumed: where as the present study of various aspects of Quaternary blanket in SONATA LINEAMENT ZONE reveled that quaternary sedimentation was a sequential and continuous process in rift valley system (Table No -3)from Mio-Pliocene Pleistocene time, has deposited complete sequence of glacial, fluvio-glacial lacustrine fluvial and tidal deposits with changing environments and climate in time & space . The present disposition of quaternary blankets in Son Narmada basin is due to post deposition Quaternary tectonics which is solely responsible for sedimentation, dislocation, faulting and shifting of different blocks and distorting ecology in rift system. The occurrence of Boulder bed and Boulder Conglomerate in Son Narmada Tapti and Purna with similar rock assemblages and suites of rock fabrics, heavy mineral assemblages, and quartz grain morphology in critical and crucial sections across the SONATA LINEAMENT ZONE strongly support tearing and rifting of quaternary blanket during late Pleistocene time. The presence of thick boulder bed in Harda inliers area, such as at Chandgarh and north east of Barwaha, boulder bed in confluence are of Tapti and waghur around Khadgaon in Tapti valley Khan et.al (1984) supports this assumption.

The Quaternary sedimentation incepting from glacial activity, followed by fluvio-glacial, lacustrine and fluvial phase within the rinsing and sinking environment, block faulting and segmental and linear displacement, dislocation, uplifting and isolated domal up- lift, Neogene rifting and Quaternary sedimentation, rift-bound Pliocene–Pleistocene rifting and volcanic activity specifically during glacial and fluvio-glacial phase are major component of the Quaternary period and tectonic processes of the Narmada Rift System. The Quaternary sedimentation was triggered by tectonic activities / up lift and climatic changes. The provenance for these sediments is the weathering products of eroding pre-Cambrian, meta-sediments, sedimentary and volcanic rocks along the watershed upland, rift escarpments and shoulders; faulted and uplifted blocks, volcanic fissure zones, and plateaus within and outside the rift. The Narmada Rift System, bounded by adjacent plateaus rising 300–700 m above the rift floor, consists of number symmetrical and symmetrical faulted blocks, escarpment, rock cut terraces, rock floors and segments of micro half grabben. Although rift-related basins started to form during the late Oligocene to early Miocene times, the Narmada Rifts were fully defined by middle to late Miocene time.

The Narmada rift system provided a unique setting for dynamic ecosystems that were characterized by Rift-related subsidence and coeval sedimentation also created an ideal loci of Quaternary sedimentation and environment for the accumulation of sediments volcanic fabrics sediments, burial, digenesis, and preservation of organic remains. Because rifts formed after widespread Quaternary sedimentation occurred and voluminous sediments in the rift basins were accumulated by glacial activity consequential upon the lowering of temperature and climatic changes in the region.

The Miocene -Pliocene–Pleistocene lake deposit of Katni on the eastern rift shoulder was created by faulting, topographic control, or isostatic depression similar to that of other Rift system.

In Narmada Quaternary blanket posses abundant faunal remains in rift settings, including hominids Sonakia (1984), suggest that the Narmada Rift System created productive ecosystems during Pliocene–Pleistocene time. The volcanic rocks within the fossiliferous sediments provide temporal information for calibrating and sequencing hominid and other faunal evolution. The detailed geological sedimentological geochemical study of interbedded tephra ,Quartz grain morphology of sediments of quaternary strata and palo-sole of and geochronological studies Khan (2012), Khan (2014), Khan (2014) from the different localities for establishing accurate biostratigraphic and lithostratigraphic data, sedimentation rates, and paleo-environmental and tectonic histories of different sediment columns revealed that inspite of tectonic dislocation subsidence and oscillation and rinsing and sinking platform of sedimentation there is intake sequential deposits in the rock basin representing the sediments of glacial fluvio-glacial, fluvial lacustrine and tidal environment in area along the rift system. Interbedded volcanic rocks allow determination of the time of rifting, the beginning of sedimentation, sedimentation rates, and the oscillation from glacial, fluvio-glacial lacustrine to fluvial environments. The cyclic environmental transitions recorded in the sedimentary sequences of the rift basins are caused by tectonic activities (uplift and subsidence), changes in relief, and climatic variations. The climatic changes in uplift, topographic and landscape features, coupled with block faulting, rinsing and sinking platform, created basins for the accumulations of thick lacustrine and fluvial sediments sequences with terrestrial and aquatic fossils. The sequential change in the sediment facies from finely bedded lacustrine deposits to fluvial sediments are commonly noted in the sedimentary sequences and reflect environmental and tectonic changes that can be temporally determined. Moreover, regional correlation based on the chemistry and geochronology of interbedded tephra has made it possible to establish accurate stratigraphic relations that are useful for paleo- environment reconstruction and evolutionary studies of fossil remains in the Narmada rift valley Khan et.al. (2012). Regional tephra correlation is being used increasingly to link sites together, and has already established that similar tephra layers are known from other parts of rift valley, as well as from other basin and peninsular India Achariya,(1998), Biswas, Khan (1992) Khan et.al. (2012) Tiwari (1992) There is a great potential for further correlation of tephra in the Rift System and marine sediments in the Arabian Sea. The Arabian Sea has a continuous record of deposition that extends to at least 7 million years. The Quaternary sediments interbedded with tephra with within the age range of the ODP Ocean Drilling Program 721/722 stratigraphic sections of the Arabian Sea are also present within the rift floor and the western rift margin of the region. The chemical and chronological correlations of ash beds within the rift sequences of have been made with ashes described in marine sections. Detailed correlations based on orbitally calibrated time scales of pale magnetic stratigraphy Rao (1997) within Quaternary sediments of rift deposits will provide ties to establish global climate changes based on the terrestrial and marine sediments of the rift system.

The tephra layers associated with Quaternary deposits of Narmada Rift valley has under gone faulting, rifting, and dislocation during sedimentation. The impact of structural disturbances and\evidence of the effects of tectonics on fauna and flora are distinct and its signatures on dislocation and concealing of fossiliferous horizons are uncontrolled and ill defined in the ecosystem in the valley during the Pliocene–Pleistocene periods. The boulder conglomerate which yielded the skull cap of *Homo eructs* in Narmada rift from Hathnora Sonakia (1984) remained only discovery of hominid fossil in last two and half decade due inconsistency concealed nature of fossiliferous horizon due faulting, dislocation and subsidence of Quaternary blanket of Narmada rift system as such researcher and scientist failed to add any further knowledge to hominid discovery in Narmada any further.

The present an integrated analysis of the stratigraphy of the Quaternary deposits of the western Narmada valley; is based on multiple criteria of morphostratigraphy, soil

stratigraphy, tephra stratigraphy, lithological assemblage, biostratigraphy volcanic ash bed and polarity. Based on critical data analysis the stratetigraphy of quaternary deposit of Narmada Valley has been attempted for the first time. Based on analysis of multiple thematic data the stratigraphic classifications summarized in(Table NoQGT_9 Plate No_15 &_17)

Summary & Conclusion

The SONATA LINEAMENT ZONE embodies the two Quaternary basins of tectonic origin on the two margins of Sapura Crustal Block. The Satpura block traversed by enechelon system of faults and lineaments is characterized by thinner crust (33-38 km deep, basement depth >2.5 km) with series of ENE-WSW trending gravity high (viz. Sendwa, Khandwa, Chicholi, Tikaria etc.) with amplitudes of 10-35 mgal. The chain of gravity high indicates extensive magmatic and emplacement of derivatives at shallow crustal levels. The associated Narmada South (Satpura North) fault and Satpura South Fault marking the two hinges of the Satpura block are fundamental in nature and extend to Moho level. The Narmada Quaternary basin in the north and Tapti-Purna basin in the south are two Graben which formed prominent loci of sedimentation in lineament zone. The area of lineament zone studied tectonically encompasses two crustal provinces of Central India Shield, namely, the Northern Crustal Province (NCP) and the Southern Crustal Province (SCP). The two provinces are separated by a crustal level shear zone, referred as Central Indian Suture. The zone has been a major locus of episodic tectonism with evidences of reactivationand Quaternary sedimentation.

The Narmada Rift valley forms an ENE-WSW lineament where Quaternary deposits are confined in a trough like basin on unstable platform which forms a prominent lineament with profound geomorphologic and geological asymmetry between the northern and southern valley walls, giving it a tectonic significance. The alluvial deposits of the Narmada valley represent the thickest Quaternary deposits in peninsular India. These sediments were deposited in faulted and sinking platform under structural riparian rift trench remained silent and unrevealed. The quaternary blanket of Narmada consists of sediments of various domains which were deposited in different environment in vertical chronology in faulted trough in time and space.

The Quaternary sedimentation in Narmada Rift valley incepting from glacial activity, followed by fluvio-glacial, lacustrine and fluvial phase within the rinsing and sinking environment, block faulting and linear displacement and dislocation, uplifting and isolated domal up- lift, Neogene rifting and Quaternary sedimentation. The rift-bound Pliocene–Pleistocene rifting and volcanic activities specifically during glacial and fluvio-glacial phase are major component of the Quaternary period and tectonic processes of the Rift System which form the base of quaternary deposits. The Narmada rift system basin platform provided a unique setting for dynamic ecosystems that were characterized by Rift-related subsidence and coeval sedimentation and environment for the accumulation of sediments volcanic fabrics sediments, burial, digenesis, and preservation of organic remains.

The present disposition of Narmada blanket of Narmada, in SONATA LINEAMENT ZONE revealed that the rift occurred after widespread Quaternary sedimentation and accumulation of sediments in the linear trench by glacial activity in late Pleistocenc.The Fluvio-glacial phase is represents by boulder conglomerate which has formed the persistent horizon in the valley. The Narmada has in the area under study has sculptured the alluvial tract into stepped sequence forming four alluvial terraces along its course. These are designated as NT0 to NT3, NT0 being the youngest terrace and NT-3 the oldest terrace where the sub terraces are designated NT2-A is NT2-B, NT2 B, besides NT2-C, NT3-A & NT3-B in increasing order of antiquity. These are both erosional and depositional terraces and confined at an elevation of, between 280 to 380 are separated by the scarp both of curvilinear and linear in nature facing towards river side. These are abandoned flood plains represent the level of former valley floor in the area, and were formed by cumulative climato-tectonic

changes in the watershed of Narmada in the Quaternary times Khan et.al (2016)

The Narmada Rift valley formed a linear trench in the middle of Indian subcontinent was an ideal locus for accumulation of sediments. The rift trench is intruded by the dolerite and other mafic and siliceous dykes and sills along lineaments in different phases of tectonic deformation. The Quaternary sedimentation incepting from glacial activity, followed by fluvial-glacial, lacustrine and fluvial phase within the rinsing and sinking environment, block faulting and segmental and linear displacement. The instability of turmoil sedimentation platform, dislocation, uplifting and isolated domal up- lift, Neogene rifting, sedimentation and rift-bound Pliocene–Pleistocene rifting and volcanic activity specifically during glacial and fluvial-glacial phase are major component of the Quaternary period and tectonic processes of the Narmada Rift System which form the base of quaternary deposits. The rift system and basin platform provided a unique setting for dynamic ecosystems that were characterized by rift-related subsidence and coeval sedimentation created an ideal ecologyand loci of Quaternary sedimentation and environment for the accumulation of sediments. The disposition of quaternary deposits, drainage configuration basin boundary and geotectonic of the area revealed that rifts was formed after widespread Quaternary sedimentation occurred and voluminous sediments in the rift basins were accumulated by glacial activity, it is also witnessed by present disposition of quaternary blankets of SONATA LINEAMENT ZONE.

The Narmada valley consists of sediments of three domains viz glacial, fluvio-glacial and sediment of paleo-domain of Narmada.

The glacial and fluvio-glacial deposits of Narmada unconformable overly the Vindhyan and the basaltic Deccan Trap rocks. The sediments consist of a Hetero-heterogeneous assemblage of sub-angular to angular, sub-rounded, unsorted, stratifiedrock fragments ranging from boulders to small pebbles, predominantly of quartzite, gneiss, sandstone, basalt, jasper, chart, gneiss, sandstone, basalt, chart, altered feldspar, ferruginous nodules, in a matrix of very coarse to very fine-sand, silt and clay. These clastics are highly angular, generally poorly sorted and isotropically imprecated. Fine sediments comprise of reddish grayish and greenish sand with appreciable amount of mica flaks, altered feldspar, brick-red and buff silt, greenish-brown silt and clay, and greenish, reddish and dark maroon hard and plastic clay. These fine sediments contain fairly good amount of ferruginous material, quartz, mica flakes and altered feldspar grain. Through these sediments are similar in composition to the other deposits of Narmada Valley, exhibit entirely different sedimentary pattern, sediment characters and mineral composition. These rock clastics are largely angular, very poorly sorted and demonstrate isotropic imbrications pattern in the valley. The sediments of glacial domain of Narmada occur between and average elevation of about 20-265 m above m.s.l. and were deposited in glacial environments during Pleistocene time. These deposits are concealed under boulder conglomerate in the valley.

The Fluvio-glacial deposits are represented by conglomerate bed that constituted the fossiliferous horizon of Narmada is sandwiched between older Alluvium and the glacio-fluvial bounder bed. This conglomerate bed is a very persistent marked horizon indicating a distance phase of sedimentation in the Narmada Valley. The boulder conglomerate predominantly consists of sub-rounded to well rounded boulder, cobble and pebble of quartzite, gneiss, sandstone, basalt, agate, jasper, chert, chalcedony tightly cemented in a matrix of sand and silt. The finer sediments include different grade of sand and silt, brown and maroon in color often laminated and cross laminated. The boulder conglomerate is fossil and skull cap of early man *Homo erectus* (Sonakia, 1984)

The boulder conglomerate consists of three sub-litho units; each sub-unit characterized by distinct rock fragment shape, size, lithological abundance and allied sediment characters. The sub-units are composed of variable assemblage of quartzite, gneiss, basalt, sandstone, agate, jasper, chalcedony, chart, sand and silt (Khan1992) These sub-

litho units display fancies variation in the valley and upper units grades into gritty sandstone upstream of Hathnora

The Fluvial sediments of paleo-domain of Narmada conformably overlie the boulder conglomerate and represent the flood-plain fluvial facies of the Narmada. The sediments of the fancies predominantly consist of clay silt and sand, discontinuous nodules and plates. The beds are horizontal, exhibit upward fining sequence typical of fluviatile deposits .This domain may be divided divided into three formations based on lithology, sediment assemblage, shape and size of rock clastics, relative disposition and diagnostic sedimentary characteristics. These formations are, viz. (i) Shohagpur, (ii) Shahganj, and (iii) Hoshangabad Formations respectively. These formations represent the sediments the complete sequence of Narmada deposited in channel and flood plain environments during Upper Pleistocene times.It consists of sediments of paleo-domain of Narmada. It is represented by a thick sequence of clay, silt-sand and rock gravels. The unit is divisible into three sub litho unit. The basal sub-unit is chiefly red and brownish sand, silt, clay containing appreciable amount of cal matrix. The average measured thickness of this sub-unit is about 6.25m. The middle sub-unit consists of yellow and brownish silt, clay with subordinate sand and occasional rock gravel lenses. The average measured thickness of this sub-unit is about 5.50m. The upper sub-units predominantly consist of compact yellow clay, silt and calcareous concretion. The average measured thickness of this sub-unit is about 3.25m.

The Narmada valley in Jabalpur- Harda Gurudeshwar- Bharuchsection possess the complete sequence of all three domain of sediments in increasing antiquity from the bottom of the rift trench, Boulder bed (glacial), Boulder conglomerate (fluvial-glacial) sediments of paleo-domain of Narmada (fluvial). The intense tectonic activities within the basins of the Narmada Rift System during the Neogene and Quaternary periods have destroyed fossil record except the fossiferous horizons exposed in river sections. The erosional-sedimentary cycle has persisted in the rift valley environment for millions of years as a result of the interplay between depositional and erosional forces driven by tectonic processes; there are numerous gaps in the fossil record, particularly in the important time period between Mio-Pliocene Pleistocene times. It is pertinent to the understand the origin of Hominid during the late Miocene, but it is difficult to disclose mysteries of human evolution in Narmada due to concealed nature of these deposits in rift system, however the complementary part of Tapti-Purna Quaternary blanket may be potential and possessive of human remain and should be studied to trace further the imprints of fossil man taking in to account of SONATA LINEAMENT ZONE as single ecosystem for evolution of man in Indian subcontinent. However, evidence of the effects of tectonics on fauna and flora are distinct and its signatures on dislocation and concealing of fossiliferous horizons are uncontrolled and ill-defined in the ecosystem in the valley during the Pliocene–Pleistocene periods. The boulder conglomerate which yielded the skull cap of *Homo eructs* in Narmada rift from Hathnora Sonakia (1984) remained only discovery of hominid fossil in last two and half decade due to concealed and hidden nature of Mio-Pliocene Pleistocene deposits in rift system and inconsistency in exposure of fosiliferous horizon due faulting, dislocation ad subsidence of Quaternary blanket of Narmada rift system.

The Narmada rock basin of Narmada is occupied by the Quaternary sediments of three domains viz. glacial, fluvio- glacial and fluvial which were deposited in distinct environments during Quaternary time. The glacial deposit comprised of thick pile of sediments occupied base of rock basin and was deposited by glacial activities in dry and cold climatic condition during early Pleistocene time. The study of these concealed sediments, their sedimentary environments and sedimentation and correlation both in vertical and horizontal columns indicates that the lower most units, Boulder bed (20 to 260 m. below ground level) is of glacial origin, where as the fossiliferous bed Boulder conglomerate (260 to 278m. above m.s.l.) is of fluvio-glacial and top four formations in increasing

antiquity Sohagpur, Shahganj, Hoshangabad and Janwasa (278 to 350m. above m.s.l.) are of fluvial origin and represent the complete sequence of Quaternary sedimentation in Central India Khan & Sonakia (1992).). The boulder conglomerate is a marker horizon of Quaternary sedimentation in Narmada Valley and as well in Central India, its disposition and relation with other deposits in the valley, indicates a significant change in regional climate from cold dry to warm and humid, during which the sediment were re-worked from glacial front intermittently and deposited in the valley over a very long time. The skull cap of *Homo erectus* (Narmada Man) and other fauna recorded along with calc- nodules within the boulder conglomerate; suggest that warm climatic phase prevailed for very long time.

The Boulder Conglomerate which is of fluvio-glacial origin and has yielded human skull from Sonakia (1982) Khan &Sonakia (1992) is exposed impersistently in scarp section of Narmada at few places only. The type section of Boulder Bed and Boulder *Conglomerate* which are potential sediments of human remains of Pliocene Pleistocene time are hidden and concealed under sediments of present and paleo- domain of Narmada in the valley.

The skull cap of *Home erectus*(Sonakia1984) and other fauna recorded along with calc-nodules near village Hathnora (22 ° 52" N; 77 ° 52" E) in fossiliferous boulder conglomerate; named as Hathnora formation Khan & Sonakia (1992). It is found to be associated with volcanic Ash bed of Quaternary age in the area around Hathnora, and upstream Khan et.at. (1991). The two levels of horizons of Ash bed identified are designated as NAB-I and NAB-II in ascending antiquity in the valley. The Ash bed NAB-1 is associated lower litho units of boulder conglomerate which is well preserved and persistent where as NAB-II is associated with younger deposits. The NAB-1 contains three micro layer (L-1 to -L3) and NB-II two micro layers (L-4 to L-5) in increasing antiquity.

In Narmada valley the association of Ash bed NAB-I with Hathnora formation at the depth of 78 m in Quaternary column and occurrences skull cape *of Homo erectus* at the depth of 83 m in decreasing antiquity from the top assumed that Toba eruption have taken place later than existence of *Homo erectus* which appeared and resided in the valley for long time before the fall of Toba ash. The association of Ash is NAB-II at the depth of 72 m with the younger deposit revealed the second cyclic fall of Toba ash which certainly have had influenced on hominines and had collective and cumulative impact on *Homo erectus* (Sonakia1984) *Homo sapiens* (Thobold 1860, 81), in Narmada valley and Indian sub-continent. Oppenheimer (2003) argues that *Homo. Sapiens*occupied India before ~74 ka and may have undergone "mass extinction" as a result of the Toba eruption. The argument of Oppenheimer (2003) is in strong conformity with the present observation of authors. As sediment & Ash bed sequence of Quaternary column of Narmada (325 m) and occurrences of fossil of skull cape *of Homo erectus* (Sonakia1984) at 83 m & human cranium *Homo sapiens* (Thebold 1960, 1981) transported have existed prior to fall of Toba ash and they are among the few who inspite of mass extinction caused by mega dislocation in ecology and environment related with volcanic eruption survived in Narmada Valley. It is further documented by the rarest occurrences of these fossils in subcontinent which also confirm the intensive impact of volcanic ash fall on these hominines and their consequential mass extinction.

The skull cap of Narmada Man *Homo erectus* was found in Narmada Valley near village Hathnora (22 ° 52" N; 77 ° 52" E) in fossiliferous boulder conglomerate, in district Sehore, M.P., India. The skull cap is completely fossilized undistorted, renal vault nearly complete except few left Supra-orbital and statures are nicely preserved. The various morphological features and robust form of skull and excessive thickness of the bones indicate that it belongs to adult male individual (Sonakia, 1984). The discovery of skull cap of *Homo erectus* in fossiliferous boulder conglomerate in association of other mammalian fossil is recorded in stratigrphic column of Quaternary deposits at the depth of 83 m , where estimated total thickness of deposits is about (325 m).This blanket

consist of sediments of three domain viz. glacial, fluvio-glacial and fluvial, which were deposited in distinct environment during Pleistocene to Holocene time (Khan & Sonakia (1992), (Khan et.al. in press).The statistical analysis of sediments form these different domain in vertical column has been conducted to ascertain the environment of sedimentation and trace the breaks in climate (Khan et.al. in press). An attempt has been made for the first time Khan et.al (2013) to correlate the various stratigraphic columns of associated hominid fossils of Narmada valley (325 m) India and that of Luochuan sequence,(90-120 m) Chenjiawoe (50m) and Congwanling sequence (36 m) of China on unified Quaternary platform tied up and developed at mean sea level. The study revealed that the depth of occurrence of Narmada skull cap on unified Quaternary platform is about (83 m) as compared to with that of Chenjiawo and Gongwangling of China which occur at very shallow depth of 38 and 26 m respectively. The estimated age of Narmada Man based on these parameters is about 1.38 m.y. (+), which is greater than *Homo erectus* of Chenjiawo 0.65 m.y. and Gongwangling 1.15 m.y. of China An Zhisheng and Ho Chuan Kun (1989). On the merits of correlation of startigraphic columns of Quaternary of Narmada, accumulation of sediment, rate of sedimentation, palaeo-environments, lithostratigraphy and biostratigraphic position of boulder conglomerate in unified Quaternary Platform, author consider it as one of the earliest and oldest *Homo erectus* in Asia. Khan et.al (2013) Khan2016).

The area around Hominid locality of Hathnora area is occupied by thick Quaternary sediments which represent various domain of sedimentation. Based on sedimentological characters, depositional environments, and erosional processess and their correlation with depositional / erosional terraces revealed that quaternary blanket is consisting of three domains of sediments viz glacial, fluvio-glacial and fluvial. The lower most units (Boulder bed) is or glacial origin, the boulder conglomerate of glacio-fluvial (Khan *el. al* 1991) and fluvial terraces are of fluvial paleo- domain of Narmada. The top four formations Sohagpur, Shahganj, Hoshangabad and Janwasa are designated as (NT_o-NT_3). Boulder conglomerate is assigned an independent formational status based on distinct lithology and fossil assemblage. The sequence of Quaternary events and the history of sedimentation of Narmada indicate that the upper 70m top 90m of the Narmada alluvium was deposited in two distinct aggradations episode with a distinct and well defined break in sedimentation in rift system. The dissection of the quaternary blanket resulted two terraces (NT_3-NT_2), after break in sedimentation.The sediments of this aggradations episode constitute three lithostratigraphy units Sohagpur, Shahganj, Hoshangabad formation. The sediments of the alluvial phase are underlain by a boulder bed of glacio-fluvial origin. Thus, the fossiliferous boulder conglomerate, the basal unit of alluvium marks a disconformity between the lower glacial-boulder layer and upper fluvial sediments. The fossiliferous basal boulder conglomerate is being of middle Pleistocene age (Khan 1992).

In India Narmada basin considering the one of a main loci of Quaternary sedimentation, and assuming the uniform accumulation rate of sediment in the basin in the line of Ma. et. al. (1978) Yobin Sun & Zhisheng, An (2005) and comparing the Narmada sequence of Quaternary deposit (325 m.) with those of Luochuan standard sequence of Chenjiawo and Congwangling sequence of China. The skull cap of *Homo erectus* (Narmada Man) recovered from the boulder conglomerate of fluvio-glacial origin in middle part of Quaternary column from deep level of Narmada, at the depth of 83 m. above glacial deposits, in association of ash bed, as compared to Chenjiawo Hominid from inter bedded sequence of paleo sols loess and silty loess at the depth of 38 m. and Congwangling 26 m. from paleo sols which are younger than Narmada deposits.

The Narmada skull cap of *Homo erectu*s which is recovered from the vom of basal unit of boulder conglomerate at the depth of 83 m. (278 m. above m.s.l.) is estimated to be of upper segment of lower Pleistocene age. It is older than the *Homo erectu*s of Chenjiawo, Congwangling of China which were recovered from paleo-sole and loess

deposit at the depth of 38 and 26 m. The Quaternary sequence of Narmada (325 m.) as compared to Louchuan (136 m.) sections of China on unified Quaternary platform is older and represents the complete and type sequence of Quaternary sedimentation in Narmada Rift System in Central India. The occurrence of skull cap of early man at the depth of 83 m. in basal unit of boulder conglomerate of fluvio-glacial origin in Narmada Valley is one of the earliest and oldest *Homo erectu*s in Asia.

The skull cap of Narmada Man *Homo erectus* was found in Narmada Valley near village Hathnora (22 ° 52" N; 77 ° 52" E) in fossiliferous boulder conglomerate, in district Sehore, M.P., India. The skull cap is completely fossilized undistorted, renal vault nearly complete except few left Supra-orbital and statures are nicely preserved. The various morphological features and robust form of skull and excessive thickness of the bones indicate that it belongs to adult male individual (Sonakia, 1984). The discovery of skull cap of *Homo erectus* in fossiliferous boulder conglomerate in association of other mammalian fossil is recorded in stratigrphic column of Quaternary deposits at the depth of 83 m , where estimated total thickness of deposits is about (325 m).This blanket consist of sediments of three domain viz. glacial, fluvio-glacial and fluvial, which were deposited in distinct environment during Pleistocene to Holocene time (Khan & Sonakia (1992), (Khan et.al. in press).The statistical analysis of sediments form these different domain in vertical column has been conducted to ascertain the environment of sedimentation and trace the breaks in climate (Khan et.al. in press). An attempt has been made for the first time Khan et.al (2013) to correlate the various stratigraphic columns of associated hominid fossils of Narmada valley (325 m) India and that of Luochuan sequence,(90-120 m) Chenjiawoe (50m) and Congwanling sequence (36 m) of China on unified Quaternary platform tied up and developed at mean sea level. The study revealed that the depth of occurrence of Narmada skull cap on unified Quaternary platform is about (83 m) as compared to with that of Chenjiawo and Gongwangling of China which occur at very shallow depth of 38 and 26 m respectively. The estimated age of Narmada Man based on these parameters is about 1.38 m.y. (+), which is greater than *Homo erectus* of Chenjiawo 0.65 m.y. and Gongwangling 1.15 m.y. of China An Zhisheng and Ho Chuan Kun (1989).

The time-stratigraphic data obtained from tephra interbedded with fossiliferous Quaternary sedimentary deposits provided an important framework for the study of hominid origins, evolution, adaptations, and cultural changes. The paleoantoological Paleoanthropological information from these localities is remained closely associated with Quaternary sedimentary deposits boulder conglomerate and boulder bed often related to the trench Quaternary sedimentation , formation and development of rift and linear basin caused by repeated uplift, and the development of rift basins that began in the middle to late Pliocene and Pleistocene period. The unfortunate part of theses deposits is that due repeated tectonic dislocation and faulting they are dislocated ad distorted ad at present are concealed under the thick pile of sediments of present and paleo domain of Narmada of late Pleistocene and Holocene time. These deposits do not provide adequate opportunity to researcher to study the human remain as postulated, except in limited section where they are exposed.

In Narmada valley the most of the hominid remains and associated artifacts in the would have been found associated with Miocene Pliocene– Pleistocene sediments of boulder bed and boulder conglomerate in increasing antiquity, unfortunately same are not exposed due rift system and tectonic setting. In the rift system the type development of Quaternary blanket is confined between Jabalpur _Harda section, and Tilakwarda _Bharouch which posses the complete sequence of all three domain in increasing antiquity in chronology in vertical coloumn from the bottom of the rift trench viz Boulder bed (glacial), Boulder conglomerate (fluvio-glacial) sediments of paleo-domain of Narmada (fluvial). The intense tectonic activities within the basins of the Narmada Rift System during the Neogene and Quaternary periods have destroyed fossil record except the fossiferous horizons

exposed in river sections. The erosional-sedimentary cycle has persisted in the rift valley environment for millions of years as a result of the interplay between depositional and erosional forces driven by tectonic processes; there are numerous gaps in the fossil record, particularly in the important time period between Mio-Pliocene Pleistocene times. It is pertinent to the understand the origin of Hominid during the late Miocene, but it is difficult to disclose mysteries of human evolution in Narmada due to concealed nature of these deposits in rift system, however the complementary part of Tapti-Purna Quaternary blanket may be potential and possessive of human remain and should be studied to trace further the imprints of fossil man taking in to account of SONATA LINEAMAN ZONE as single ecosystem for evolution of man in Indian subcontinent.

The Hominids skull cap of Sonakia (1984), including other fossil assemblage suggest that the Narmada Rift System created productive ecosystems during Pliocene–Pleistocene time. The volcanic rocks within the fossiliferous sediments provide temporal information for calibrating and sequencing hominid and other faunal evolution. The detailed study geological, sedimentological, geochemical, aspects of interbedded tephra quartz grain morphology of sediments of quaternary strata paleo-sole and geochronological studies of different localities for establishing accurate biostratigraphic and lithostratigraphic data, sedimentation rates pale environmental and tectonic histories of different sediment columns in area along of the rift system, Interbedded volcanic rocks allow determination of the time of rifting, the beginning of sedimentation, sedimentation rates, and the oscillation of rift platform from glacial, fluvio-glacial lacustrine to fluvial environments. The cyclic environmental transitions recorded in the sedimentary sequences of the rift basins are caused by tectonic activities (uplift and subsidence), changes in relief, and climatic variations. The climatic changes in uplift, topographic and landscape features, coupled with block faulting, rinsing and sinking platform, created basins for the accumulations of thick lacustrine and fluvial sediments sequences with terrestrial and aquatic fossils. The sequential change in the sediment fancies from finely bedded lacustrine deposits to fluvial sediments are commonly noted in the sedimentary sequences and reflect environmental and tectonic changes that can be temporally determined. Moreover, regional correlation based on the chemistry and geochronology of interbedded tephra has made it possible to establish accurate stratigraphic relations that are useful for pale- environment reconstruction and evolutionary studies of fossil remains in the Narmada rift valley Khan et.al. (2013). Regional tephra correlation is being used increasingly to link sites together, and has already established that similar tephra layers are known from other parts of rift valley, as well as from other basin and peninsular India Basu, Biswas, and Acharyya, S.K. (1987): Achariya,(1993), Khan, (1992) Khan et.al. (2013).There is a great potential for further correlation of tephra in the rift system and marine sediments in the Arabian Sea. The Arabian Sea has a continuous record of deposition that extends to at least 7 million years. The Quaternary sediments interbedded with tephra with within the age range of the ODP Ocean Drilling Program 721/722 stratigraphic sections of the Arabian Sea are also present within the rift floor and the western rift margin of the region. The chemical and chronological correlations of ash beds within the rift sequences of have been made with ashes described in marine sections. Detailed correlations based on orbitally calibrated time scales of pale magnetic stratigraphy Rao (1985) within Quaternary sediments of rift deposits will provide ties to establish global climate changes based on the terrestrial and marine sediments of the rift system.

The rift system and platforms of sedimentation bear the imprints of and evidence of the effects of tectonics on fauna and flora are distinct, however the signatures of subsidence dislocation and concealing of fossiliferous horizons are uncontrolled and ill defined in the ecosystem in the valley during the Pliocene–Pleistocene periods. The boulder conglomerate which yielded the skull cap of *Homo eructs* in Narmada rift from Hathnora Sonakia (1984) remained

only discovery of hominid fossil in last two and half decade due to concealed and hidden nature of Mio-Pliocene Pleistocene deposits in rift system and inconsistency in exposure of fosilifrous horizon of Narmada rift system which is the handicapp in search of further human remains in Narmada valley after Sonakia (1984).

References

- Acharyya, S.K., Kayal, J.R. and Roy, A. 1998 "Jabalpur Earthquake of May 22, 1997: Constraint from after Shock Study", Journal Geological Society of India, Vol. 51, pp. 295-304. Agarwai, B.N.P., Das, L.K., Chakraborty, K. and Sivaji, C.H. 1995 "Analysis of the Bouger anomaly over central India: A
- Acharyya, S.K., Kayal, J.R. and Roy, A. 2000, Tectono thermal history of the central India tectonic zone and reactivation of major faults, Jour.Geol.Soci. India 55,239-256.
- Bhattaacharji,S; Chatterji,N; Wampler J.M. 1996 Zones of Narmada Tapti area activation and Deccan volcanisam: geochronological and geochemical evidences. Chaube, V.D.(1970): The Narmada Son line thrust, the geat boundary fault along the southern margin of the Vidhyan basin, Central India, West Commomoration Volume, Today and Tommarow printers and publishers, Faridabad. Pp.420 – 438.
- Chanda, S.K (1960) on certain structures of Heavy minerals of Assamtertiaries and their gelogical interpretation. Quart.Jour, Min.Met, India, vol 52, 141-444
- Chaube, V.D.(1970): The Narmada Son line thrust, the geat boundary fault along the southern margin of the Vidhyan basin, Central India, West Commomoration Volume, Today and Tommarow printers and publishers, Faridabad. Pp.420 – 438.
- Jain, S.C., Nair, K.K.K.and Yedekar, D.B. (1991): Geology of Son-Narmad-Tapti lineament zone in Central India, in final report "on studies in phase II special project CRUMANSONATA" progress report (unpublished) Geol. Surr. Ind.
- Jain, S.C., Nair, K.K.K.and Yedekar, D.B. (1991): Geology of Son-Narmad-Tapti lineament zone in Central India, in final report "on studies in phase II special project CRUMANSONATA" progress report (unpublished) Geol. Surr. Ind.
- Jain, S.C., Yedekar, D.B.and Nair, K.K.K (1991): Central Indian shears Zone, a major Precambrain Crustal boundary. Jour.Geol Soc. India Vol.37. pp.521 – 531.
- Jain, S.C., Yedekar, and D.B.and Nair, K.K.K (1991): Central Indian shears Zone, a major Precambrain Crustal boundary. Jour.Geol Soc. India Vol.37. pp.521 – 531.
- Jain, S.C., Nair, K.K.K.and Yedekar, D.B.(1993): Geology of Son-Narmada-Tapti lineament zone in Central India, In final report "on studies in phase II special project CRUMANSONATA" progress report (unpublished) Geol. Surr. Ind.
- Khan A.A. & Balchandran,V (1974-75) Records Volume109 of Gelogical survey Of India partI,pp.59
- Khan A.A. 1984 Geology of Geomorphological studies in parts of Narmada Basin, Sehore Dist. Of M.P. GeolSurv. Of India Progress Report (Unpublished).
- Khan, A.A. & Banerjee, S.N. (1984) Geology and Geomorphological studies in the parts of Narmada Basin, Sehore district of M.P. Un Pub. Report. Geol. Surv. India.
- Khan, A.A. (1984) Geological and Geomorphological studies around Tapti-Vagher confluence district Jalgaon, Maharashtra. Geol, Surv. India Rec. V.113 pt 6 pp 99-109
- Khan A.A. and Bajerjee, S.N. 1985: Geomorphological and geological studies of Quaternary sediments in collaboration with project Crumansonata in parts of the Narmada basin, Sehore, Dewas and Hoshangabad districts unpublished Geol. Surv. Ind. Progress Report.
- Khan, A.A. (1990) Geomorphology of Narmada Valley Of Jabalpur_ Handia Section Unpublished G.S.I Note.
- Khan, A.A., and Rahate, D.N (1990-91 & 1991-92) Geological and Geomor -

phological studies in parts of Narmada Basin) parts Hoshangabad and Narshingpur district, M.P. Geol. Surv. Of India Unpublished Progress Report

- Khan, A.A.(1991).Geological studies of Harda – Barwaha basin in parts of Dewas, Sehore, Hoshangabad and Khandwa districts with the Aid of Satellite imagery and Remote Sensing Techniques, Geol. Surv. Ind, Rec. Vol; 126 pt-6
- Khan, A.A, Rahate, D.N. (1991) Volcanic Ash from Quaternary deposits of Narmada Valley Central India. Proceed, of 78th session of Indian Sci. Cong. Association. (Abstract) pt. III pp 28-29
- Khan, A. A, Rahate, D.N, Fahim, M & Banerjee, S.N.(1991) Evaluation of Quaternary terrace of lower Narmada valley , Districts Sehore and Hoshangabad, Madhya Pradesh
- Khan, A.A., Rahate, D.N; Shah; (1991) M.R. and Fahim; M. volcanic Ash from Quaternary deposits of Narmada valley central India. Indian science Congress 1991
- Khan, A., &Sonakia, A. (1992). Quaternary deposits of Narmada with special reference to the hominid fossil. *Journal of the Geological Society of India*, *39*, 147-154.
- Khan, A.A, Rahate, D.N,, FAHIM, M. and Banarjee,S.N (1992) Evaluation of Geology and Geomorphology in Central Narmada Valley (Districts Sehore and Hoshangabad, Madhya Pradesh) Scientific Publishers, Jodhpur.
- Khan, A.A; Rahate D.N, Fahim, M. and Banarjee, S.N. (1992): Evaluation of Geology and Geomorphology in Central Narmada Valley (Districts Sehore and Hoshangabad, Madhya Pradesh) Scientific Publishers, Jodhpur
- Khan A.A. 1994 Geological and Geomorphological studies around Tapti-Vagher confluence district JaloaonMaharastra, Geol. Surv. Of India, Rev. Vol. 113 pt. 6 pp 99 – 109.
- Khan A.A. & Maria Aziz (2012)"Homo erectus On Unified Quaternary Platform in India and China a Correlation & Sequential Analysis". Status Published Research Scapes International Journal Vol I, Issue IV October -December 2012. (ISSN: 2277-7792).
- Khan. A.A. & Aziz, Maria (2012) "Homo Erectus & Homo Sapiens In Spectrum Of Volcanic Ecology, Narmada Valley (M.P) India"Status Published Research Scapes International Multidisciplinary Journal VolI, Issue III July-September 2012
- Khan, A.A. & Aziz; Maria (2013) Homo Erectus & Homo Sapien in Spectrum of Volcanic Ecology, Narmada valley (M.P.) India Research scapes vol. i issue -4 pp-161 -178
- Khan A.A; & Joshi O.P. (2014) Geology Lithostratigraphy And Correlation of Basaltic Lava Flows of Parts of Western Madhay Pradesh With Special Reference To Megacryst Bearing Horizons And Geotechnical Aspects For Heavy Engineerging Structures
- Khan, A.A & Aziz, Maria (2014-15) Tectonics Evolution, Quaternary Sedimentation, And The Paleoanthropological Record InThe Narmada Rift System (m.p.) Central India Khan*, A.A. Aziz, Maria International Journal for Research and Technological Sciences Vol. 1, Issue 1 (2014) 91-93 ISSN -2349-0667.
- Khan A.A. & Aziz, Maria (2015) Quaternary Tectonics & Sedimentation in Narmada Rift Valley, With Special Reference to Garudeshwar and Bharuch Section Gujarat State India, ISSN 2320-5407 International Journal of Advanced Research (2015), Volume 3, Issue 3, 430-457 430 Journal homepage: http://www. journalijar. com.
- Khan, A.A. & Aziz; Maria (2014-2015). Quaternary volcanic Eruption Toba Ash fall its impact on Environment of late Pleistocene Hominines in Indian subcontinent with Special Reference to Narmada Valley. International journal of Research in Technological sciences vol.1, Issue 2 & Vol-2 issue-1 July -January 2014 January-June 2015 PP1-18 (ISSN-2349-0667)
- Khan, A.A. Aziz; Maria (2015) A critical analysis of statistical

parameters of quaternary deposit of Hominid locality, Hathnora, Narmada valley, distirctsehore (M.P), India Jour. Of Agriculture, Foresty and Environment al Science Vol.IIssue.I July –Aug 2015 .I pp 17-29 ISSN 2454-2792.

- Khan A.A. & Aziz, Maria (2016) Heavy Minerals assemblage of quaternary column of hominid locality Hathnora, Nnarmada valley district SehoreM.P India. ISSN 2320-5407 International Journal of Advanced Research (2016), Volume 4, Issue 7, 1748-1780 Journal homepage: http://www. journalijar. com.
- Khan A.A. Maria Aziz. (2016) Quaternary tectonics & geomoprhic evolution of Narmada vally, its impact on tracing the remains of Homo erectus and other quaternary fauna & flora. ISSN 2320-5407 International Journal of Advanced Research (2016),
- Kaila, K.L.1988: Mapping the thickness of Deccan Trap flows from DSS studies and inferences about a hidden Mesozoic basin in Narmada-Tapti Region. Proc. workshop on Deccan Flood Basalts, December 1988. Geol. Surv. India. pp. 81-177
- Mishra, P.S., Venkatraman, N.V., Roy, Abhinaba and Tiwari, M.P., 1999**:** Seismotectonics evaluation of Quaternary sedimentary basins yoked with Satpura horst. Gondwana Geological magazine, Special Vol. 4, pp. 81-
- Nayak, P.N.(1990) Deep crustal configuration of central India .Geol. Surv.Ind spec. pub 28, pp 67-98
- Roy, A.K. 1971 Geology and Ground Water Resources of Narmada Valley Bult of Geol
- Ravi Shankar, 1987 : History and status of geothermal exploration in the Central Region (M.P. & Maharashtra). Rao, Geol. Surv. Ind., 115, pt. 6 , pp. 7-29.
- Sonakia A. 1984 The Skull Cap of Early man and associated mammalian fauna from Narmada Valley alluvium Hoshangabad area. Madhya Pradesh, India Rec. GeolSurv. India Vol. 113, Pt. 6 pp 159-172

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Plate No.1

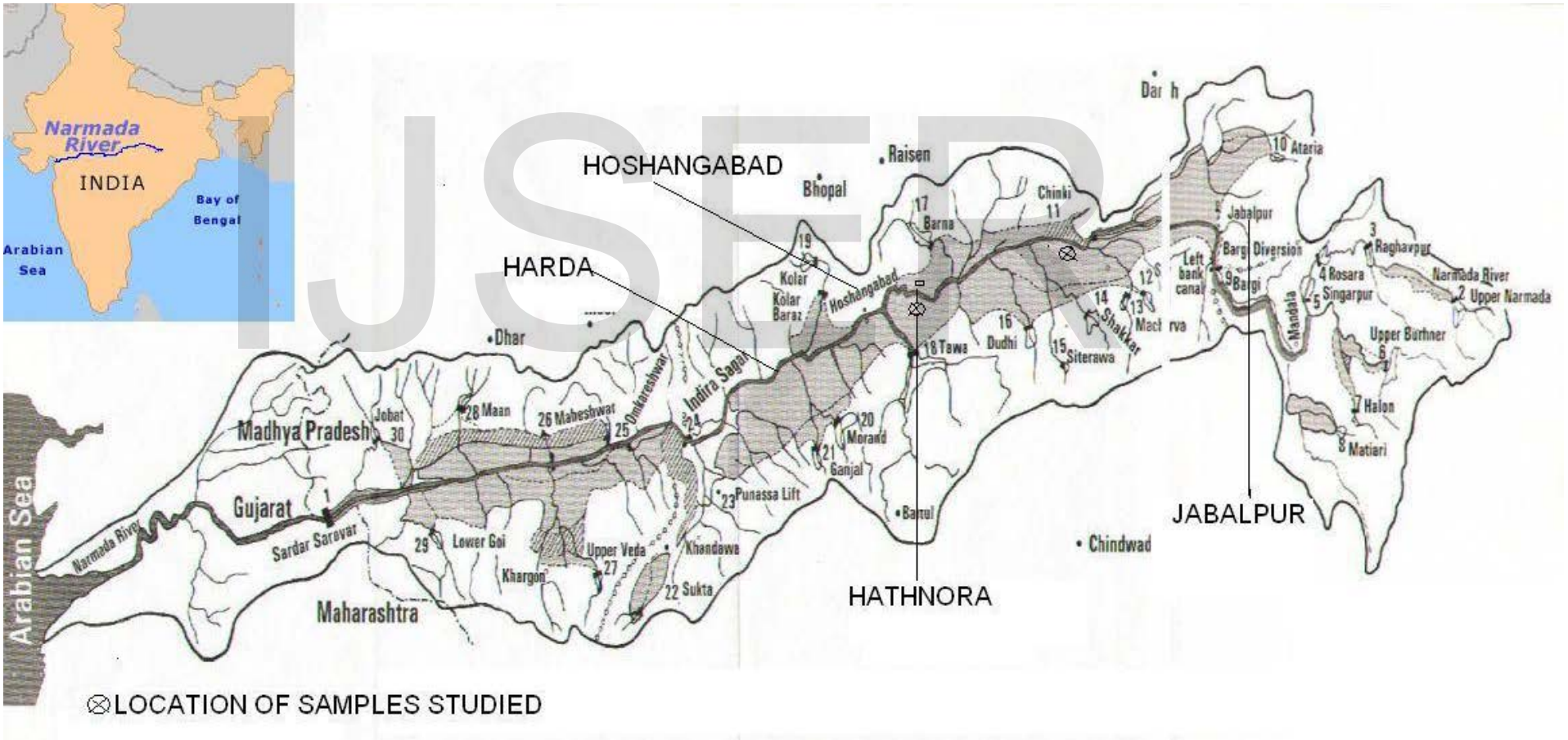
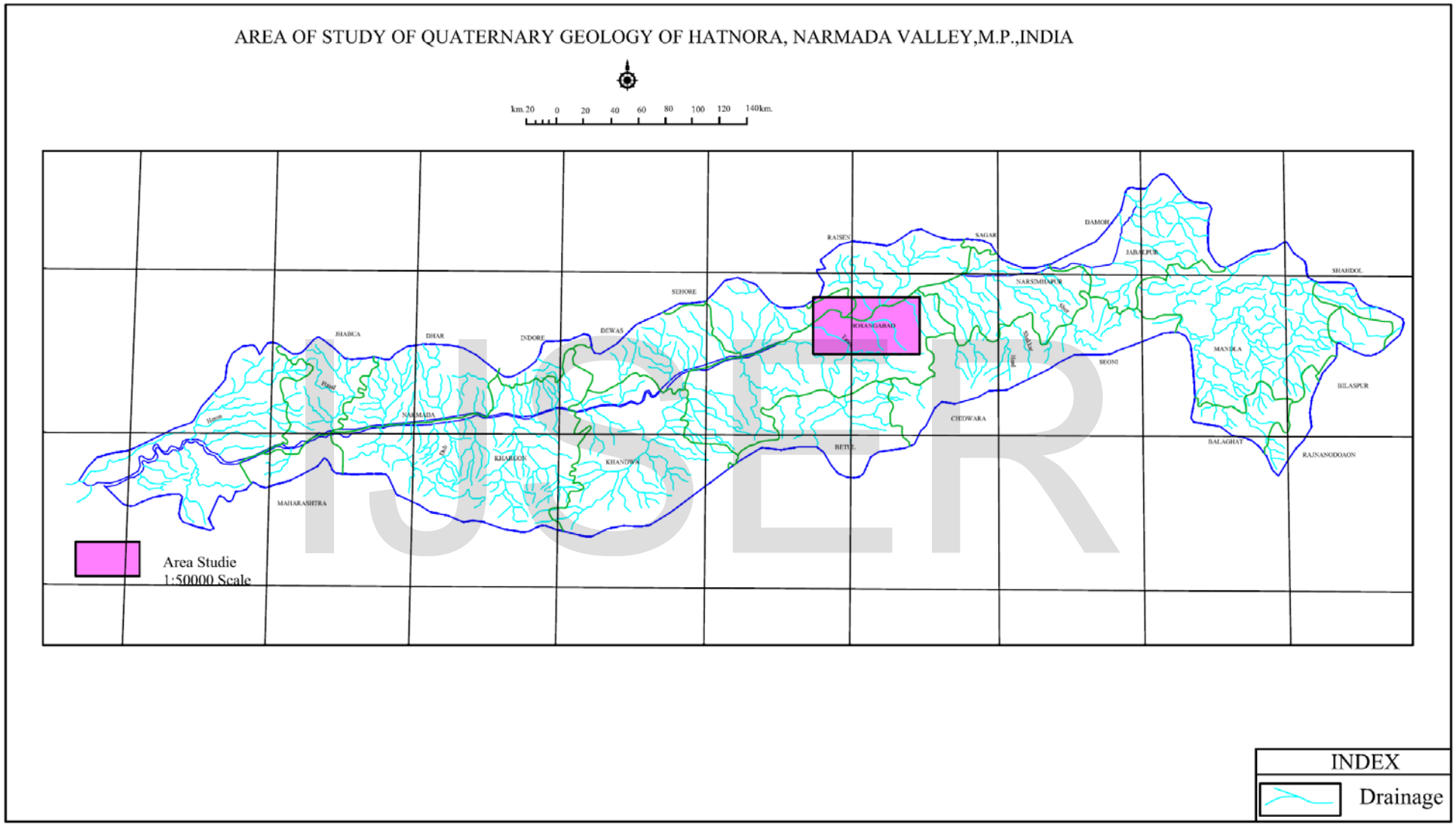

Narmada River
INDIA
Bay of Bengal
Arabian Sea
HOSHANGABAD
HARDA
HATHNORA
JABALPUR
Bhopal
Raisen
Dhar
Madhya Pradesh
Gujarat
Maharashtra
Arabian Sea
Narmada River
Sardar Sarovar
Indira Sagar
Omkareshwar
Maheshwar
Jobat
Maan
Lower Goi
Upper Veda
Khargon
Khandawa
Sukta
Punassa Lift
Barwal
Chindwad
Ganjal
Morand
Siterawa
Dudhi
Tawa
Kolar
Kolar Baraj
Hoshangabad
Barna
Chinki
Shakkar
Ataria
Jabalpur
Barga Diversion
Left bank canal
Bargi
Rosara
Singarpur
Raghavpur
Narmada River
Upper Narmada
Mandala
Upper Burhner
Halon
Matiari
LOCATION OF SAMPLES STUDIED

Plate No.2


AREA OF STUDY OF QUATERNARY GEOLOGY OF HATNORA, NARMADA VALLEY,M.P.,INDIA
km.20 0 20 40 60 80 100 120 140km.
JHABUA
DHAR
INDORE
DEWAS
SEHORE
RAISEN
SAGAR
DAMOH
JABALPUR
NARSIMHAPUR
HOSANGABAD
SHAHDOL
SEONI
MANDLA
BILASPUR
CHIDWARA
BALAGHAT
RAJNANDGAON
BETUL
KHARGON
KHANDWA
MAHARASHTRA
NARMADA
Area Studie
1:50000 Scale
INDEX
Drainage

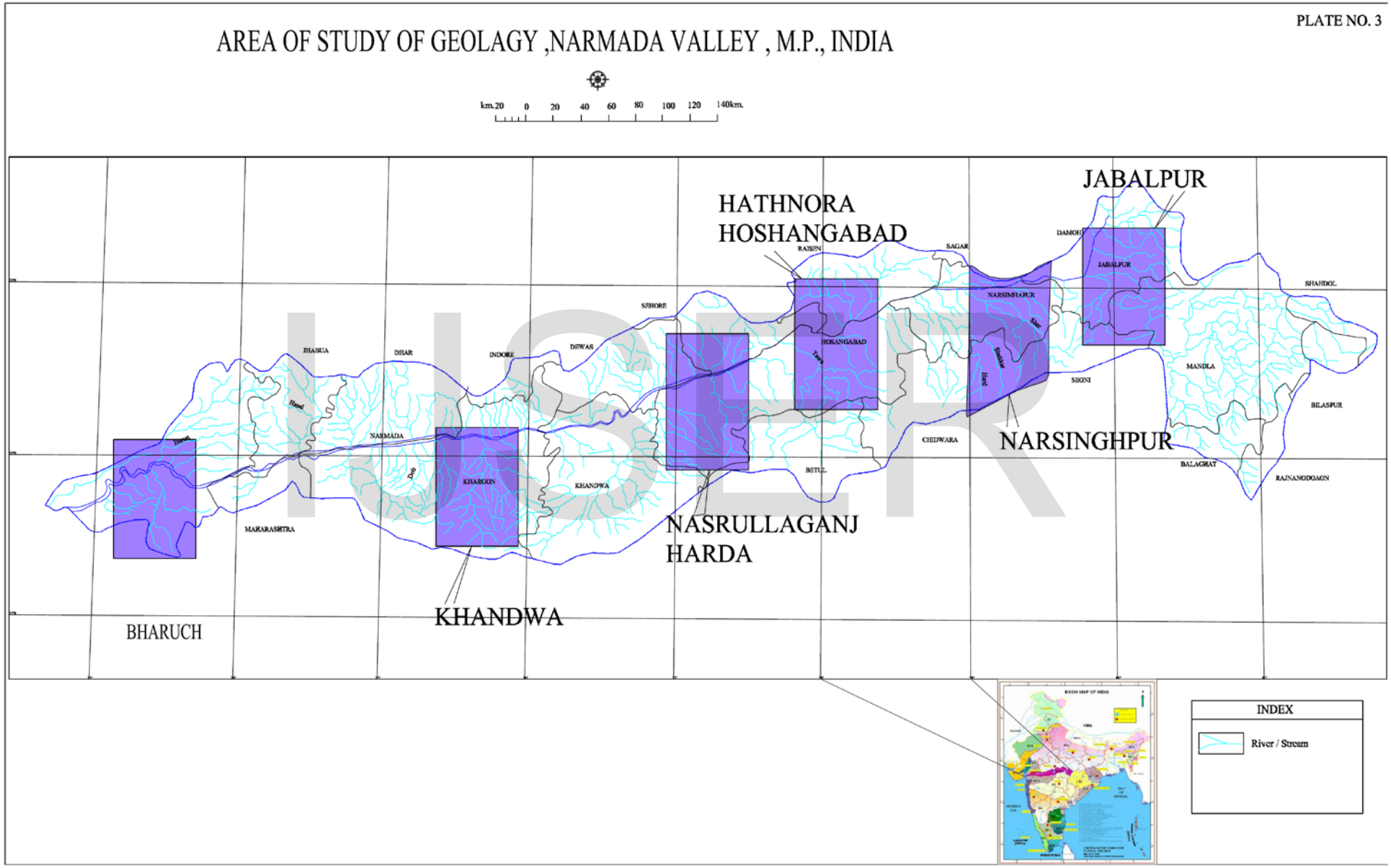


PLATE NO. 3
AREA OF STUDY OF GEOLAGY ,NARMADA VALLEY , M.P., INDIA
km.20 0 20 40 60 80 100 120 140km.
HATHNORA
HOSHANGABAD
JABALPUR
NARSINGHPUR
NASRULLAGANJ
HARDA
KHANDWA
BHARUCH
RAISEN
SAGAR
DAMOH
JABALPUR
SHAHDOL
NARSIMHAPUR
SEHORE
HOSANGABAD
DEWAS
INDORE
DHAR
JHABUA
SEONI
MANDLA
BILASPUR
CHHINDWARA
BETUL
KHARGON
KHANDWA
NARMADA
MAHARASHTRA
BALAGHAT
RAJNANDGAON
INDEX
River / Stream

Plate No. 4

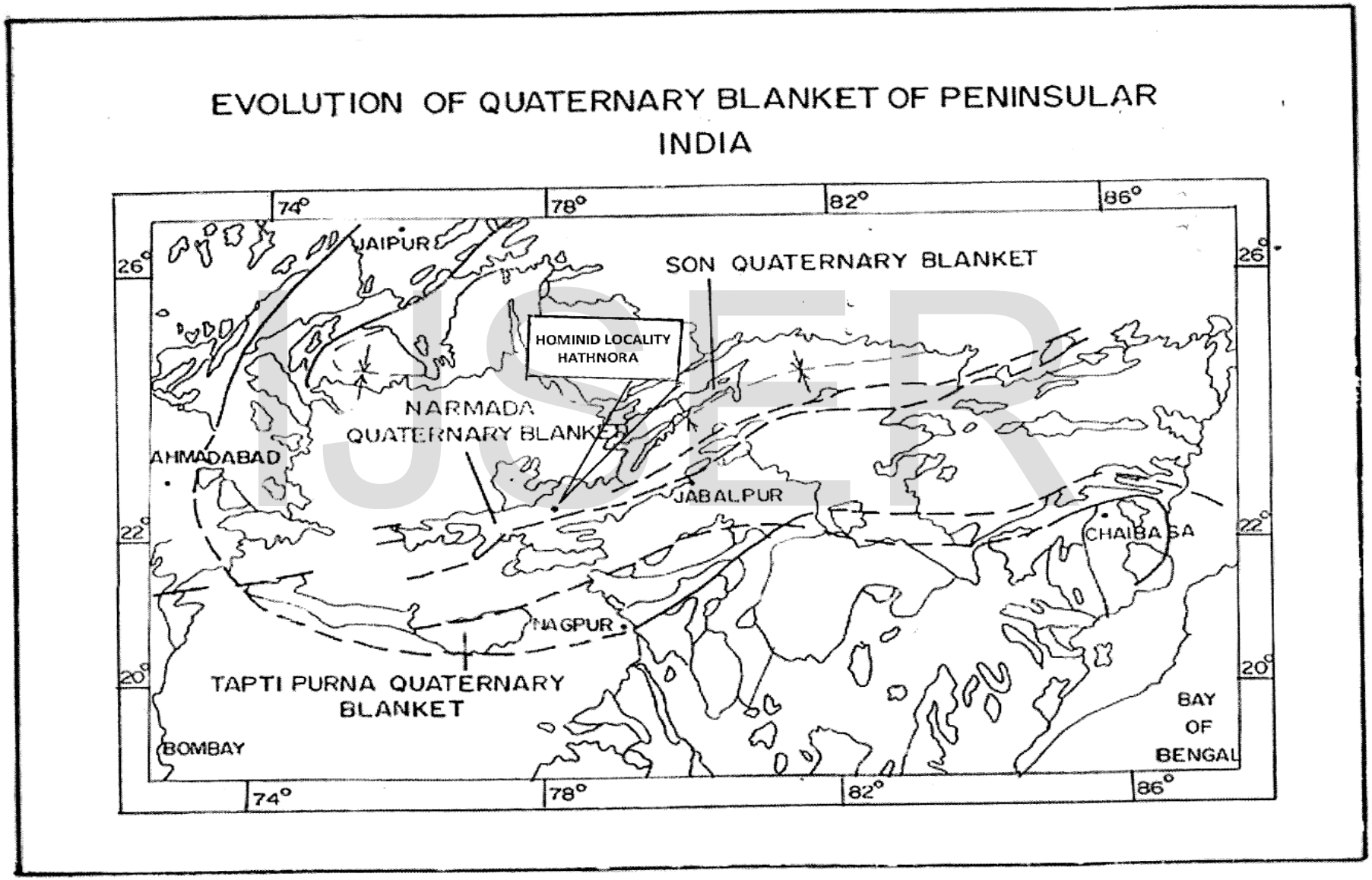
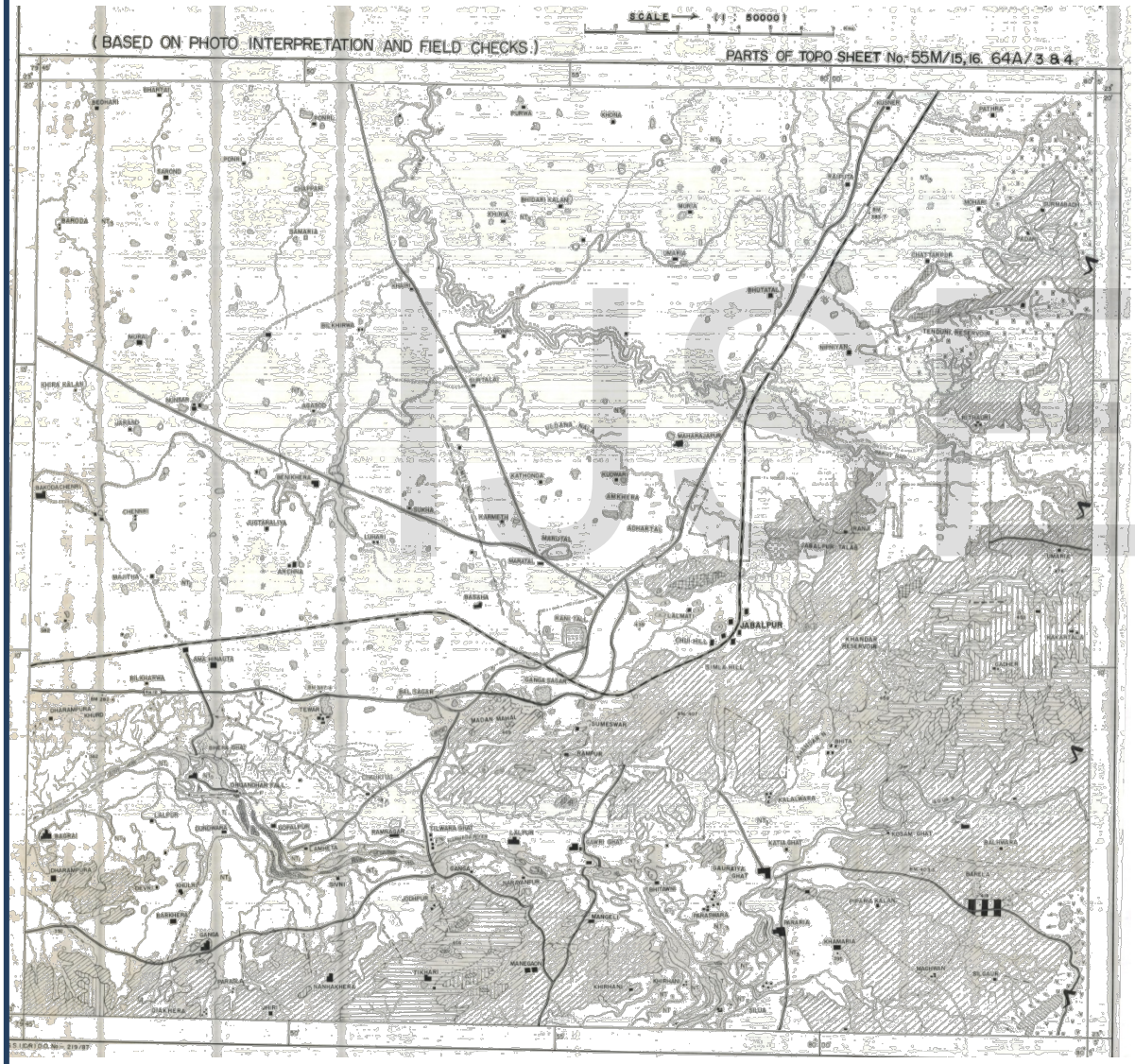

EVOLUTION OF QUATERNARY BLANKET OF PENINSULAR INDIA
74°
78°
82°
86°
26°
22°
20°
JAIPUR
SON QUATERNARY BLANKET
HOMINID LOCALITY
HATHNORA
NARMADA
QUATERNARY BLANKET
AHMADABAD
JABALPUR
CHAIBASA
NAGPUR
TAPTI PURNA QUATERNARY
BLANKET
BOMBAY
BAY
OF
BENGAL

Plate No_5

GEOLOGICAL MAP OF THE AREA AROUND JABALPUR M.P.INDIA



INDEX

QUATERNARY SURFACES
DEPOSITIONAL SURFACES
NT_0 BHERAGHAT SURFACE. (340 mts. above M.S.L.)
Aggradation & Degradation of younger Alluvium.
NT_1 LAMETA SURFACE. (340 to 345 mts. above M.S.L.)
Aggradation & Degradation of older Alluvium.
NT_2 JABALPUR SURFACE (345 to 360 mts. above M.S.L.)
Aggradation & Degradation of older Alluvium.
NT_3 NUNSAR SURFACE.(380 to 400 mts. above M.S.L.)
Aggradation & Degradation of older Alluvium.

PRE - QUATERNARY SURFACES.
EROSIONAL SURFACES
BARELA SURFACE. (400 to 420 mts. above M.S.L.)
Dissection & Partial Aggradation.
LALMATI SURFACE. (440 to 460 mts. above M.S.L.)
Peneplanation.
TIKHARI SURFACE. (460 mts. above M.S.L.)
Peneplanation.
GADHARI SURFACE. (480 mts. above M.S.L.)
Peneplanation.

GEOMORPHIC LAND FORM ELEMENTS & FEATURES.

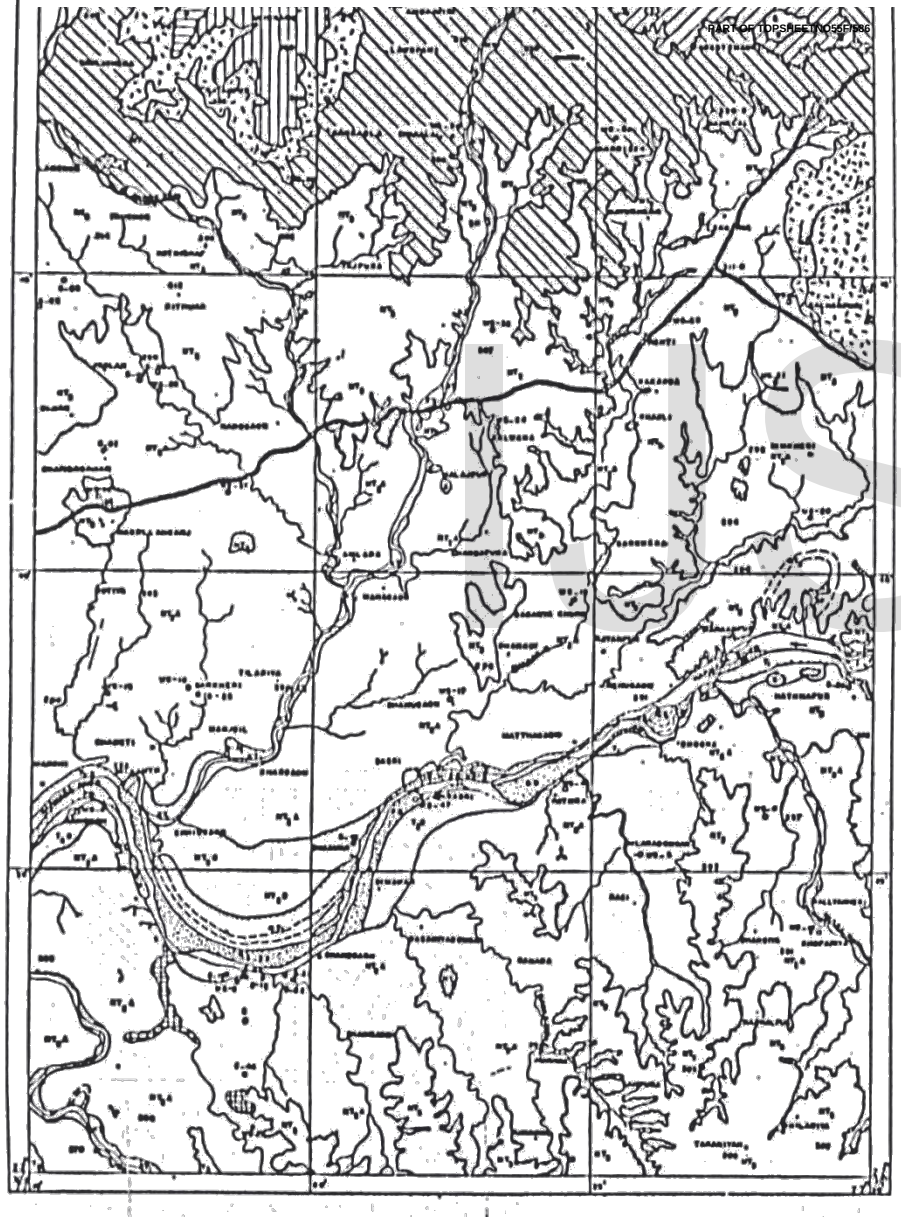
- ACTIVE FLOOD PLAIN.
- POINT BAR.
- SAND BAR.
- VERTICAL BANK CUTTING.
- LATERAL BANK CUTTING.
- RAVINES.
- ACCELERATED HEADWARD EROSION.
- DEEP GULLY EROSION.
- SCREE.
- BUTTE / MESA.
- RELICT SURFACE.
- ROCKCUT TERRACE.
- BIJAWAR / DECCAN TRAP UPLAND.
- LINEAR SCARP.
- CURVILINEAR SCARP.
- JOINT.
- FAULT.
- LINEAMENT.

BUILT UP AREA

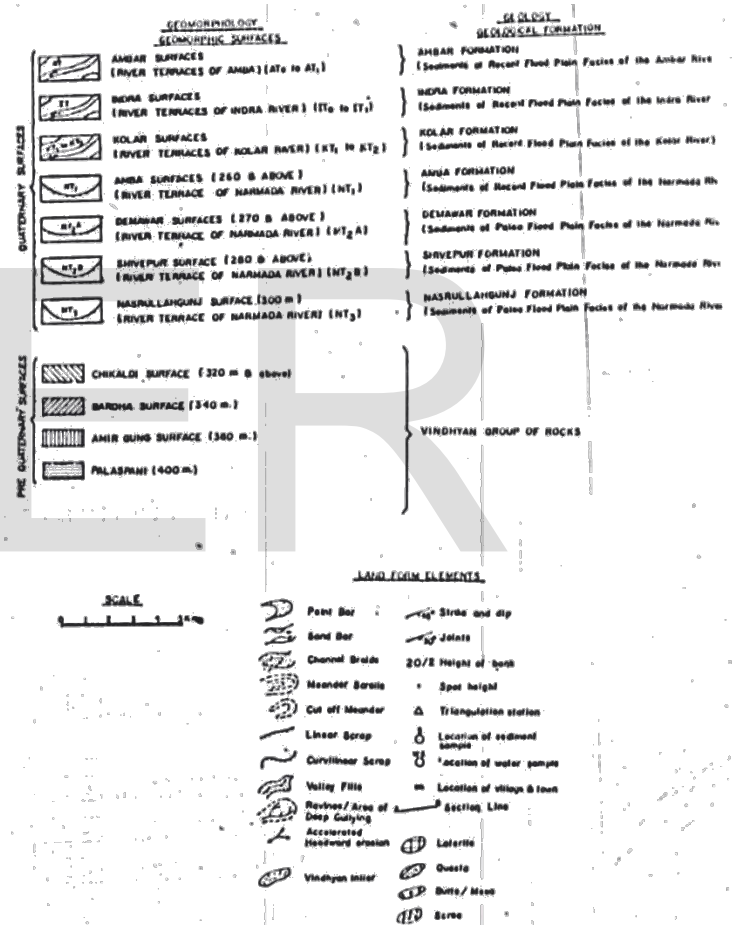
- TOWN / VILLAGE.
- ROAD.
- RAILWAY.
- LIMIT OF JABALPUR METROPLIS.
- POND / TANK
- DRAINAGE.
- RESERVOIR.
- HEIGHT STATION. TRIANGULATED.

Plate No_6

GEOLOGICAL &GEOMORPHOLOGICAL MAP OF PARTS OF THE NARMADA BASIN SEHORE,



INDEX



GEOLOGICAL &GEOMORPHOLOGICAL MAP OF NARMADA VALLEY PARTS OF RAISEN AND HOSHNAGABADM.P.PLATE NO_7

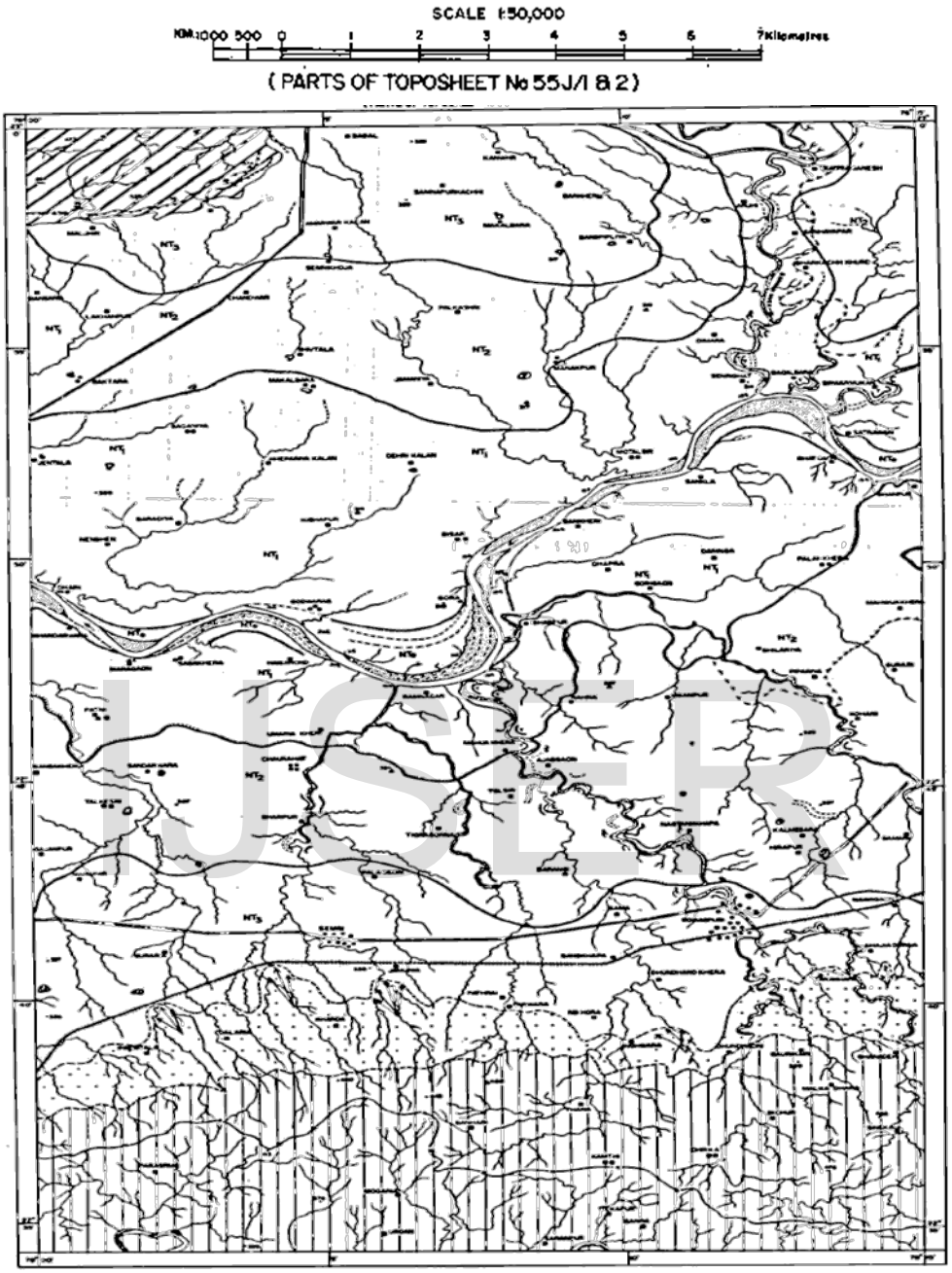
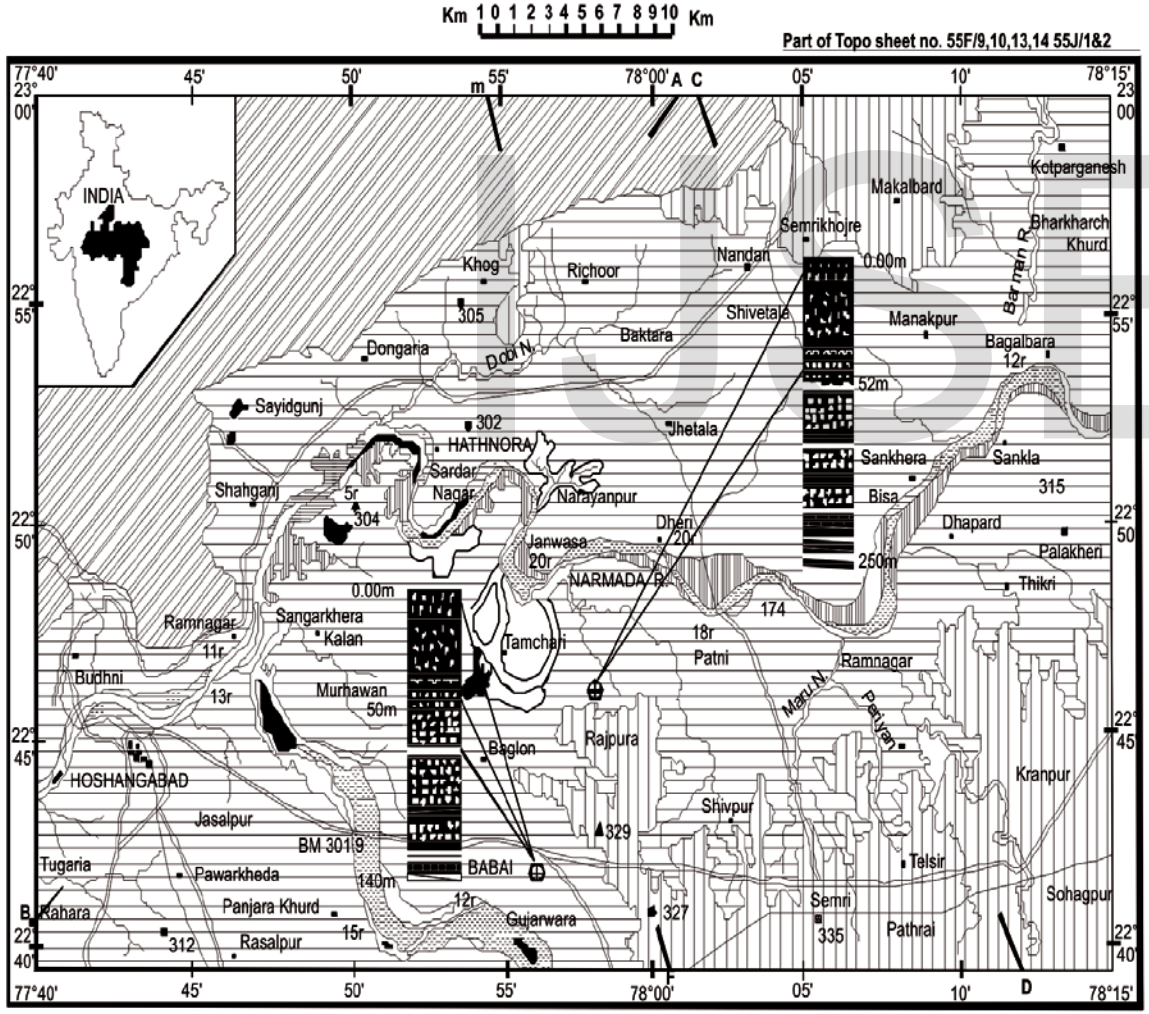


Plate No_8

GEOLOGICAL MAP OF THE AREA AROUND HOMINID FOSSIL LOCALITY HATHNORA, NARMADA VALLEY SEHORE AND HOSHANGABAD DISTRICT, MADHYA PRADESH, INDIA



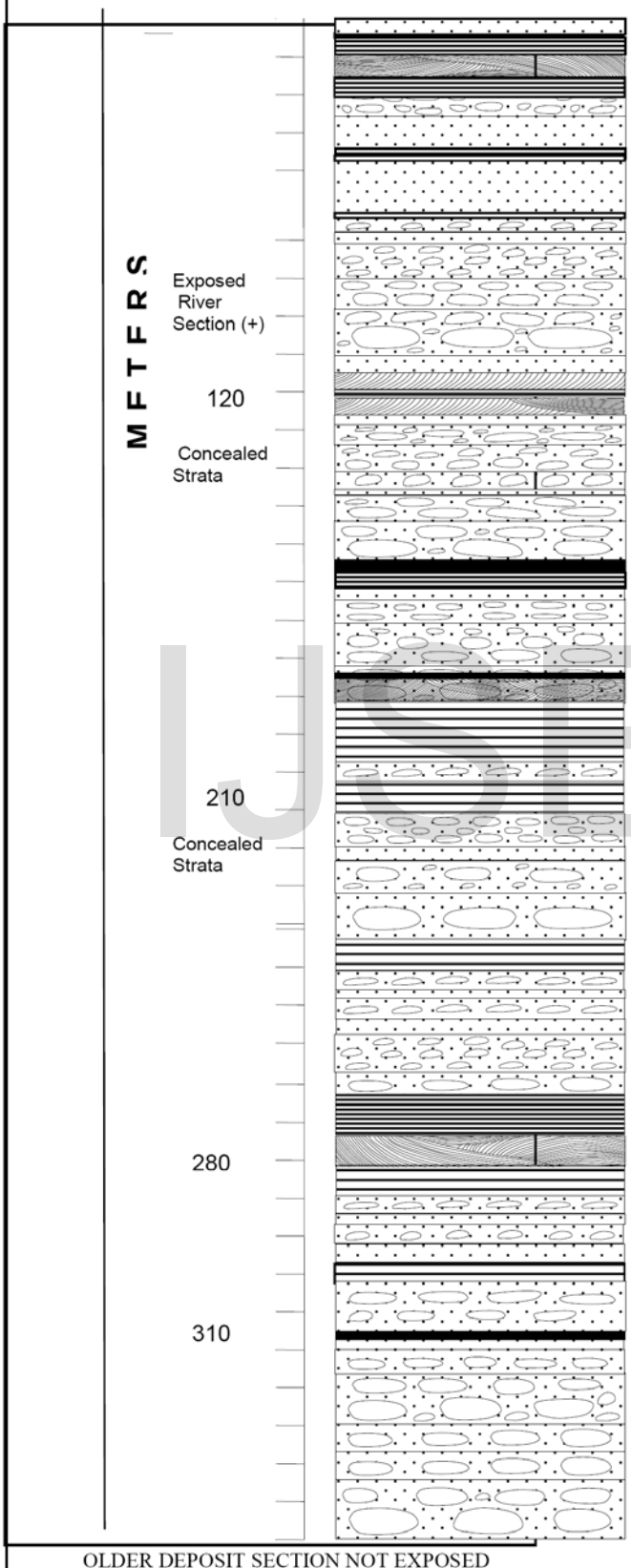
INDEX

AGE	QUATERNARY DEPOSITS	QUATERNARY FORMATION	ENVIRONMENT OF SEDIMENTATION
HOLOCENE TO RECENT	YOUNGER ALLUVIUM	JANWASA FORMATION	ACTIVE CHANNEL & FLOOD PLAIN ENVIRONMENT
UPPER PLEISTOCENE	OLDER ALLUVIUM	HOSHANGABAD FORMATION, SHAHGANJ FORMATION, SOHAGPUR FORMATION	CHANNEL & FLOOD PLAIN ENVIRONMENT
	UNCONFORMITY		
MIDDLE PLEISTOCENE	BOULDER CONGLOMERATE	HATHNORA FORMATION	FLUVIO-GLACIAL ENVIRONMENT
	UNCONFORMITY		
LOWER PLEISTOCENE	GLACIAL / FLUVIO-GLACIAL DEPOSITS		GLACIAL ENVIRONMENT
	UNCONFORMITY		
	VINDHYAN / DECCAN TRAP (BASEMENT ROCKS)		

Plate No_9

HATHNORA SECTION _ I: - (22 ° 52" N; 77 ° 58" E) **Plate No QG__5**

QUATERNARY GEOLOGY COMPOSITE LITHOSTRATIGRAPHIC SECTION OF QUATERNARY DEPOSITS OF PALEO DOMAIN OF NARMADA AND CONSEALLED STRATA BASED ON STUDY OF EXPOSED STRATA & BORE HOLE LOGS.



HATHNORA SECTION I:- (22 ° 52" N; 77 ° 58" E)
Collectively studied for Quaternary Geology Lithostratigraphy, Ash bed association, Sediment logical aspects Heavy Mineral Assemblage Cyclic sedimentation, Rock Pathology PahologyPathology Size distribution & Sedimentary Structure Quartz Grain Morphology and Palesole

Coarse to fine sand laminated & cross laminated with fine ferruginous matrix.

Boulder Cobble Pebble with fine sand well bedded
I -----Boulder Conglomerate at the Bsae of
***35m Exposed River Section SEDIMENTOLOGICAL I BREAK (BOULDETR CONGLOMERATE)*----------**
Brown coarse to fine sand with silt
Boulder Cobble pebble cemented in with Brown red coarse to fine sand silt and clay
Yellow hard compact clay

II---------210m Concealed Strata of Boulder Bed SEDIMENTOLOGICAL BREAK---
Boulder Cobble Pebble tightly cemented in fine sand and silt well bedded layer

Fine sand laminated & cross laminated with fine ferruginous matrix with pebble at base

Yellow brown hard compact clay&silt

Pebble with coarse to fine well bedded and layered

Small pebble with o fine well bedded and layered

Cobble pebble with coarse to fine well bedded and layered sand & silt at the base

-------280m

III SEDIMENTOLOGICAL BREAK (BOULDER BED)

Pebble with sand
Fine sand Laminated & Cross laminated with fine ferruginous matrix
Boulder Cobble Pebble with coarse tofine sand silt and caly

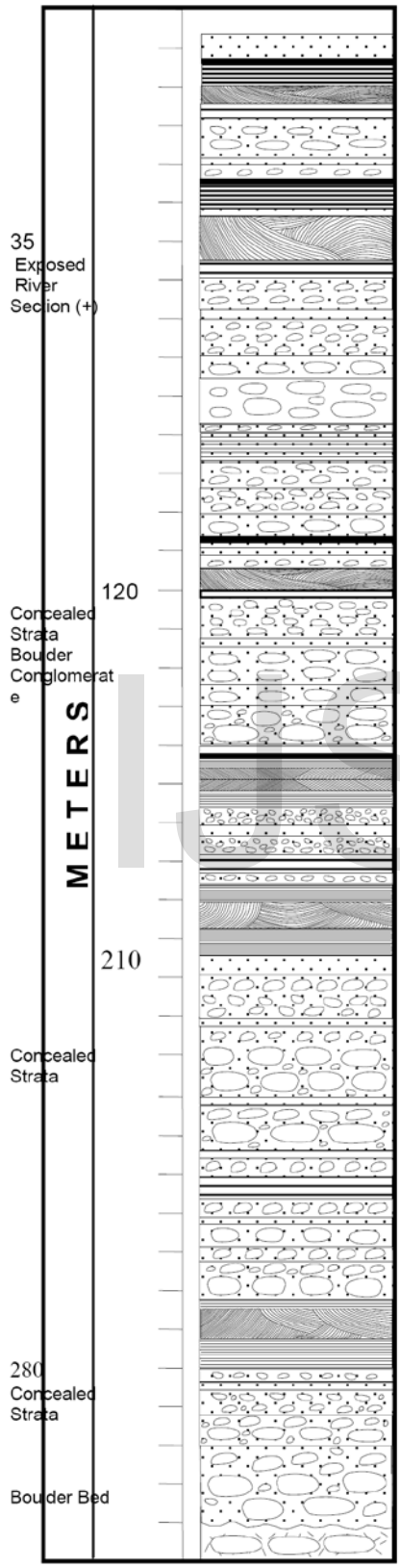
INDEX

LAMINATION
CROSS LAMINATION CROSS BEDDING
CLAY/SILT
FINE SAND
COARSE SAND
PEBBLE
COBBLE
BOULDER

Plate No_10

HATHNORA SECTION _ II:- (22 ° 52" N; 77 ° 58" E) Plate No QG_6

QUATERNARY GEOLOGY COMPOSITE LITHOSTRATIGRAPHIC SECTION OF QUATERNARY DEPOSITS OF PALEO DOMAIN OF NARMADA AND CONSEALLED STRATA BASED ON STUDY OF EXPOSED STRATA & BORE HOLE LOGS



HATHNORA SECTION II:- (22 ° 52" N; 77 ° 58" E) Collectively studied for Quaternary Geology Lithostratigraphy, Ash bed association, Sediment logical aspects Heavy Mineral Assemblage Cyclic sedimentation, Rock Pathology PahologyPathology Size distribution & Sedimentary Structure Quartz Grain Morphology and Palesole

Coarse to fine sand laminated & cross laminated with fine ferruginous matrix.

Cobble Pebble with fine sand well bedded

I -----Boulder Conglomerate at the Bsae of 35m Exposed River Section

SEDIMENTOLOGICAL BREAK ----------

Yellow hard compact clay

Boulder Cobble pebble cemented in with Brown red coarse to fine sand silt and clay

II----------210m Concealed Strata of Boulder Bed SEDIMENTOLOGICAL BREAK (BOULDER BED)

Boulder Cobble Pebble tightly cemented in fine sand and silt well bedded layer

Fine sand laminated & cross laminated with fine ferruginous matrix with pebble at base

Brown coarse to fine sand with silt

Pebble with coarse to fine well bedded and layered

Fine sand laminated & cross laminated with fine ferruginous matrix

Fine sand laminated & cross laminated with fine ferruginous matrix with pebble at base

Small pebble with o fine well bedded and layered

Cobble pebble with coarse to fine well bedded and layered sand & silt at the base

Fine sand Laminated & cross laminated with fine ferruginous matrix

III----280m

SEDIMENTOLOGICAL (BREAK (BOULDER BED

Boulder Cobble Pebble with coarse to fine sand silt and caly

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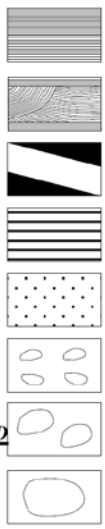


LAMINATION

CROSS LAMINATION CROSS BEDDING

CLAY/SILT

FINE SAND

COARSE SAND

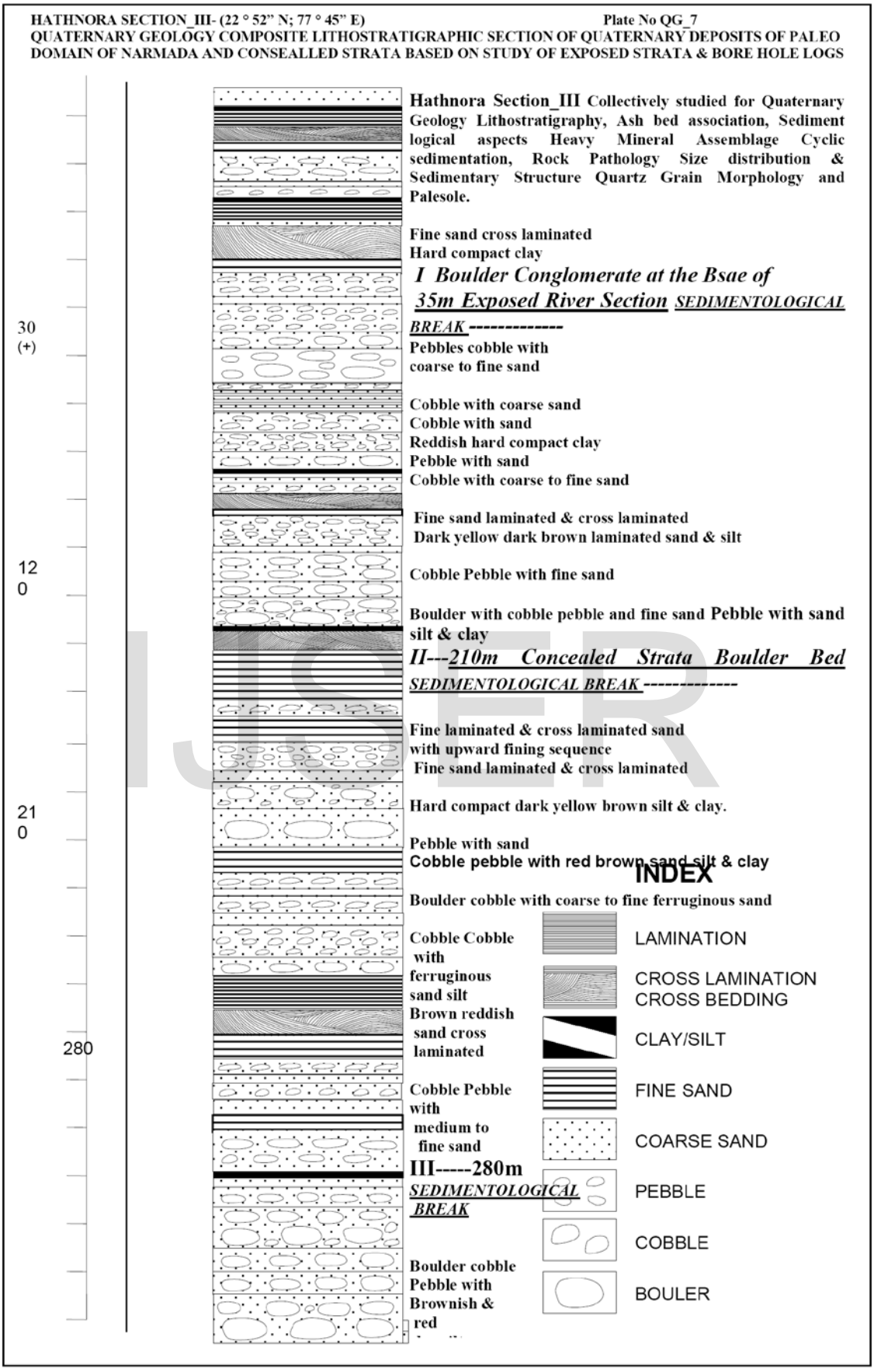
PEBBLE

COBBLE

BOULER

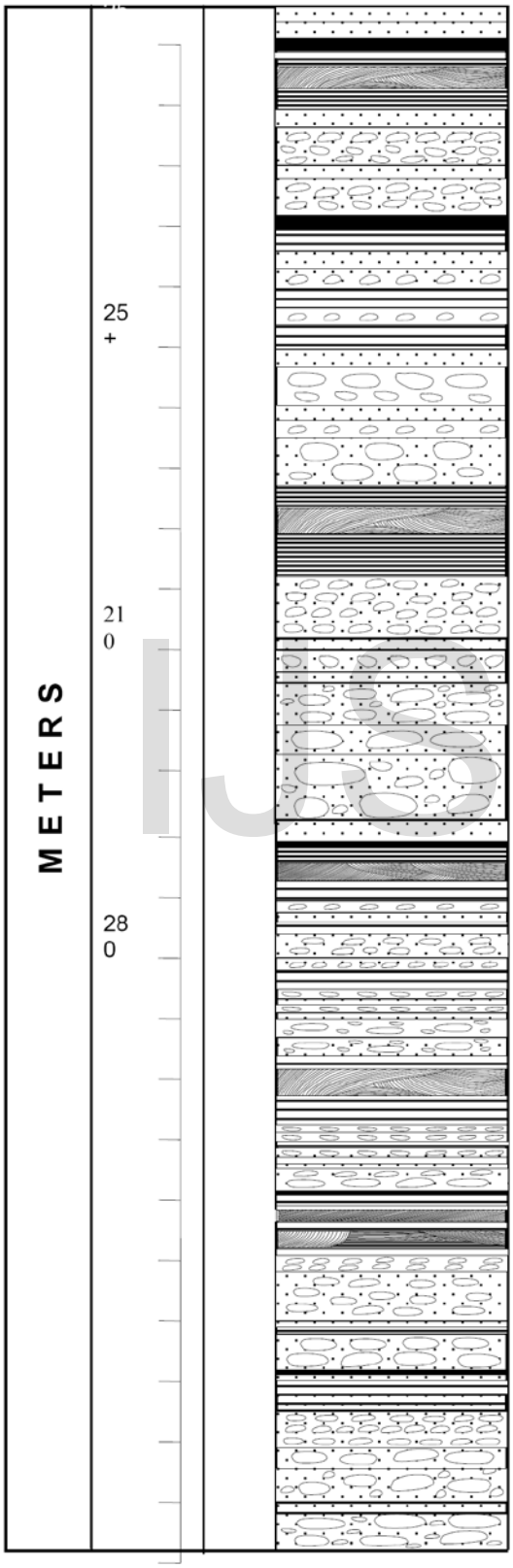
OLDER DEPOSIT SECTION NOT EXPOSED

Plate No_11



HATHNORA SECTION_ IV:- (22 ° 52" N; 77 ° 40" E) **Plate No QG_8**

QUATERNARY GEOLOGY COMPOSITE LITHOSTRATIGRAPHIC SECTION OF QUATERNARY DEPOSITS OF PALEO DOMAIN OF NARMADA AND CONSEALLED STRATA BASED ON STUDY OF EXPOSED STRATA & BORE HOLE LOGS



OLDER DEPOSIT SECTION NOT EXPOSED

Hathnora Section IV:- (22 ° 52" N; 77 ° 40" E) Collectively studied for Quaternary Geology Lithostratigraphy, Ash bed association, Sediment logical aspects Heavy Mineral Assemblage Cyclic sedimentation, Rock Pathology Size distribution & Sedimentary Structure Quartz Grain Morphology and Palesole

Pebble cobble
With sand
Hard compact clay

Coarse snd with pebbles

Coarse sand well bedded

I-----Boulder Conglomerate-at the Bsae of – 35m Exposed River Section

SEDIMENTOLOGICAL BREAK ----------

Cobble with sand

Boulder Cobble with coarse to fine sand

Fine sand laminated & cross laminated Hard compact caly at base

II----------210m Concealed Strata of Boulder Bed ----------

Boulder Cobble Pebble tightly cemented in fine sand and silt well bedded layer

Boulder Cobble with coarse to fine sand

Medium cobble with pebble and fine sand

Boulder Cobble pebble with red brown sand silt & clay

Boulder cobble with coarse to fine ferruginous sand

Cobble with ferruginous sand silt

III-------280m ***SEDIMENTOLOGICAL BREAK***

Pebble with fin e sand

Pebble with fine sand

Fine sand cross Laminated

Pebble cobble With sand

Pebble well bedded with in sand

coarse to fine sand

Boulder cobble

Pebble with sand

INDEX

LAMINATION

CROSS LAMINATION
CROSS BEDDING

CLAY/SILT

FINE SAND

COARSE SAND

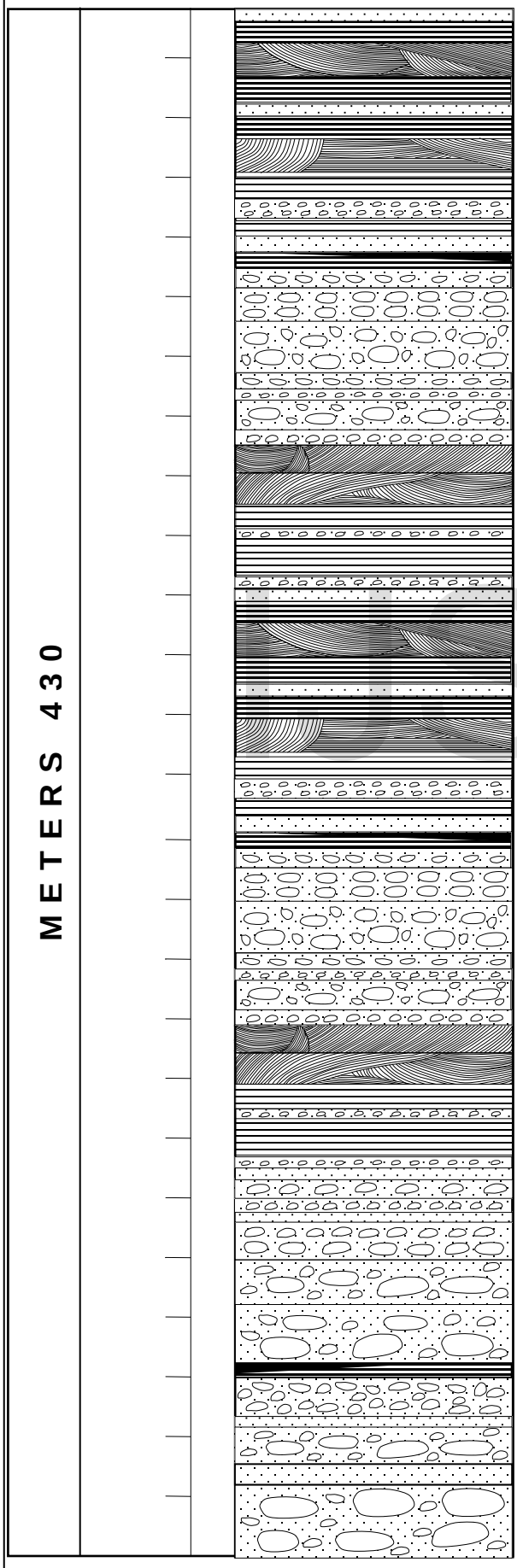
PEBBLE

COBBLE

BOULER

(i) JABALPUR _HOSHANGABAD SECTION Plate No _13

QUATERNARY GEOLOGY COMPOSITE LITHOSTRATIGRAPHIC SECTION OF QUATERNARY DEPOSITS OF PALEO DOMAIN OF NARMADA AND CONSEALLED STRATA BASED ON STUDY OF EXPOSED SECTION STRATA & BORE HOLE LOGS.



JABALPUR_HOSHANGABAD SECTION
Collectively studied for Quaternary Geology Lithostratigraphy, Ash bed association, Sediment logical aspects Heavy Mineral Assemblage Cyclic sedimentation,Rock Pathology PahologyPathology Size distribution &Sedimentary Structure Quartz Grain Morphology and Palesole
----Coarse to fine sand laminated & cross laminated with fine upward fining sequence
Cobble Pebble with fine sand well bedded

I --- ----------SEDIMENTOLOGICAL BREAK --------
(00.00m to180m)
Boulder Cobble pebble cemented in with Brown red coarse to fine sand silt and clay

Boulder Cobble Pebble tightly cemented in fine sand and silt well bedded layer
Brown coarse to fine sand sand laminated & cross laminated with fine ferruginous matrix

Yellow hard compact clay
pebble with coarse to fine well bedded and layered

Fine sand laminated & cross laminated with fine ferruginous matrix with pebble at base

Yellow hard compact clay with fine sand
Fine sand silt with caly laminated & cross laminated

II----------*SEDIMENTPLOGIAL BREAK 180 to 260m*--------
Cobble pebble with coarse to fine sand well bedded and layered

Cobble pebble with coarse to fine well bedded and layered sand &
silt at the base

Pebble with coarse to fine

III-----
----------*SEDIMENTOLOGICALBREAK--*
(260 to360m)
Fine sand silt with caly laminated & cross laminated
With clay layer at base

Hard compact clay
Bounded by Pebble
Hard compact clay
Pebble with sand

Boulder Cobble
Pebble with very coarse to fine sand

Boulder with sand
Hard compact clay
Pebble with sand

Cobble pebble and sand

Boulder Cobble
Pebble with very
Coarse to fine sand

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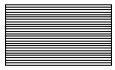
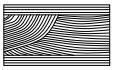
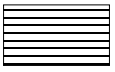
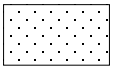
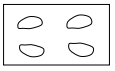

LAMINATION


CROSS LAMINATION
CROSS BEDDING


CLAY/SILT


FINE SAND


COARSE SAND


PEBBLE

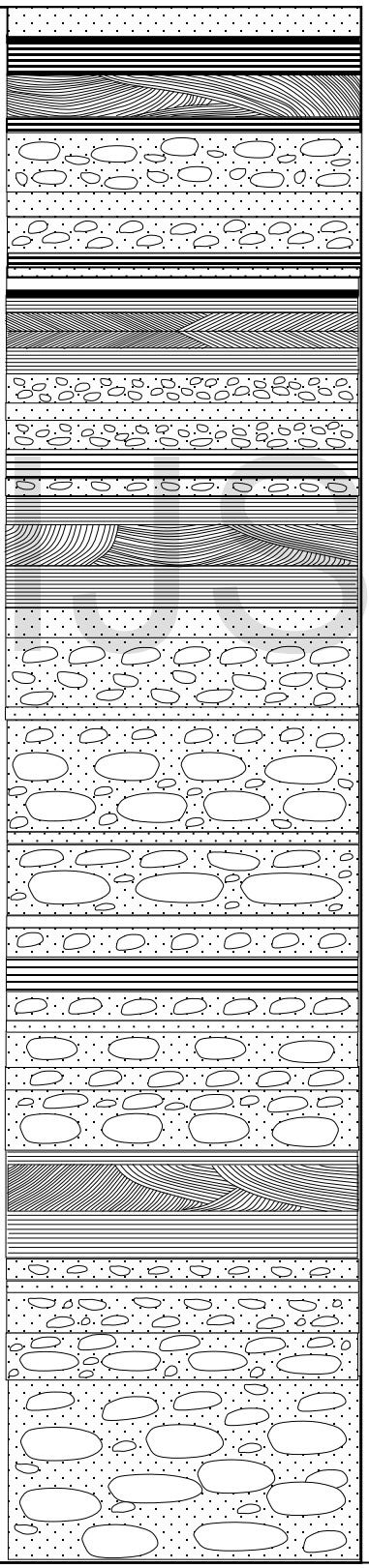
COBBLE

Plate No_14

HOSHANGABAD -HARDA SECTION

QUATERNARY GEOLOGY COMPOSITE LITHOSTRATIGRAPHIC SECTION OF QUATERNARY DEPOSITS OF PALEO DOMAIN OF NARMADA AND CONSEALLED STRATA BASED ON STUDY OF EXPOSED SECTION AND BORE HOLE LOGS

METERS 390



HOSHANGABAD-HARDA SECTION

Collectively studied for Quaternary Geology Lithostratigraphy, Ash bed association, Sediment logical aspects Heavy Mineral Assemblage Cyclic sedimentation,Rock Pathology PahologyPathology Size distribution &Sedimentary Structure Quartz Grain Morphology and Palesole

Fine sand laminated & cross laminated with fine ferruginous matrix

Pebble cobble with coarse to fine sand, red fine sand laminated & cross laminated with fine upward finning sequence

Cobble Pebble withwell bedded fine sand
Hard compact clay
Yellow fine sand cross laminated
Brown coarse to fine sand laminated & cross laminated with fine ferruginous matrix
Pebble with coarse to fine well bedded separated by hard compact clay and sand
Brown reddish fine sand cross laminated and laminated
Dark brown hard compact clay with ferruginous matrix

I --- ---------- SEDIMENTOLOGICAL BREAK -------
(00.00m to180m)

Pebble with fine sand
Cobble with coarse to fine sand
Boulder Cobble pebble cemented in with Brown red coarse to fine sand silt and clay
Boulder Cobble pebble sand &silt
Boulder Cobble pebble fine sand
Boulder Cobble pebble coarse sand & caly

II ---------- SEDIMENTOLOGICAL BREAK --------
(180 260m)

Yellow hard compact clay

Boulder Cobble Pebble tightly cemented in fine sand and silt well bedded layer
Cobble pebble with coarse to fine well bedded and layered

Brown coarse to fine sand sand laminated & cross laminated with fine ferruginous matrix with hard compact clay at base.

III --- SEDIMENTOLOGICAL BREAK --------
(260-320m)

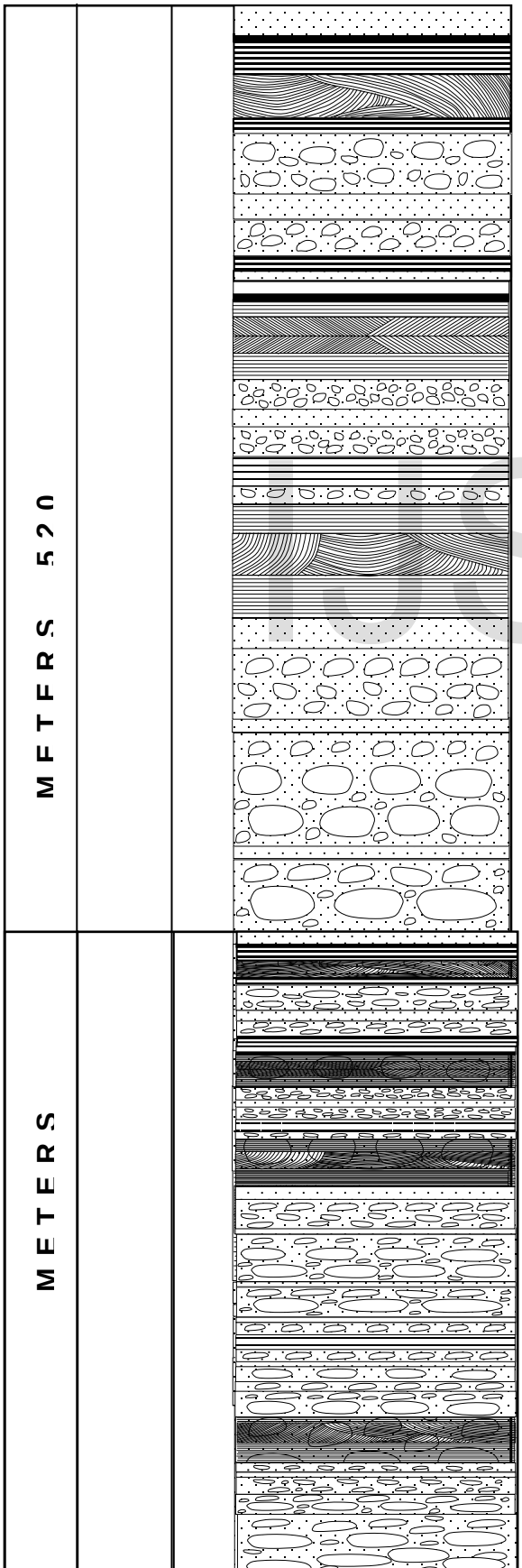
Pebble with coarse to fine sand
Cobble pebble wth coarse to fine well bedded sand & silt
Fine sand laminated & cross laminated with fine ferruginous matrix

Boulder Cobble Pebble with very coarse to fine sand

Boulder Cobble Pebble with very coarse to fine sand

BHAROUCHE SECTION **Plate No_15**

QUATERNARY GEOLOGY COMPOSITE LITHOSTRATIGRAPHIC SECTION OF QUATERNARY DEPOSITS OF PALEO DOMAIN OF NARMADA AND CONSEALLED STRATA BASED ON STUDY OF EXPOSED SECTION AND BORE HOLE LOGS



BARWAHA SECTION

Collectively studied for Quaternary Geology Lithostratigraphy, Ash bed association, Sediment logical aspects Heavy Mineral Assemblage Cyclic sedimentation,Rock Pathology PahologyPathology Size distribution &Sedimentary Structure Quartz Grain Morphology and Palesole

Cobble pebble with brown red coarse to fine sand silt and clay laminated & cross laminated with fine upward finning sequence

Hard brown clay silt

Fine sand laminated & cross laminated

Hard brown clay silt

Pebble with fine sand well bedded

Fine sand laminated & cross laminated with fine ferruginous matrix embedded by hard ferruginous clay at the base and top
Yellow hard compact clay with fine sand

I ---------- SEDIMENTOLOGICAL BREAK -------- (00.00m to180m)

Pebble with very coarse to fine sand

Cobble pebble with coarse to fine well bedded and layered

Boulder Cobble pebble cemented in with Brown red coarse to fine sand silt and clay

Boulder Cobble pebble cemented in with Brown red coarse to fine sand silt and clay

II --- -------SEDIMENTOLOGICAL BREAK -------- (180 to260m)

Fine sand laminated & cross laminated with ferruginous matrix
Brown coarse to fine sand sand laminated & cross laminated with fine ferruginous matrix
Red brown clay silt
Pebble with very coarse to fine sand well bedded
Fine sand laminated & cross laminated with ferruginous matrix

III ---------- SEDIENTOLOGICAL BREAK -------- (340 to 520m)

Boulder Cobble Pebble tightly cemented in fine sand and silt well bedded layer

Cobble Pebble tightly cemented in fine sand and silt.

Brown coarse to fine sand sand laminated & cross laminated with fine ferruginous matrix

Boulder Cobble Pebble with very coarse to fine sand

Plate No.16

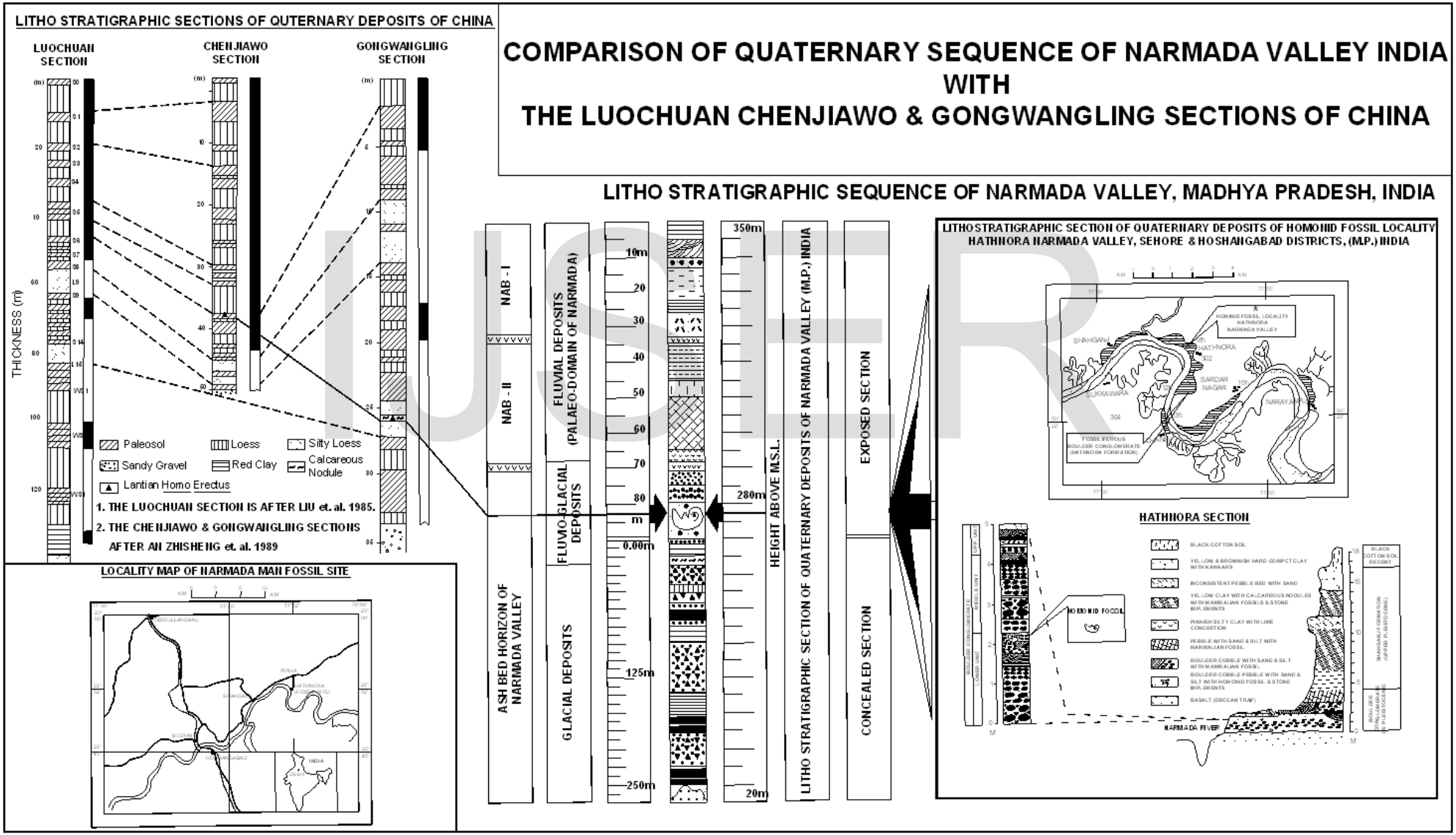

LITHO STRATIGRAPHIC SECTIONS OF QUTERNARY DEPOSITS OF CHINA
LUOCHUAN SECTION
CHENJIAWO SECTION
GONGWANGLING SECTION
THICKNESS (m)
Paleosol
Loess
Silty Loess
Sandy Gravel
Red Clay
Calcareous Nodule
Lantian Homo Erectus
1. THE LUOCHUAN SECTION IS AFTER LIU et. al. 1985.
2. THE CHENJIAWO & GONGWANGLING SECTIONS AFTER AN ZHISHENG et. al. 1989
LOCALITY MAP OF NARMADA MAN FOSSIL SITE
COMPARISON OF QUATERNARY SEQUENCE OF NARMADA VALLEY INDIA WITH THE LUOCHUAN CHENJIAWO & GONGWANGLING SECTIONS OF CHINA
LITHO STRATIGRAPHIC SEQUENCE OF NARMADA VALLEY, MADHYA PRADESH, INDIA
NAB - I
NAB - II
FLUVIAL DEPOSITS (PALAEO-DOMAIN OF NARMADA)
FLUVIO-GLACIAL DEPOSITS
GLACIAL DEPOSITS
ASH BED HORIZON OF NARMADA VALLEY
HEIGHT ABOVE M.S.L.
LITHO STRATIGRAPHIC SECTION OF QUATERNARY DEPOSITS OF NARMADA VALLEY (M.P.) INDIA
EXPOSED SECTION
CONCEALED SECTION
LITHOSTRATIGRAPHIC SECTION OF QUATERNARY DEPOSITS OF HOMONID FOSSIL LOCALITY HATHNORA NARMADA VALLEY, SEHORE & HOSHANGABAD DISTRICTS, (M.P.) INDIA
HATHNORA SECTION
HOMONID FOSSIL
NARMADA RIVER

Plate No.17