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RESEARCH ARTICLE

QUATERNARY VOLCANIC ERUPTION TOBA ASH FALL ITS IMPACTS ON ENVIRONMENT OF LATE PLEISTOCENE HOMININES IN INDIAN SUBCONTINENT WITH SPECIAL REFERENCE TO NARMADA VALLEY. INDIA

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Abstract

The 74,000 year-old super eruption of the Toba volcano, located in northern Sumatra, is recognized as one of Earth's largest known eruptions and was certainly the largest of the Quaternary period (Smith and Bailey, 1968). It is presumed that it have led to both global climatic and environmental deterioration and had a impact on decimation of modern human populations (Rampino et al., 1988; Rampino and Self, 1992, 1993a) (Rampino and Self, 1993b; Ambrose, 1998, 2003a, 2003b; Rampino and Ambrose, 2000). However, the severity of Toba's impact on climate and hominines has been contested and debated by scientist (Oppenheimer, 2002; Gathorne-Hardy and Harcourt-Smith, 2003). Geological, paleontological and archaeological evidence from the Indian subcontinent provides an excellent opportunity to address these issues. The intensity and scale of the Toba super eruption was multi dimensional and its column of eruption was so vast that it forma canopy of volcanic matrix led to the deposition of a blanket of volcanic ash across the continents and river valleys over India, Malaysia, the Indian Ocean, and the Arabian and South China Seas. Resulting persistent terrestrial tephra deposits have been documented in a number of river valleys throughout India. (Khan et.al 1991 Acharyya and Basu, 1993; Shane et al., 1995; Westgate et al., 1998). The occurrences of volcanic ash have been located in Narmada, Tapti, Purna Son valleys. These occurrences are associated and preserved with archaeological, paleontological sites in these valleys. The present work is first attempt to collect condense the data on various aspects of eruption of the Tuba volcano, its impact on environment on population with special reference to Narmada valley.

It is also attempted to study the relationship between Tuba ash and archaeology from Narmada valley and adjoining area. Besides attempts were made to study the nature of occurrences of ash bed its composition chemical and physical characteristics to assess paleo- environment. In Narmada valley and Indian sub continent the Environment

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and climate during late Pleistocene has been significantly affected after Toba eruption, according to Rampino et al. (1988) the size of Toba at 74 ka could have induced a volcanic winter, similar to predicted nuclear winter scenarios, as modeled by Turco et al. (1983, 1990). The injection of vast amounts of gaseous aerosols and volcanic dust and matrix into the atmosphere, which follow large volcanic eruptions, is predicted to have detrimental and decisive consequences for changes of global climate. Past historical eruptions, such as Tambora in 1815 (Stothers, 1984) and Pinatubo in 1991 (McCormick et al., 1995), have provided evidence of post-eruption climatic deterioration and climatic. With the eruption of Toba having been far larger than both of these historical eruptions, its consequences are therefore assumed to have been far more devastating. The imprints of divesting impacts in the area of study and specific on human population are matter of scientific concerned and yet to be investigated.

The studies conducted of Ash bed associated with Quaternary deposits of Narmada Valley consist of sediments of two domain viz. deposits of interglacial domain (Boulder conglomerate-Hathona formation) and fluvial deposit of paleo-domain of Narmada. The boulder conglomerate is fossil ferrous horizon of Narmada and has yielded skull cap of Homo erectu Sonakia (1984). (Khan & Solaria (1991) .It is marker horizon and represents interglacial phase in the history of Quaternary sedimentation in Narmada Valley. The occurrence of ash bed reported from Quaternary sediments of Narmada are associated with two horizons of ash beds of middle and upper Pleistocene age (Khan et.al.1991). These ash beds are designated as NAB-I and NAB-II consisting of five layers designated as (L1 to L5) in ascending antiquity in the valley. The Ash bed NAB-1 (L1- to L-3) is associated with upper gritty units of boulder conglomerate (Hethnora formation) and is identified at an elevation of about 290m. above m.s.l. The Ash bed NAB-II (L-4 to L5) is associated with upper units of clay silt deposits of paleo-domain of Narmada (Shahganjg formation) and is identified at an elevation of 310m. above m.sl.

The study of grain morphology of glass matrix, their- relation with other minerals shape, size, texture of lithic fragments and association of other ashy sediments of pyroclastic origin suggest that sediments were brought from distant source by Aeolian agencies, during the different phases of sedimentation in Narmada Valley. It is observed that in stratigraphic column two horizons of Ash bed occurred at the vertical distance of about 20 m. which indicate that there were two phases of settling volcanic ash in Narmada valley and Indian subcontinent as a whole with significant time break. The element of time break is in terms of sedimentation perceptible appears to be related with global climatic changes induced by the super volcanic eruption. These ash beds are used as tool in correlation of different quaternary deposits and archeological sites in the valley. The occurrences of two horizons of Ash bed and their deposition by settling of volcanic dust with time gape suggest induced and defused atmospheric conditions in Narmada valley for a very long time after volcanic eruption. The atmosphere contaminated by volcanic ash volcanic matrix and huge amount of gases and dust particles had definitely affected the atmosphere and climate had have led to temporarily darkened skies in the Narmada valley and Indian subcontinent for very long time. The study of grain morphology of glass matrix, their- relation with other minerals shape, size, texture of lithic fragments and association of other ashy sediments of pyroclastic origin suggest that sediments were brought from distant source by Aeolian agonies, during the different phases of sedimentation in Narmada Valley. It is commonly argued that if Toba was truly devastating for H. sapiens then comparable bottlenecks should also be seen in many other species.

Introduction:-

The Quaternary tract of Narmada basin covers an area of about 12950 sq. km starting from west of Jabalpur ($23^0 07^0 790530$) to east of Handia (22^0 29'; 76^0 58') for a distance of about 320 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 total average estimated thickness of Quaternary sediments in the central sector of Narmada is about 325 m. where the level of Ash bed occurrence has been identified between the depths of 75-83 m of Quaternary column in unified Quaternary Platform.

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. The area around Hathnora and in Central Narmada valley possesses rich Paleolithic occurrences about and 300 Lower Paleolithic occurrences have been reported in different contexts. The present work deals with these assemblages and

associated raw material sources in valley .These rock types were used as raw material by various hominines populations. The area appears to be thickly inhabitated and influence by human activity which was adversely affected by severe Toba volcanic eruption and hominines were forced to be migrated in struggle of survival to the safe places. The nearest safe place was Bhimbetka about twenty kilometers in the norh located in obsequent slope of Vindhyan rocks of Bhopal inliers which possess about 700 rock shelters of different size and dimention.The study of human activity in the area around Bhembetka indicates the hominines populations lived around 100000 years.
The occurrences of volcanic ash have been located in Narmada, Tapti, Purna Son valleys. These occurrences are associated and preserved with archaeological, paleontological sites in these valleys. The present work is first attempt to collect and condense the data on various aspects of eruption of the Tuba volcano, its impact on environment on population with special reference to Narmada valley. It is also attempted to study the relationship between Tuba ash and archaeology from Narmada valley and adjoining area. Besides attempts were made to study the nature of occurrences of ash bed its composition chemical and physical characteristics to assess pale environment. This data can be combined with additional evidence from a wider context in order to give a broader understanding of the regional impacts of the eruption on Narmada valley and Indian subcontinent as a whole.

The 74,000 year-old super eruption of the Toba volcano, located in northern Sumatra, is recognized as one of Earth's largest known eruptions and was certainly the largest of the Quaternary period (Smith and Bailey, 1968). It is presumed that it have led to both global climatic and environmental deterioration and had a impact on decimation of modern human populations (Rampino et al., 1988; Rampino and Self, 1992, 1993a) (Rampino and Self, 1993b; Ambrose, 1998, 2003a, 2003b; Rampino and Ambrose, 2000). However, the severity of Toba's impact on climate and hominines has been contested and debated by scientist (Oppenheimer, 2002; Gathorne-Hardy and Harcourt-Smith, 2003). Geological, paleontological and archaeological evidence from the Indian subcontinent provides an excellent opportunity to address these issues. The intensity and scale of the Toba super eruption was multidimensional and its coloumn of eruption was so vast that it forma canopy of volcanic matrix led to the deposition of a blanket of volcanic ash across the continents and river valleys over India, Malaysia, the Indian Ocean, and the Arabian and South China Seas. Resulting persistent terrestrial tephra deposits have been documented in a number of river valleys throughout India. (Khan et.al 1991 Acharyya and Basu, 1993; Shane et al., 1995; Westgate et al., 1998).

Pleistocene Sedimentation in Narmada Rift Valley:-
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 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 basin platform 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.

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 sediment logical 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 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,(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 ( ) 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 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 fossilierous 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 .

The Narmada Rift System consists of symmetrical basins that have been evolved in different stages of tectonisam. The 100 -120 km-wide ad 1300 km long rift bounded by Satpura in south and Vindhyan in north constitutes conspicuous ENE-WSW to E-W rift basin zone is filled with Pliocene–Pleistocene sediments, whereas some of them contain Miocene sedimentary deposits. Most of the sedimentary sequences contain faunal and floral remains including hominid species. Most of the basin-fill sediments were derived from topographically elevated rocks that are present within and outside the rift basins. Lava flows and tephra are interbedded with the fossiliferous sediments clastic sediments derived from The provinces of sediment mostly from crystalline basement volcanic, sedimentary, meta basic and sedimentry rocks, aided in the cementation and preservation of organic remains by providing secondary minerals released during alteration in a burial environment. Quick burial minimized the effect of reburials taphonomic processes. Moreover, chemical constituents released by the alter have provided critical temporal and spatial information without which the study of hominid evolution and pale- environmental reconstruction in the Rift System would have been impossible.

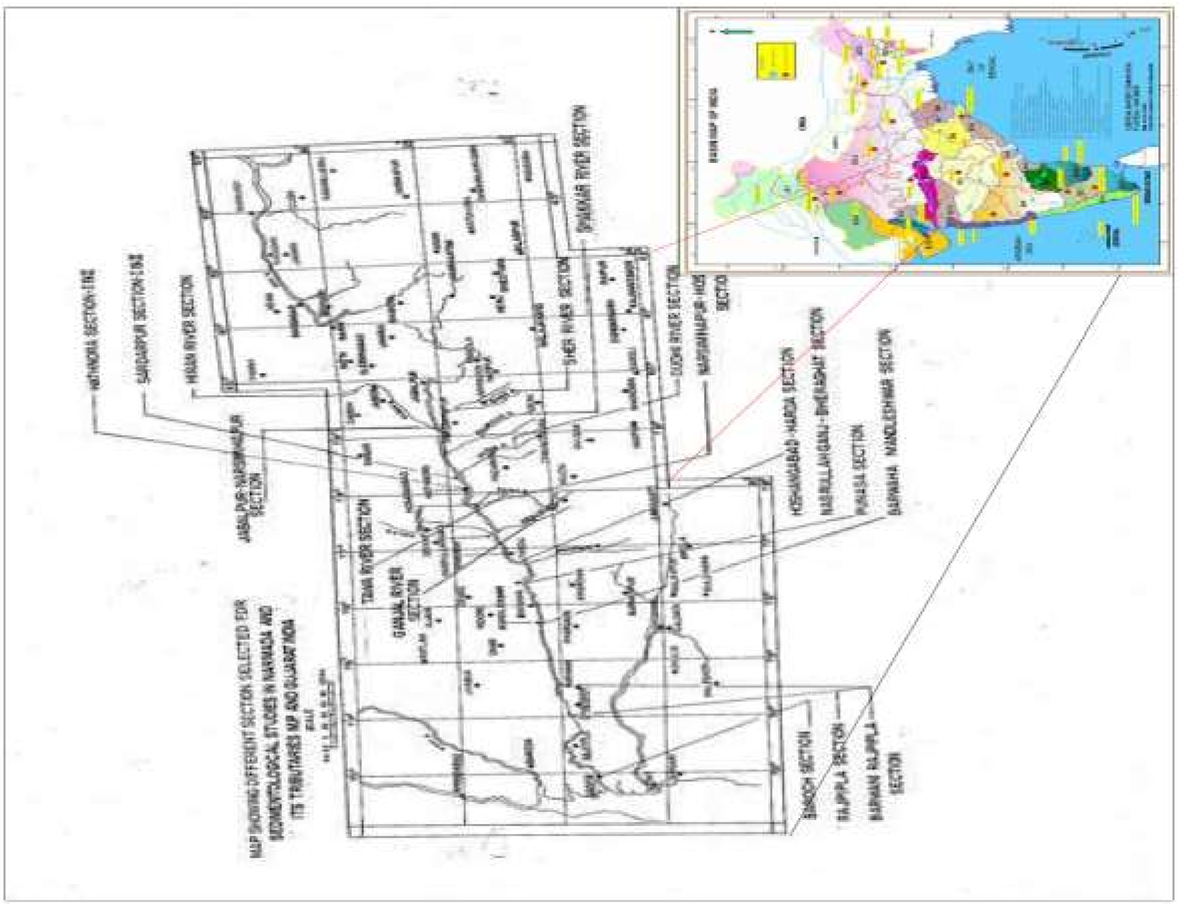
Moreover, because of tephra layers in sedimentary basins of different geologic periods, processes such as faulting, rifting, sedimentation and diagenesis, impact of climatic changes, age of fossils, nature and acquisition of archeological implements, and the origin, distribution, and functional significance 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 silica eruptions in the geologic past , 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 Narmada 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 and Federal agencies drill in lower Narmada valley under various projects.

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, stratified rock 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 elastics 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 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.



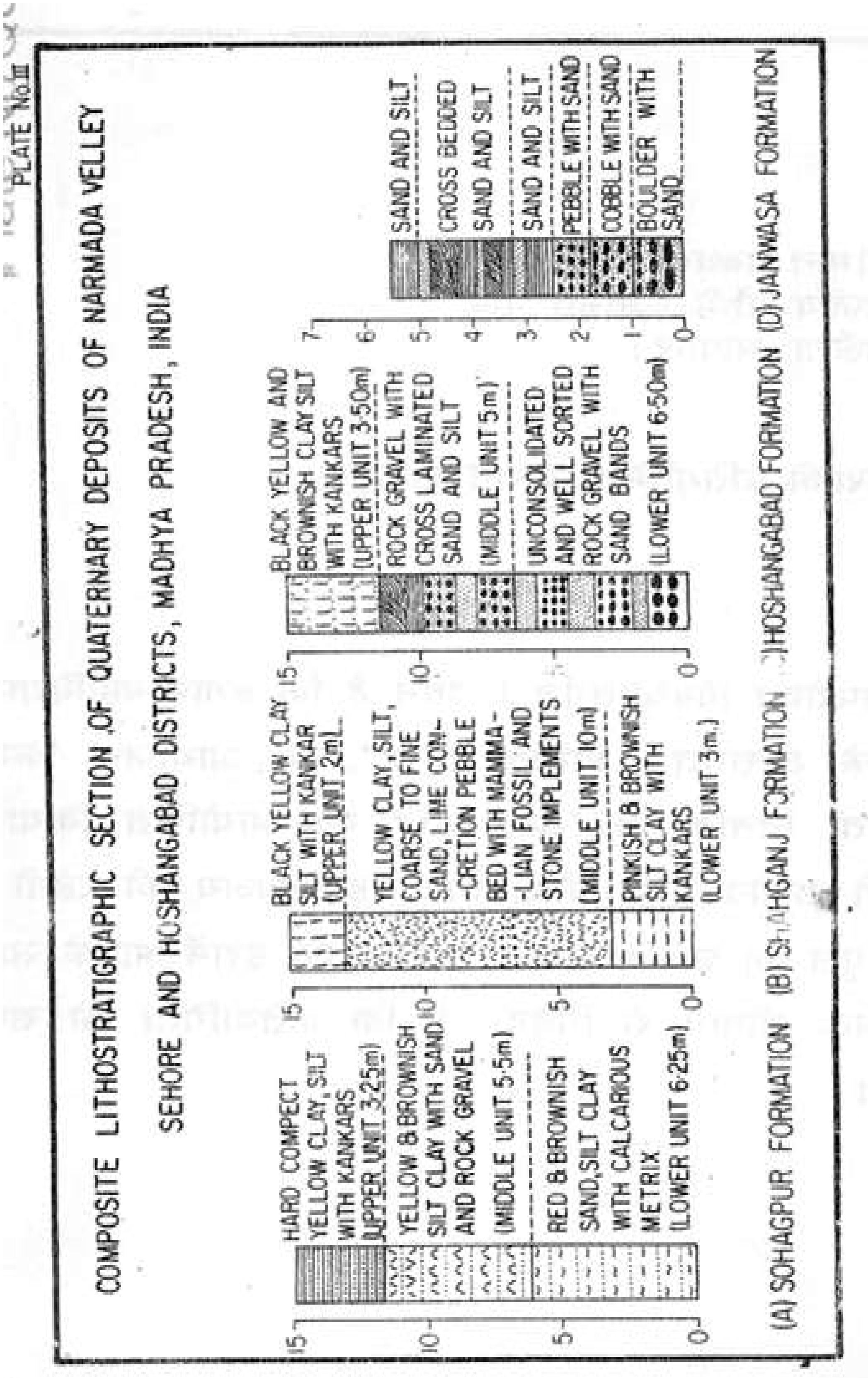
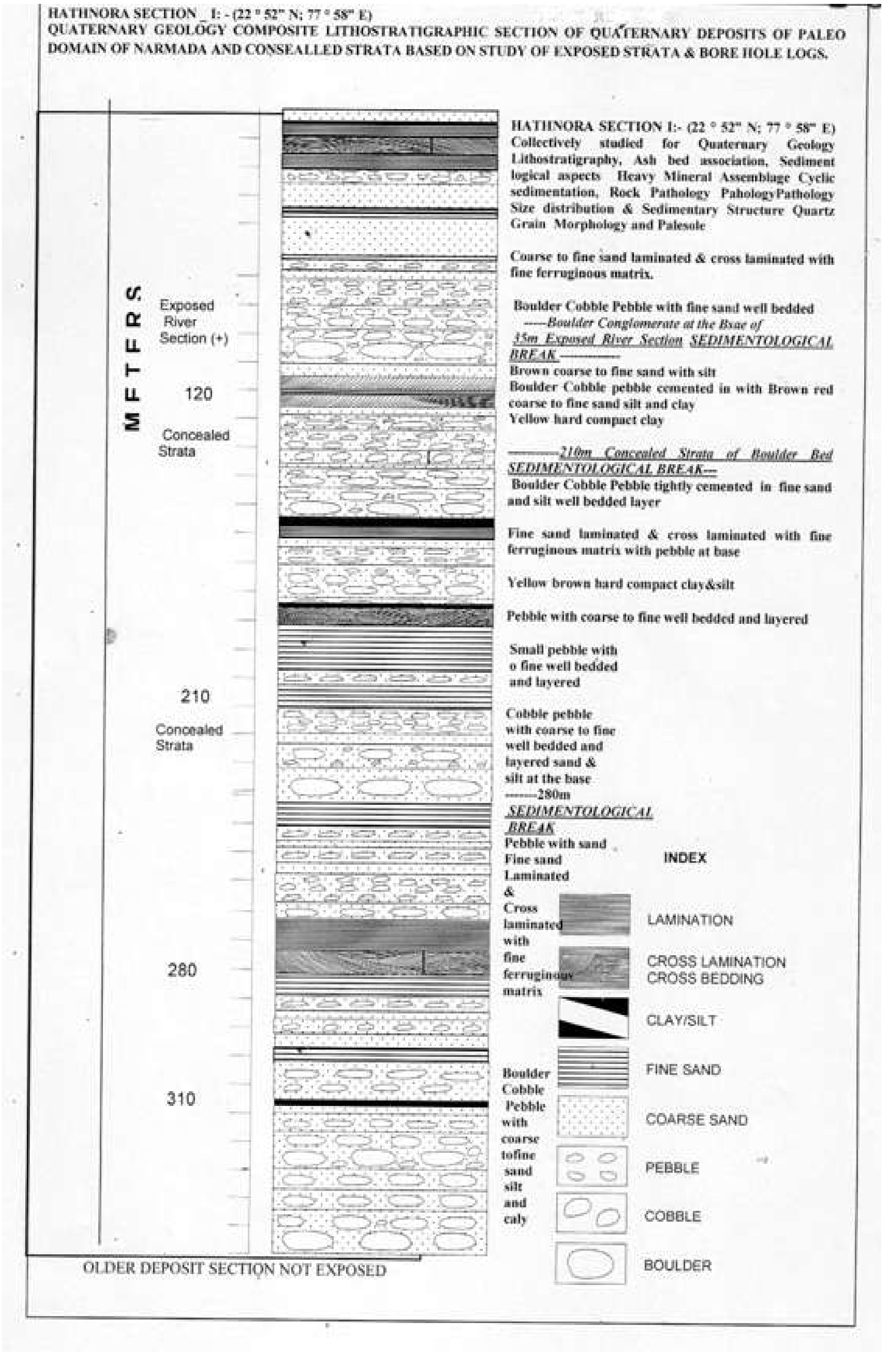
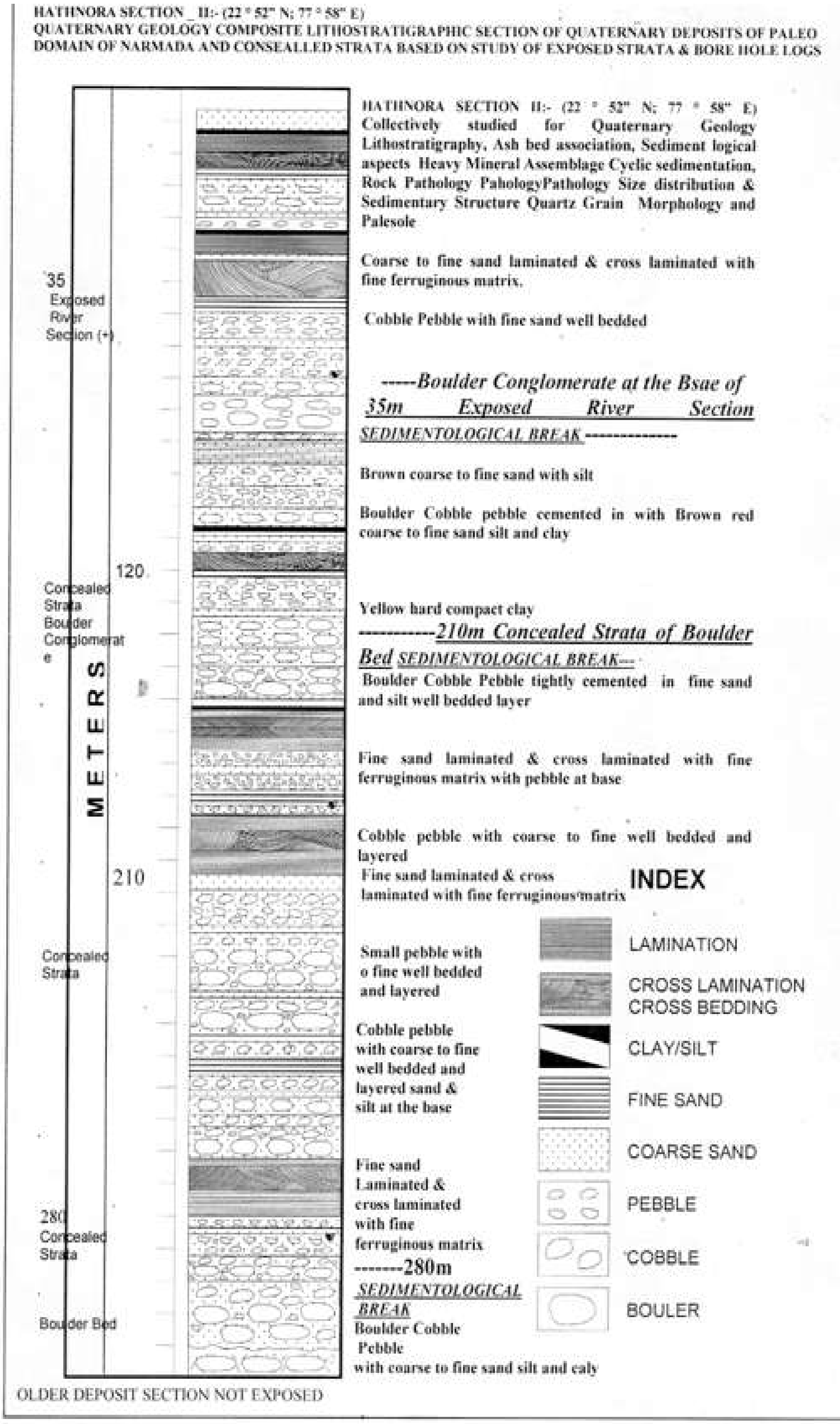


PLATE No.III
COMPOSITE LITHOSTRATIGRAPHIC SECTION OF QUATERNARY DEPOSITS OF NARMADA VELLEY
SEHORE AND HOSHANGABAD DISTRICTS, MADHYA PRADESH, INDIA
HARD COMPECT YELLOW CLAY, SILT WITH KANKARS (UPPER UNIT 3.25m)
YELLOW & BROWNISH SILT CLAY WITH SAND AND ROCK GRAVEL (MIDDLE UNIT 5.5m)
RED & BROWNISH SAND, SILT CLAY WITH CALCARIOUS METRIX (LOWER UNIT 6.25m)
BLACK YELLOW CLAY SILT WITH KANKAR (UPPER UNIT 2m)
YELLOW CLAY, SILT, COARSE TO FINE SAND, LIME CON-CRETION PEBBLE BED WITH MAMMA-LIAN FOSSIL AND STONE IMPLEMENTS (MIDDLE UNIT 10m)
PINKISH & BROWNISH SILT CLAY WITH KANKARS (LOWER UNIT 3m)
BLACK YELLOW AND BROWNISH CLAY SILT WITH KANKARS (UPPER UNIT 3.50m)
ROCK GRAVEL WITH CROSS LAMINATED SAND AND SILT (MIDDLE UNIT 5m)
UNCONSOLIDATED AND WELL SORTED ROCK GRAVEL WITH SAND BANDS (LOWER UNIT 6.50m)
SAND AND SILT
CROSS BEDDED SAND AND SILT
SAND AND SILT
PEBBLE WITH SAND
COBBLE WITH SAND
BOULDER WITH SAND
(A) SOHAGPUR FORMATION
(B) SHAHGANJ FORMATION
(C) HOSHANGABAD FORMATION
(D) JANWASA FORMATION


HATHNORA SECTION _ I: - (22 ° 52" N; 77 ° 58" E)
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.
METERS
Exposed River Section (+)
120
Concealed Strata
210
Concealed Strata
280
310
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 -----Boulder Conglomerate at the Bsae of 35m Exposed River Section SEDIMENTOLOGICAL BREAK -----------
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
----------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 SEDIMENTOLOGICAL BREAK
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
OLDER DEPOSIT SECTION NOT EXPOSED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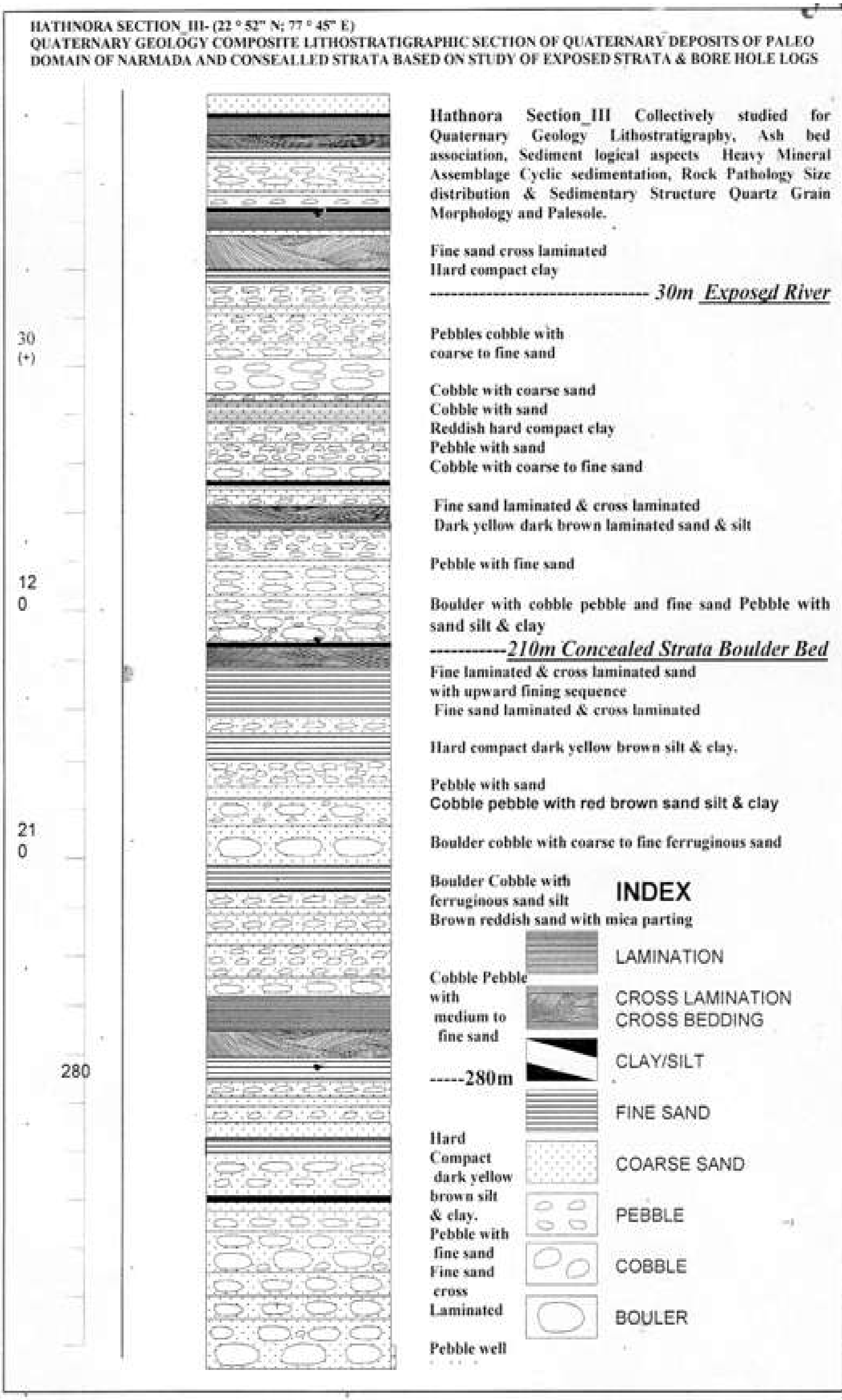
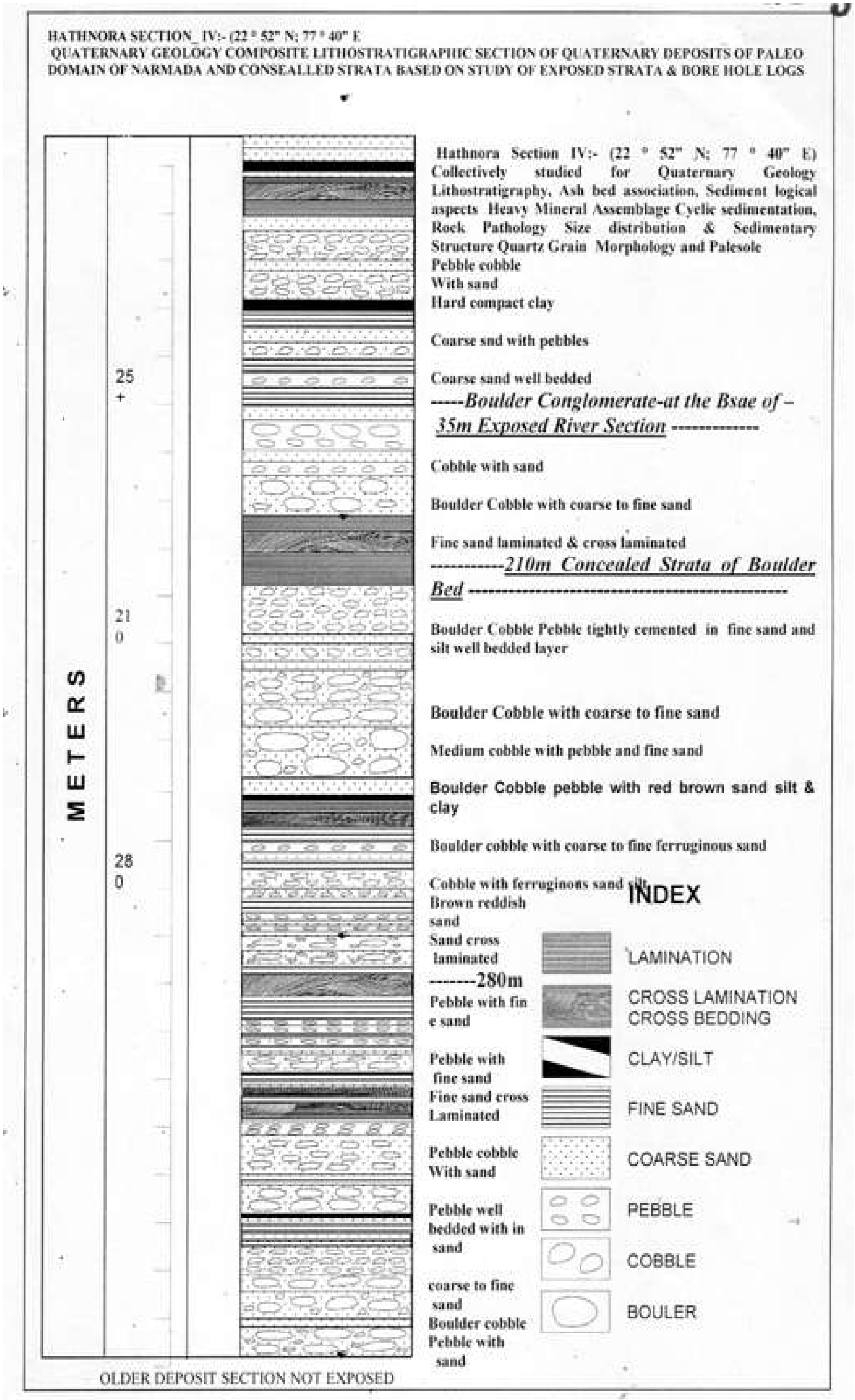
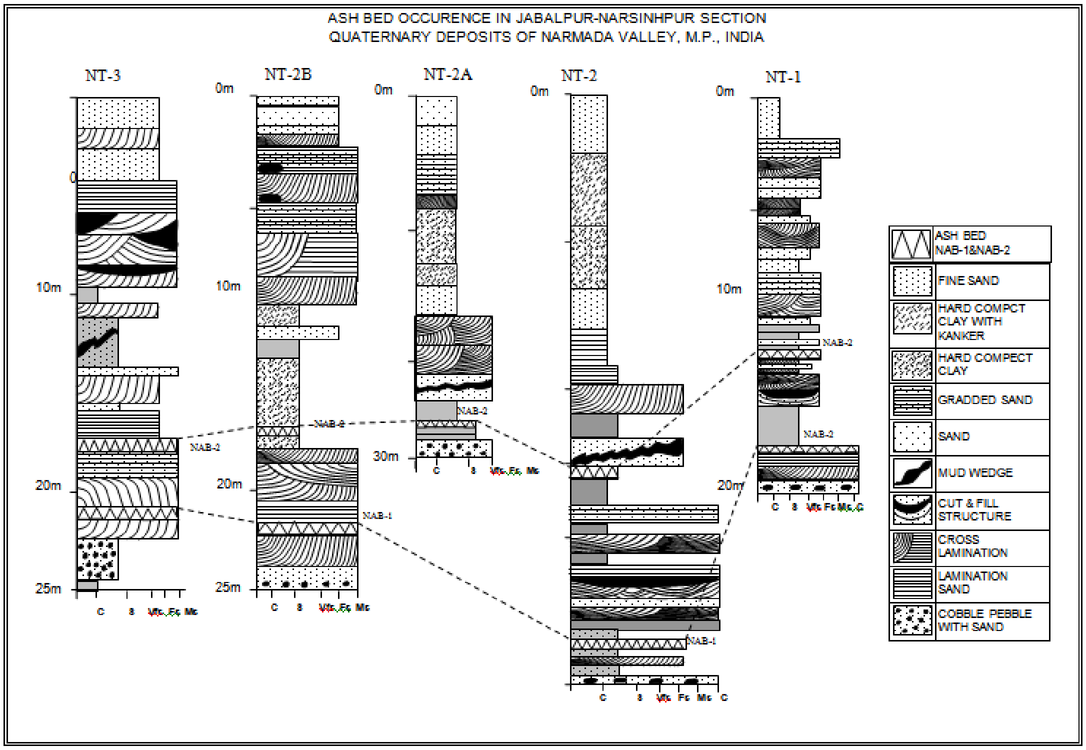
Coarse to fine sand laminated & cross laminated with fine ferruginous matrix.
Cobble Pebble with fine sand well bedded
-----Boulder Conglomerate at the Bsae of 35m Exposed River Section
SEDIMENTOLOGICAL BREAK --------------
Brown coarse to fine sand with silt
Boulder Cobble pebble cemented in with Brown red coarse to fine sand silt and clay
Yellow hard compact clay
-----------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
Cobble pebble with coarse to fine well bedded and layered
Fine sand laminated & cross laminated with fine ferruginous matrix
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
-------280m
SEDIMENTOLOGICAL BREAK
Boulder Cobble Pebble with coarse to fine sand silt and caly
35
Exposed River Section (+)
120
Concealed Strata Boulder Conglomerat e
METERS
210
Concealed Strata
280
Concealed Strata
Boulder Bed
OLDER DEPOSIT SECTION NOT EXPOSED
INDEX
LAMINATION
CROSS LAMINATION CROSS BEDDING
CLAY/SILT
FINE SAND
COARSE SAND
PEBBLE
COBBLE
BOULER


HATHNORA SECTION_III- (22 ° 52" N; 77 ° 45" E)
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_III 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.
Fine sand cross laminated
Hard compact clay
-------------------------------- 30m Exposed River
30 (+)
Pebbles cobble with coarse to fine sand
Cobble with coarse sand
Cobble with sand
Reddish hard compact clay
Pebble with sand
Cobble with coarse to fine sand
Fine sand laminated & cross laminated
Dark yellow dark brown laminated sand & silt
Pebble with fine sand
12 0
Boulder with cobble pebble and fine sand Pebble with sand silt & clay
-----------210m Concealed Strata Boulder Bed
Fine laminated & cross laminated sand with upward fining sequence
Fine sand laminated & cross laminated
Hard compact dark yellow brown silt & clay.
Pebble with sand
Cobble pebble with red brown sand silt & clay
21 0
Boulder cobble with coarse to fine ferruginous sand
Boulder Cobble with ferruginous sand silt
Brown reddish sand with mica parting
INDEX
LAMINATION
CROSS LAMINATION CROSS BEDDING
CLAY/SILT
FINE SAND
COARSE SAND
PEBBLE
COBBLE
BOULER
Cobble Pebble with medium to fine sand
280
-----280m
Hard Compact dark yellow brown silt & clay.
Pebble with fine sand
Fine sand cross Laminated
Pebble well


HATHNORA SECTION_ IV:- (22 ° 52" N; 77 ° 40" E
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 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
-----Boulder Conglomerate-at the Bsae of – 35m Exposed River Section -------------
Cobble with sand
Boulder Cobble with coarse to fine sand
Fine sand laminated & cross laminated
-----------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
Brown reddish sand
Sand cross laminated
-------280m
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
25 +
21 0
28 0
METERS
OLDER DEPOSIT SECTION NOT EXPOSED
INDEX
LAMINATION
CROSS LAMINATION CROSS BEDDING
CLAY/SILT
FINE SAND
COARSE SAND
PEBBLE
COBBLE
BOULER

Plate/Figure No.AF-4



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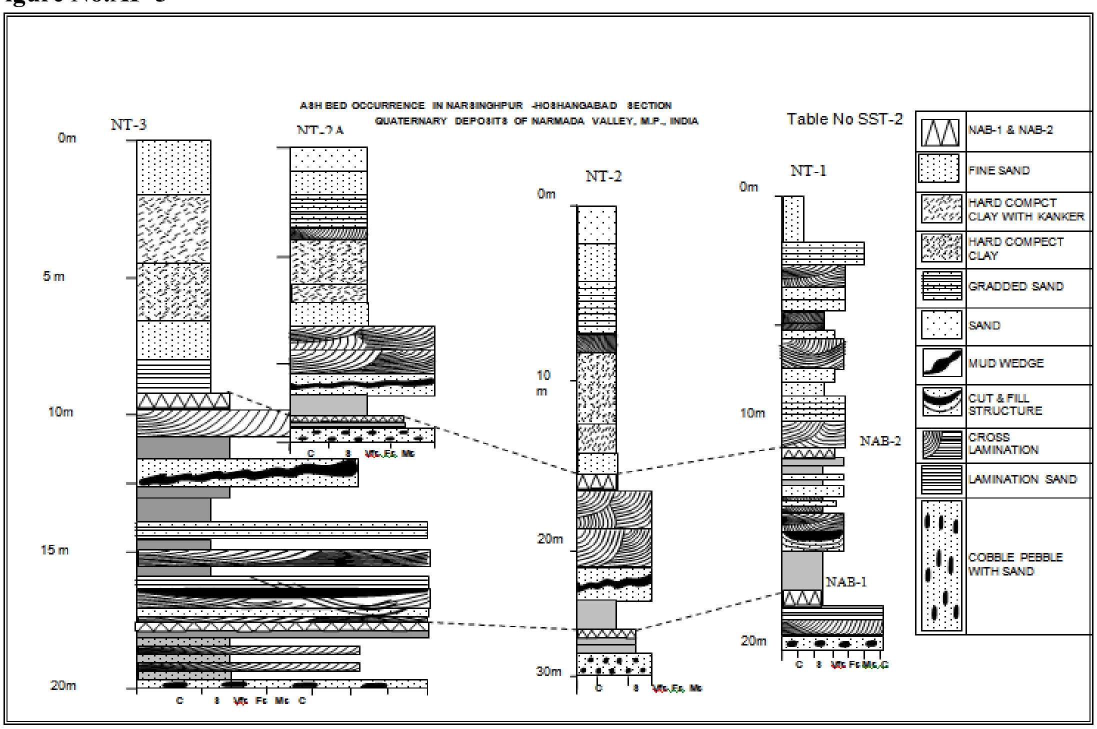

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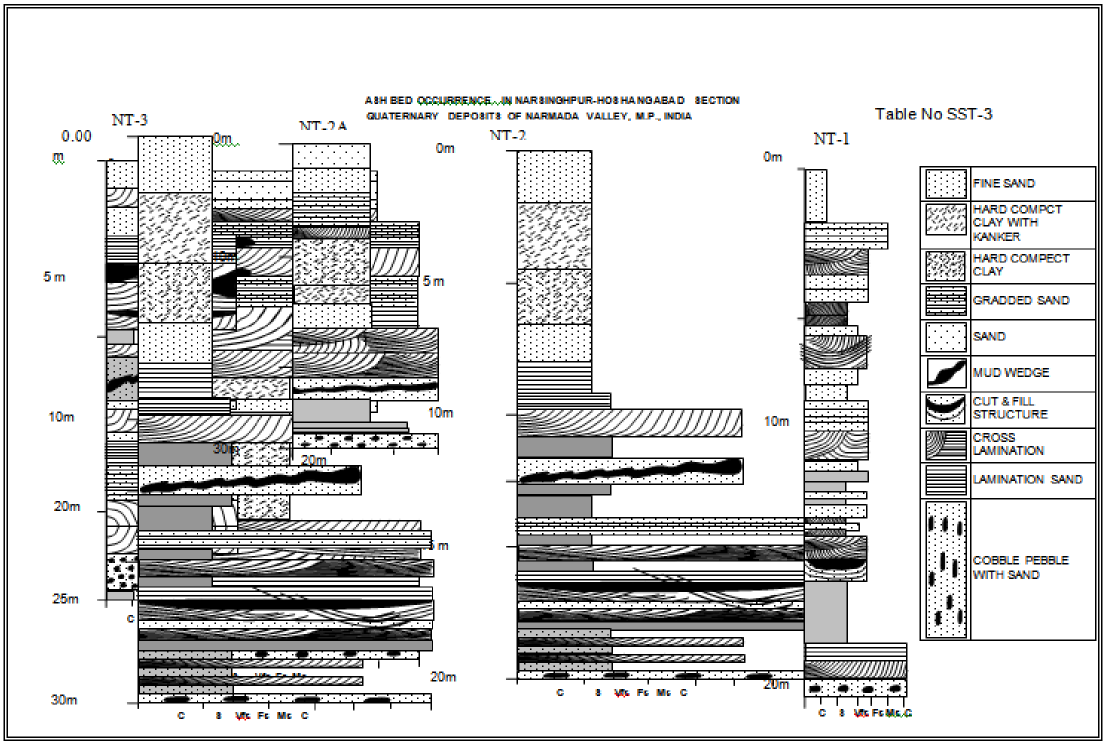

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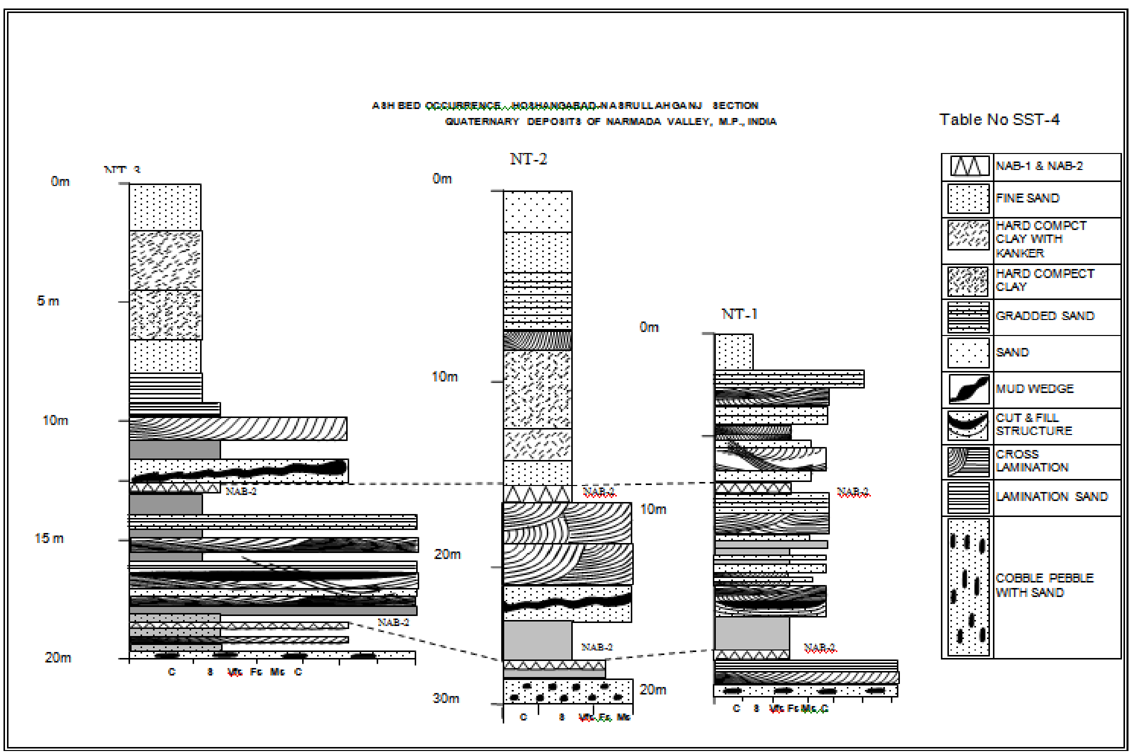

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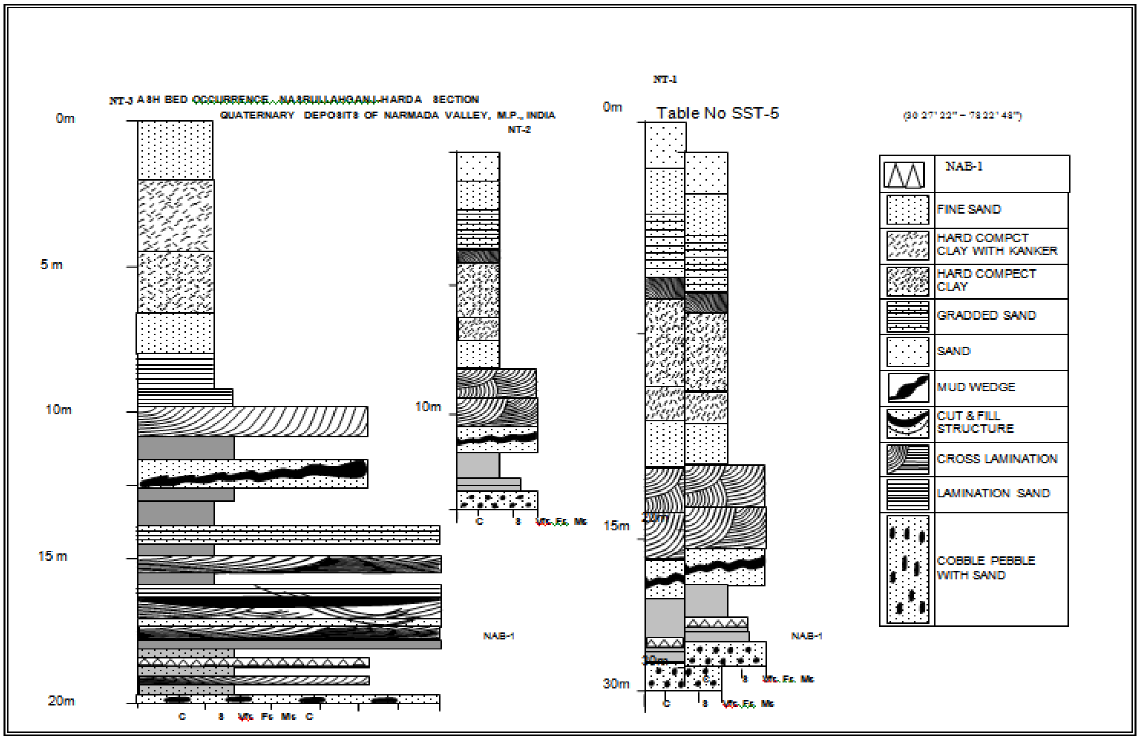

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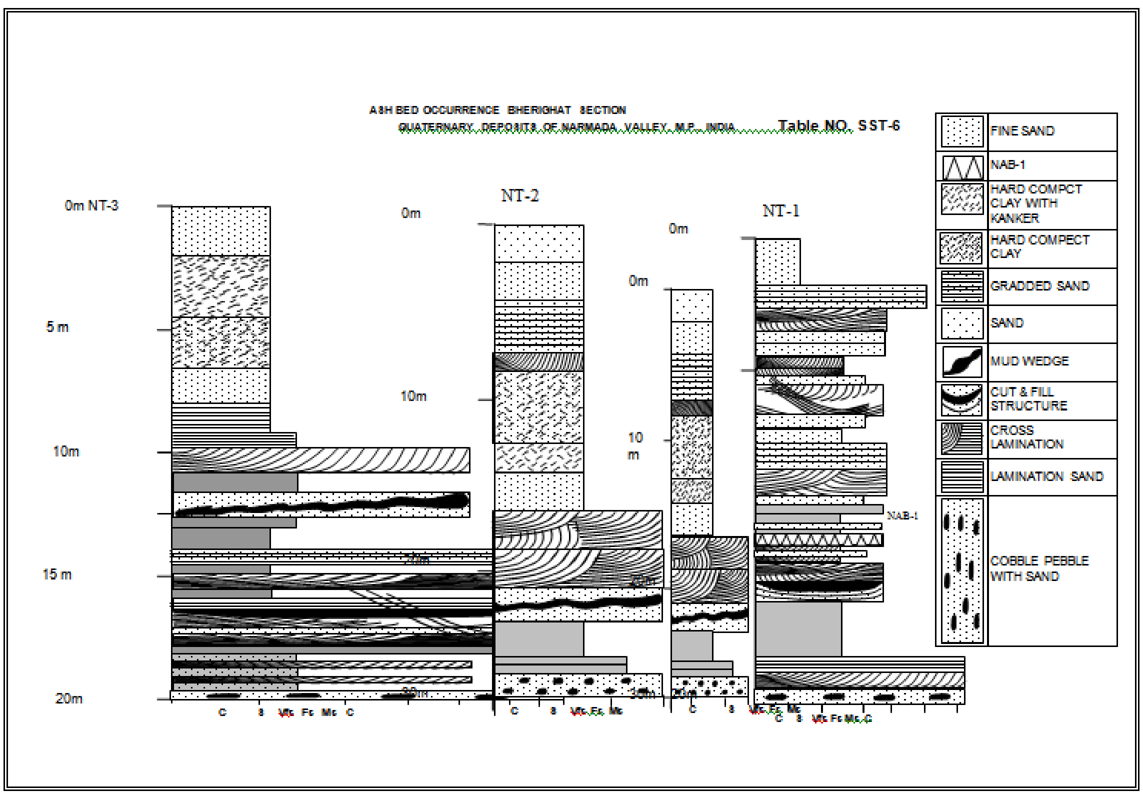

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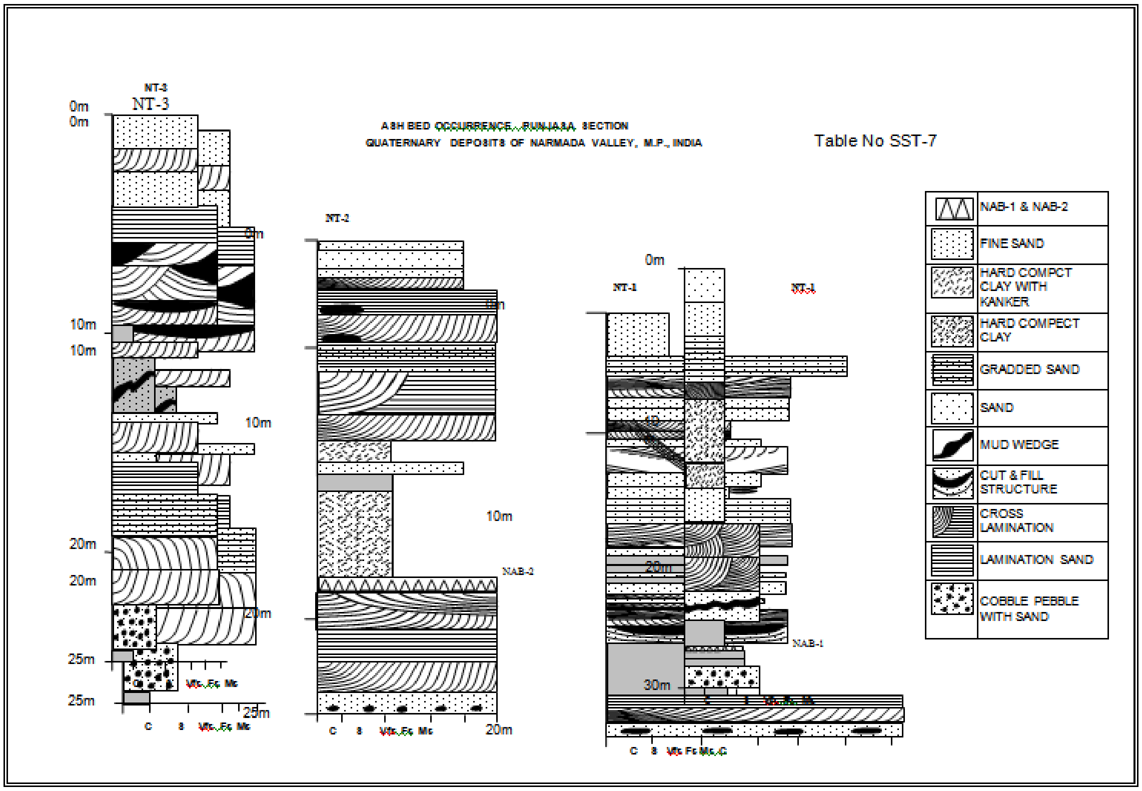

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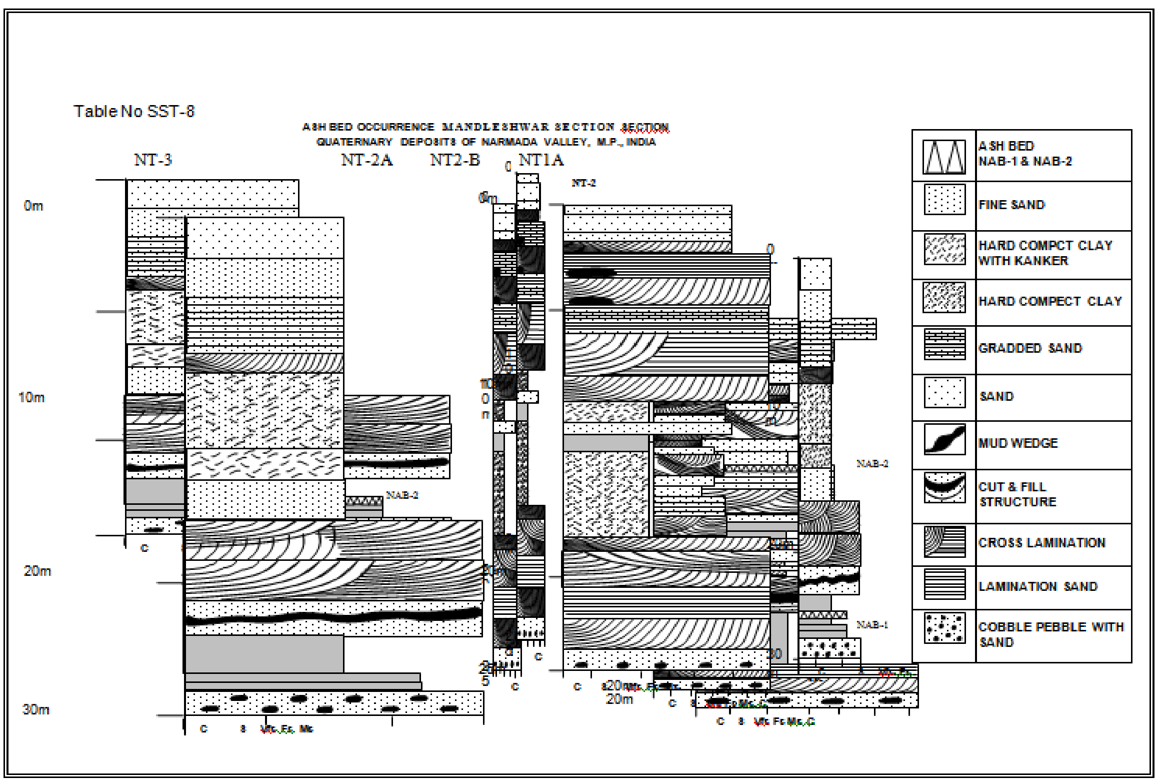

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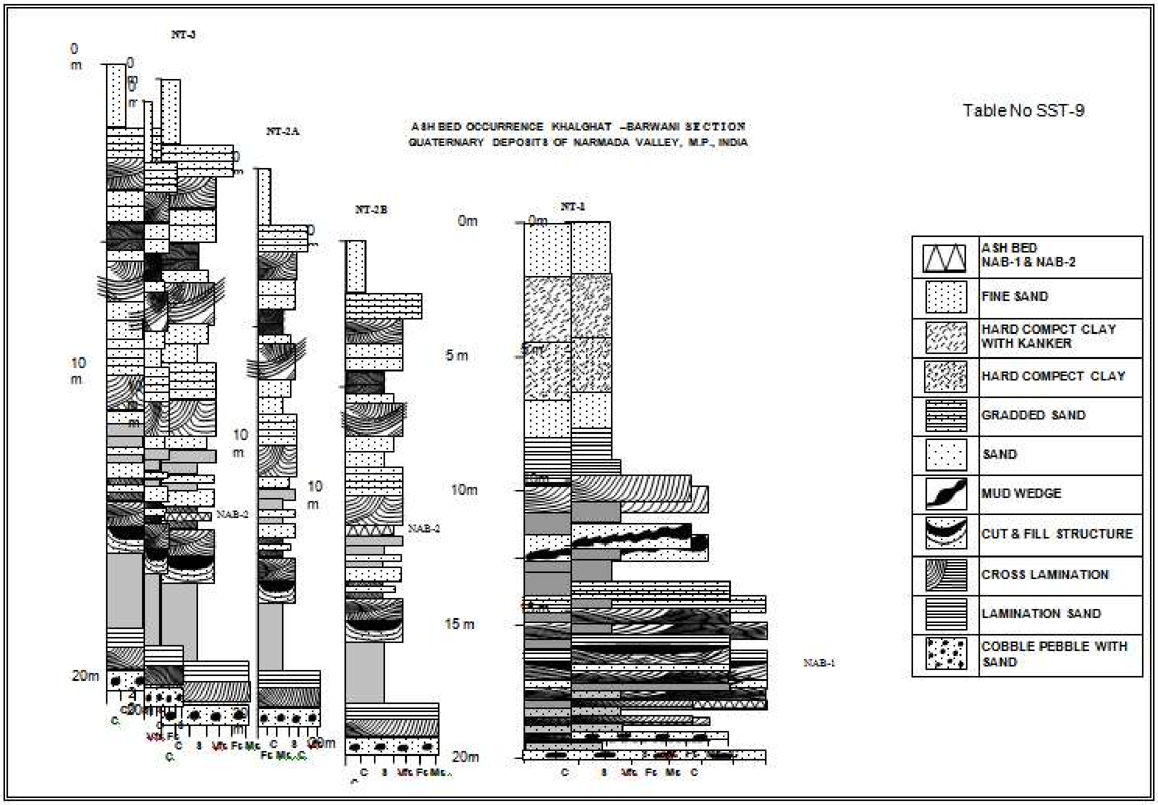

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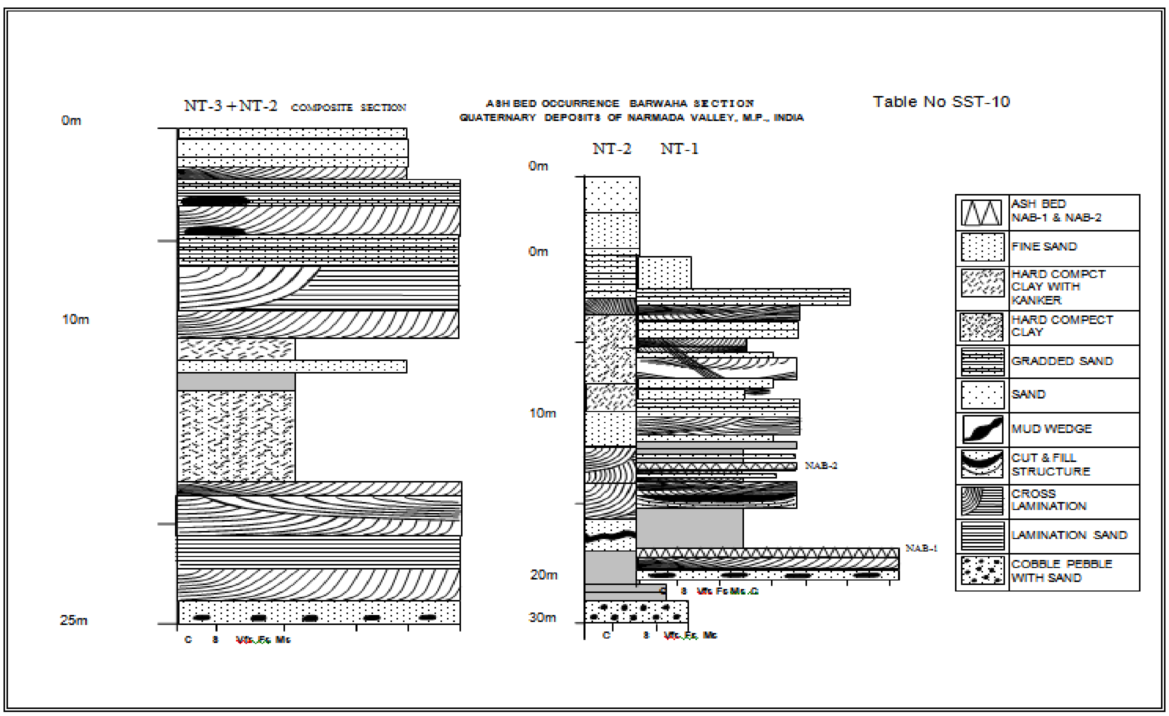

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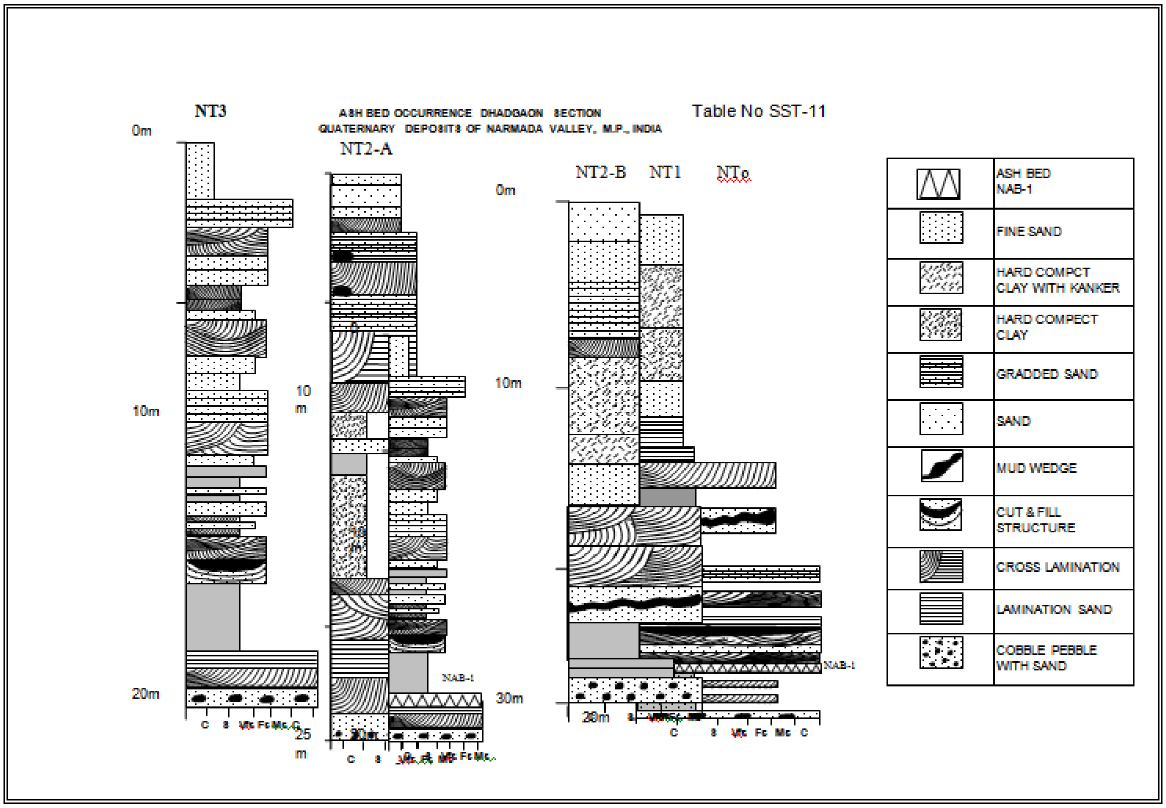

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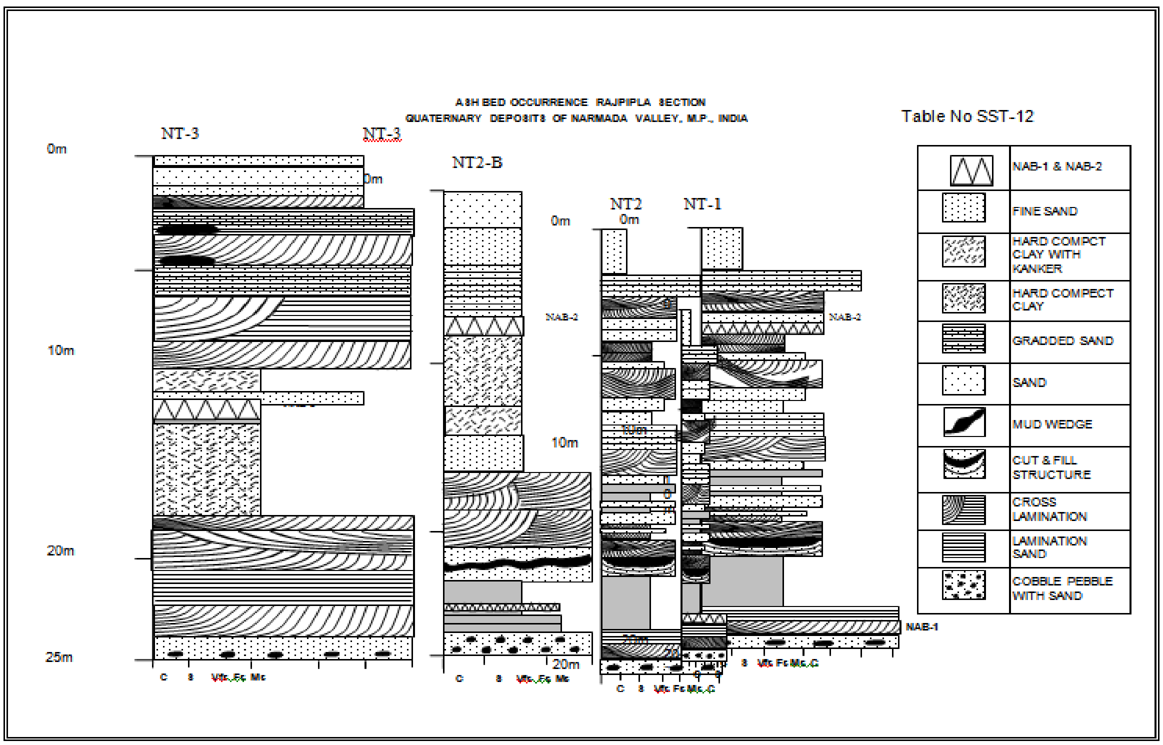

The boulder conglomerate is of middle Pleistocene age equivalent to Siwalik boulder conglomerate (India), Trini bed of Java (Indonesia) and boulder conglomerate of Tapti Khan (1982). These deposits have yielded skull cap of early man, Homo erectus Narmadensis along with other mammalian fossils Sonakia, (1984). 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.

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 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. The Quaternary deposits of Narmada are known for fossil assemblage (Biswas 1997) these deposits and identified two biostratigraphic units Lower assemblage and

Upper assemblage. The lower assemblage comprises Stegodon namadicus, Equus namadicus, Elephas namadicus (broad mollared) and Homo erectus. The upper assemblage comprises Elephas namadicus (narrow mollared); Hippopotamus namadicus and Equus onager khur, Fossils of the lower assemblage are found in the Surajkund Formation. Fossils of the upper assemblage occur in the Baneta, Hirdepur and Bauras Formations. Fossils are not reported from the stratotype section of the Dhansi Formation as well as from its other two localities (Burhi-Narmada and Shakkar river section).

The Quaternary deposit of the Narmada valley is known since the last century for their rich content of mammalian fossil. Some of the early records are by Splibury (1844), Falconer and Cautly (1847), Theobald (1860) and Pricep (1883). A systematic description of these mammalian fossils was given by Lydekker (1874-80) and Pilgrim (1926, 1939). During the last fifteen years, some additional collection of fossil mammals has been made with precise stratigraphic record (Biswas and Dassarma, 1981, 1984; Tripathi and Basu, 1983; Biswas, 1988). A new dimension has recently been added by the discovery of a skull of Homo erectus (Sonakia, 1984).The present biostratigraphic work is based on the field work carried out in parts of Hoshangabad, Sehore, and Raisen, Narsinghpur and Jabalpur district of M.P. and subsequent detailed taxonomic studies in the laboratory.

A large number of fossil mammals have been collected so far, but they represented only a few genera and spice. Systematic description for some of these has been published recently. Mention may be made of skull of Stegodon namadicus (Biswas and Dassarma, 1981) skull of Elephas cf namadicus (Tripathi and Basu, 1983), skull and mandibles of Hippotamus namadicus (Biswas and Dassrma, 1984), isolated teeth of Equus namadicus, skull, mandible and isolated teeth of Equus onager khur (Biswas, 1988) skull of Homo erectus (Sonakia, 1984; Lumely and Sonakia, 1985) a mandible of Cuon alpinus (Biswas and Basu, in press), and a skull of Hystrix (Biswas et al, 1988).

During the progress of the present multi-disciplinary project, a number of fossil vertebrates have also been collected. These included skulls, mandibles, horncores and other post-cranial bones of Stegodon namadicus Elephas namadicus, Bos namadicus, Bubalus palaiendicus, Boselaphus namadicus, Antilope cervicapra, Hippopotamus namadicus. Sus namadicus, Equus Boselphus namadicus, Antilope cervicapra, Hippopotamus namadicus. Sus namadicus, Equus namasdicxus, Equus onager khur, onager khur, Cervus cf unicolor and C. duvauceli. Amongst these some.

No remarkable distinction has been made between the fossil of Dhansi / Nasrullaha, Shivepuri Formation Khan (1992), Tiwari (1997). Fossil of Dhansi Nasrullahaganj formation, are, however, very fragmentary. These formations have yielded species species like stegodon namadicus, Equus namadicus, Hippopotamus namadicus, Cuon alpinus tripathii and Homo erectus, stregodon namadicus shows affinity with the middle Pleistocene S.orintalis of SE Asia (Biswas and Dassarma, 1981). The Equns namadicus originated from the lower Pleistocene, giving way to extant Equus onager Khur during the late Pleistocene (Biswas, 1988). Sus namadicus, Cuon alpinus tripathi and Homo erectus also show Middle Pleistocene affinity Pilgrim (1929); Biswas and Basu, in press and Sonakia (1984). The present study indicated that Surajkund / Shivepur formation is Middle Pleistocene in age whereas the underlying the Dhansi/--- Nasrullahaganj formation probably lowers Pleistocene to Middle Pleistocene in age.

The faunal contact of Baneta Sahaganj Hirdepur/ Demawar Shahganj / Hoshnagabad formations more or less similar. Khan (1992) Other than the species of Bos, Bubalus, Boselaphus, Antilope, Cervus and Elephas, characteristic forms of these formations include Hippopotamus palaeindicus, Hystrix crassidens and Equus onager Khur Hippopotamus palaeindicus succeeded Middle Pleistocene H. namadicus and itself became extinct probably during late Pleistocene or Lower Holocene. There is no evidence for Hippopotamus in the archaeology sites or cave painting in India. Prolific development of Hippopotamus palaeindicius has been reported from the adjacent Late Pleistocene Son Valley deposit (Dassarma and Biswas, 1997 Hystrix crassidenc is also an extinct from and is reported fromo late Pleistocene to lower Holocene deposits of Bankura (Dassarma et al 1982)and kurnool caves (Lydekkar, 1886). Equus onager khur is an extant from. A significant feature of Deonawar Baneta formation is the total absence of Stegodon which is more or less prolific in the underlying Shivpur / Surajkund and Formation. All these criteria taken together point to late Pleistocene to Lower Holocene Age for three Formations.

The mammalian genera listed above are more or less specialized and sensitive to climate condition. They are mainly warmth loving. None of t7he above mentioned fauna is indicative of cold climate. However, giantism observed in some Narmadsa Middle Pleistocene forms. May by indicative of the Pleistocene's freezing climate. This may be also due to the fact that Narmada fauna mostly represent intermediate stage between the Siwalika fauna and the extent fauna.

The analysis of the available data reveals the dominance of grazers over browsers. This may be party due to chance of better preservation of grassers. Grass-feeders roaming on flat terrains by the side of the river, definitely had a better chance of preservation as fossils than the browsers roaming in the jungles or hills slopes. Some forms like Bubalus, Hippoptamus, Stegodon, Cervus, Sus etc. suggest a prevailing, tropical, humid climate. At the same time some fauna like Equus point towards aridity. Admixture of the fauna like Equus point towards aridity. Admixture of the fauna depicting humidity and aridity is due to oscillation of climate from humid to arid in warm temperature.

The Narmada Homo eructs and associated Human culture:-

The Quaternary deposits of Narmada valley in the area Hominid Fossil locality Hathnora consists of 70 to 90 m of Narmada alluvium was deposited in single aggradational episode with minor pauses when dissection of the alluvium produced two terraces (NT1-NT2) The Sediments of gradational episode constitutes three lighostratigraphic units viz Boulder conglomerate, Sohagpur Formation. A Boulder bed of glacio-fluvial origin underlies the sediments of the alluvium phase. Thus the fossiliferous boulder conglomerates, the basal unit of the alluvium marks disconformities between the lower glacio – fluvial boulder layer and the upper fluvial sediments. The fossiliferous boulder conglomerate is considered to be middle Pleistocene age (Khan & Sonakia 1992). The Boulder Conglomerate (Hathnora Fomation) is thick wedge of semi consolidated fossiliferous sediments and concealed under thick deposits of clay and silt of the older alluvium in valley. It may contain the richest vertebrate fossil assemblage and has yielded only known Hominid fossil from the Indian sub-continent (Sonakia 1984). The Boulder bed which yielded Hominid fossil for the first time reported to be of glacial & fluvial origin Khan & Sonakia (1992). The fossiliferous horizons is concealed wedge, it is exposed only at some places in valley by lateral dissection by superimposed drainage, lateral river cutting, dissection of quaternary blanket, and other emotional activities. The Concealed and hidden disposition of fossiliferous horizon and its mysterious intricacy in tectonic zone and due to failure to understand basin configuration has disappointed the geoscientists to add further to any new find of Human skull, in spite of keen interest and intensive and extensive work.

However early human settlements have left widespread signatures on Indian river valley systems in the form of extensively large Paleolithic industry sites, whereas the hominid fossil evidences are very rare of scanty. The skull cop of Homo eractus, the 'Narmada Man' is the only example in the long stretch of Quaternary alluvial deposits occurring at varying topographic levels in the Narmada river valley of Central India. Some of the terraces are pretty rich in Paleolithic and Neolithic cultural materials, bearing testimony to the hunting and gathering abilities of early man. Elsewhere in the world, a century of discoveries precedes the discovery of the Indian fossil in 1982. The pioneering discoveries succeeded, with a couple of few finds from java in Indonesia and from China. Later, when the search involved the continents of Africa and Europe there was a spurt in the rate of discoveries and as a result, a large number of human fossils were discovered, thereby making the study of human evolution more logical and factual. It has to be mentioned here that initially discoveries of human fossils from Germany in Europe and from java in Asia, were very much neglected. The Indian fossil mentioned by Theobald (1881) was lost due to sheer curatorial negligence (Kennedy, 1980), whereas the Garman Neandethal specimen was initially misinterpreted.It took time to describe the Narmada specimen in detail and it also invited controversies regarding its taxanomic. (De Lumley and Sonakia, (1985); Kennedy at al, (1991). Some of the observations made later during detailed studies of the Narmada specimen are listed in the description given below.

The Narmada hominid specimen was discovered way back in 1982, during the course of systematic collection of faunal material in the Quaternary alluvial deposits of the Narmada Valley to erect the mammalian biostratigraphy. The Specimen lay exposed with its left Lateral cross-section leveled along with the eroded, gravelly terrace deposits on the right bank of the Narmada river near the village Hathnora in Shahganj block of Sehore district, about 80 km South South East of Bhopal.

Better preservation of human fossils at the beginning of burial as a ritual, has always been a matter of very rare chance. This leaves much of it to reconstruction of missing parts. Like many other controversies, the Narmada hominid has preserved many vital parts, thus leaving little scope for baseless speculations. Barring parts of facial lets parital and left temporal; all other bones are intact in the skull. The brownish color has developed as a result of intense mineralization. The skull is heavy, massive and to some extent robust. Contrary to the progressive brachycephalic trend, the Narmada skull is long and low. It has been classed in the dolicocephalic primitive group. The skull is wider near the base, whereas with progressive evolution the human skull grew wider and bulbous in the parietal region. In posterior view, a peculiar angularity, casting a pentagonal form is observed, the apex of this angularity is formed due to sagittal prominence and while descending laterally due to a wide angularity at the level of superior temporal line, from where the skull wall actually falls apart. There is a slight acute angle, when the temporal bone curves down in basal part of the skull. The mid sagittal curve is regular, gentle and smooth. The glabellar region is detached but the adjacent supr-orbital torus is quite massive and prominent, which project interiorly, shielding the eye sockets with almost circular portals a feature very much common to East African predecessors.

A sharp and prominent superior temporal line, developed as a remarkable positive relief, gradually curves down posterior to form a very strong, knot-like, angular torus. The mastoid and supra mastoid crests bulge more prominently than in some of the Homo erectus crania. The partially abraded mastoid process is typically small as observed in the primitive crania. Its shorter length is further confirmed by the posterior lengthening of incisures parietalis. Placed in a slightly higher position clutched between two secondary branches of the root of zygamatic process the external auditory meatus shows archaic features in tympana area. There is more or less a deep fissure between the petrosol crest of tympanic plate and the mastoid process. This sort of primitive trait is very much present in almost all the Indonesian and Sinanthrope skulls.

In Homo erectus occipital, the inion-endinion distance is quite a complex figure. It is as a result of interaction two morphologies, the endocrinal proportions and the nuchal musculature (stringer 1984). The inion is placed at a moderately higher level and coincides with opisthocranion, thereby leaving significant occipital plenum below, bounded by a definitely strong but abraded occipital torus. The sagittal suture is placed in a raised and prominent parietal keel which is flanked continuously on either side by a pair of shallow parasagittal depression.There are certain basic similarities between the Narmada skull and the better established Homo erectus crania viz., the Sagiran 17 Sinanthropes Pakinenis (Particularly skull XI) studied by Weidenreich (1943) many of the so called primitive features are restricted to the Asian clan of Homo erectus, whereas others are restricted to the African continent and are not reflected in Asian counterparts.

The gravel that yielded the Narmada Homo erectus carries heavy hand axes, cleavers and scrapers. While taking cross-traverses between Vindhyachal and Satpura mountains vast industry sites of the same palaeolithic implements have been located closeto oth the mountain rages.These sites appear to have been inhabited by Narmada hominid and its contemporaries for generations together. The excavation out by Deccan College, Pune (personal communication from V.N.Mishra) have yielded the lower Palaeolithic assemblage, in an excavation near Samnapur 10 km North of Narsimhpur. A Similar excavation was planned 4 km north of the Hathnora hominid site near villages Nimton and Rampura where the cultivated land is practically strewn with Paleolithic implements. The excavation was carried out in three pits measuring 1 m x 1mx .60 m.In all the pits each dig was approximately 10 cm. Thus nearly 6 digs were made. Debit age included a very large proportion of the material excavated. The size of debit age gradually decreased towards bottom. The debit age material comprises mainly Vindhyan quartzites which are found locally. Thus excavation, if carried out in the Narmada Valley, would provide an excellent correlation of the Paleolithic and Neolithic cultures which prevailed in Central India

The Quaternary deposited of Narmada Valley consist deposit of sediments of two domain viz. deposits of interglacial domain (Boulder conglomerate-Hathona formation) and fluvial deposit of paleo-domain of Narmada. The boulder conglomerate is fossil ferrous horizon of Narmada and has yielded skull cap of Homo erectus Narmadencis at (1984). It is marker horizon and represents interglacial phase in the history of Quaternary sedimentation in Narmada Valley around Hathnora upstream of Hathnora, Gurwara, and Sardapur. The occurrence of ash bed reported from Quaternary sediments of Narmada (1991).The Quaternary deposit of Narmada is associated with two horizons of ash beds of middle and upper Pleistocene age. These ash beds are designated as NAB-I and NAB-II in ascending antiquity in the valley. The Ash bed NAB-1 is associated with upper gritty units of boulder conglomerate (Hethnora formation) and is identified at an elevation of about 290 m above m.s.l. The Ash bed NAB-II is associated with upper units of clay silt deposits of paleo-domain of Narmada (Shahganjg formation) and is identified at an elevation of 310 m above m.s.l. The study of grain morphology of glass matrix, their- relation with other minerals shape, size, texture of lithic fragments and association of other ashy sediments of pyroclastic origin suggest that sediments were brought from distant source by Aeolian agencies, during the different phases of sedimentation in Narmada Valley. These ash beds are used as tool in correlation of different quaternary deposits in the valley.

The Quaternary geological history of Narmada is characterized by eruption of voluminous Deccan basaltic lava flows in the southern margin represented by Satpura and Vidhyan sedimentation represented by cuesta on the northern margin which have sharp cut across the deep valley floor of pre Cambrian basement. The rift linear trench is intruded by the dolerite and other mafic and siliceous dykes and sills along lineaments in different phases of tectonic deformation. The mafic and siliceous volcanic activity is both isolated and simultaneous and their disposition is mostly asymmetric across the rift zone. 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. 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 basins 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.

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 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 sdimt coloumns 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 paleoenvironment 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, (2002), Biswas, 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 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 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 .

The Narmada Rift System consists of symmetrical basins that have been evolved in different stages of tectonisam. The 100 -120 km-wide ad 1300 km long rift bounded by Satpura in south and Vindhyan in north constitutes conspicuous ENE-WSW to E-W rift basin zone is filled with Pliocene–Pleistocene sediments, whereas some of them contain Miocene sedimentary deposits. Most of the sedimentary sequences contain faunal and floral remains including hominid species. Most of the basin-fill sediments were derived from topographically elevated rocks that are present within and outside the rift basins. Lava flows and tephra are interbedded with the fossiliferous sediments clastic sediments derived from the provinces of sediment mostly from crystalline basement volcanic, sedimentary, meta basic and sedimentry rocks, aided in the cementation and preservation of organic remains by providing secondary minerals released during alteration in a burial environment. Quick burial minimized the effect of preburial taphonomic processes. Moreover, chemical constituents released by the alter have provided critical temporal and spatial information without which the study of hominid evolution and pale environmental reconstruction in the Rift System would have been impossible.

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 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 fossiliferous horizon in Narmada valley. Historical or modern analogs illustrate the potential of the regional and sometimes global effects of such major silica 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 from known area in Rift system.

The critical study of the area around Hathnora (22°52’77°52’) between Vindhyachal and Satpura mountains vast industry sites of the same palaeo lithic implements have been located along the edge and pediment slope of the Vindhyan and basaltic upland. These sites appear to have been inhabited by Narmada hominid and its contemporaries for generations together as they left over stone industry sites and unfinished material haphazardly indicate sudden dissemination and migration of hominines in search of shelter and safe places after volcanic eruption. .The reporting of remains of H. sapiens in the area of Bhembetaka about 20 Kms north of hominid locality of Hathnora and relicts of rocker shelter and ancient human signature documents the dispersal of hominines after the eruption of volcanic matrix and its fall Wakankar, V.S., 2002 .The association of skull cap Sonakia (1984) and Sankhyan (2007) described two new hominine fossils from Netankheri up stream of Hathnora in the Central Narmada valley. They include a partial left humeral diaphysis and a distal shaft fragment of the left femur associated with Hathnora formation Khan & Sonakia 1992 and analysis of quartz grain morphology of sediment columns of Hathnora and quartz grain morphology of paleosole across the quaternary strata of bore hole sampling across 556 m of rock basin revealed that Homo eructus of Narmada partly sustain in the glacial and fluvio-glacial environment which is documented and witnessed by Hathnora formation which marks the end hostile climate and environment of sedimentation in Narmada valley Khan (2013).

The study of quartz grain and their micro structures of paleo soil identified in concealed blanket of quaternary deposits display relatively heterogeneity in sediment characteristics throughout across the Quaternary column of Hathnora section in Central Narmada valley. The quartz grain of paleo soil and sediments display digonestic characteristics of glacial fluvio-glacial and fluvial under concealed environment of sedimentation at different depth. The significant breaks in grain morphology of quartz grain surface texture and associated elements and granular matrix in the sequence of quaternary strata is recorded at to, 150, 350 and 350 and beyond which linked to long evolution of glacial fluvio glacial and fluvial environment of sedimentation in time and space in increasing antiquity in the valley from the base Khan (2013). The occurrence of Bolder conglomerate and occurrence of haphazard and disserted sites of Palaeolithic sites indicates that area suffered dual hostility first the end of glacial activity with the stratigraphic column at the level of 83 m where the Homo eructs survived Sonakia (1984) both by glacial activity and volcanic eruption, whereas in the second hostility evolving human activity by volcanic eruption and dense smoke and dust and darkness. And consequent upon H Sapiens and associated were forced to migrated to safer places. In view of the recorded observation the concealed quaternary strata to the level of about 350 m below ground level further needs attention of geoscientist for the search of human remains in Narmada valley.

The study of assemblage of glass matrix of Ash bed, grain morphology of glass their- relation with other minerals shape, size, texture of litho fragments of pyroclastic origin suggest that sediments were brought from distant source by Aeolian agencies in the form of thick cloud containing volcanic dust, rock matrix and different gases which remained in atmosphere for very long time and settled down across the Indian sub continent during the different phases of river sedimentation. Further study of Ash bed material and silica revealed diagnostic morphological characters of glass shards which are typical of silica volcanism (Heiken, 1972, 1974) and show close similarity with those reported from the Quaternary tephra beds of the Narmada, Son, Purna and Kukdi basins (Basu et. al., 1987; Khan et.al. 1991 Basu and Biswas, 1991; Singaraju and Shivaji, (1991) Mukhopadhyay, (1992). It is significant to note that the occurrences and association of two marked horizons at different levels further reveal that the cyclic eruption and settling of volcanic matrix has taken place with pause in the valley.

In Narmada valley the association of Ash bed NAB-I with Hathnora formation at the depth of 78 m in Quaternary column and occurrences of skull cap 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.

Using phytogeographic data, 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 cap 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 Toba eruption of 74 ka was distinctly and clearly a mega event of very great magnitude and intensity, far greater than any known historical eruption, suggesting it had very devastating impact and repercussions. It has change the global climate environment and ecology.

The Quaternary deposit of Narmada Valley consists of sediments of three domain viz. deposits glacial, fluvio-glacial (interglacial) and fluvial. The boulder conglomerate is fossiliferous horizon of Narmada and has yielded skull cap of Homo erectus Narmadenesis Sonakia (1984).The Ash bed is found associated with Hathnora formation Khan et.at.(1991), in the area around Hathnora, upstream of Hathnora, Gurwara , Sardapur two horizon of Ash bed are identified in Boulder conglomerate (Hathnora formation). These 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 quite persistent and well preserved. The NAB-1 (L1 to L 3) contains three micro layer and NB-II (L-4 to L-5) two micro layers in increasing antiquity. The lower unit of boulder conglomerate is associated with NAB-I, where as NAB-II is associated with younger deposits. The study of grain morphology of glass matrix, their relation with other minerals shape, size, and texture of lithic fragments and association of other ashy sediments of pyroclastic origin suggest that sediments were brought from distant source by Aeolian agencies which fell and settled down during the different phases of sedimentation in valley. The Ash bed NAB-I is embedded within the reddish brown sand silt and in the upper pebbly gritty unit of boulder conglomerate (Hathnora formation).

The Ash bed NAB-II is associated with yellow, reddish, brown, clay and silt of fluvial deposits Khan et. al. (1992). It is pinkish grey, light brown in colour, fine grained, porous and non-plastic in nature. The average thickness is about 25 cms

The study of grain morphology of glass matrix, their inter-relation with other minerals shape, size, texture of lithic fragments and association of other ash sediments of pyroclastic origin, indicate that they are the product of highly explosive silica volcanism. Pumice shards tend to develop from relatively high viscosity rhyolitic magmas with temperature less than 850 C whereas cuspate shards are most likely to develop from low viscosity rhyolitic magma with temperature more than 850 C suggest that sediments of pyroclastic origin and were brought from distant source by Aeolian agencies, after extrusive volcanic activity in middle and upper Pleistocene time.

There are quarries and questions that necessitate consideration of two separate aspects of the eruption; first, the consequences of possible rapid global climatic deterioration and second, the direct effects of the ash-fall on hominines and their environments in Narmada valley and in Indian subcontinent.

The association of Ash bed NAB-I with Hathnora formation at the depth of 78 m in Quaternary column of Narmada and occurrences skull cape of Homo erectus of Narmada at the depth of 83 m assumed that Toba eruption might have taken place later than that of existence of Homo erectus which appeared and resided in the valley for long time before the fall of Toba ash. The association of Ash bed NAB-II at the depth of 72 m with the younger deposits indicates the second cyclic of fall of Toba ash which might have influenced the younger Hominines i.e Homo erectus & Homo sapiens, in Narmada valley.

The occurrences of these skull caps with short range of their occurrences in the stratigraphic column of Narmada with the Ash beds horizon NAB-I and NAB-II and specially with the Hathnora formation one at the top at an average elevation of about 268-273 m above the mean sea level and other with younger deposits had revealed the close association with volcanic activity with their existence. The Toba Ash fall is also in very close range with the sequence of sedimentation and occurrences with both the skull caps, which certainly has its impact on the middle and late Pleistocene Hominines in Narmada valley and Indian subcontinent.

The oldest fossil from India is represented by the Narmada hominine dated to not less than 236 ka (Cameron et al., 2004), or to some time in between 150 and 250 ka (Kennedy, 2001:167). Modern human remains have been discovered in an undated Late Paleolithic context at Bhimbetka rock shelter III-A-28 (Wakankar, 2002:5) which is situated about 20 km north of Hominid locality Hathnora and from three cave sites in Sri Lanka, dating from 27.7 ka (Kennedy 1999, 2001).Using phytogeographic data, Oppenheimer (2003) argues that H. sapiens occupied India before ~74 ka and may have undergone "mass extinction" as a result of the Toba eruption. The later argument is in conformity with the observation of authors as it is well illustrated by close association of Ash bed and Homo erectus of in sediment sequence of Quaternary column of Narmada.

The study of grain morphology of glass matrix, their relation with other minerals shape, size, and texture of fragments and sediments of pyroclastic origin suggest that sediments were brought from distant source in the form of thick cloud containing dust matrix and volcanic ash which was highly explosive and siliceous in nature and remained in atmosphere for quite long time. The height of the eruption column appears to be considerable. It is postulated that the tephra preserved as disconnected bodies within the river valley sediments represent rapidly settled ash falls from a volcanic ash cloud which formed a canopy over a large part of river basins for longer time of Peninsular India where sedimentation was on in different river basins including Narmada valley. The discontinuity of Ash bed in Narmada valley and Indian subcontinent is attributed to be associated with column of volcanic eruption, quantum of volcanic matrix, wind direction, moisture density of air and rate of fall of matrix on oscillating platforms of sedimentation in different basin. It is significant to note that the occurrences and association of two marked horizons at different levels further reveal that the cyclic eruption and settling of volcanic matrix was with pause in the valley which perhaps related with pause in volcanic eruption

The volcanic eruption and consequential ash fall has created severe dislocation in ecology and environment and adversely affected hominines in Narmada valley and Indian subcontinent. It is witnessed by association of Ash bed NAB-I with Hathnora formation at the depth of 78 m in Quaternary column and occurrences skull cap 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 have had influenced collective and cumulative the Homo erectus (Sonakia1984) Homo sapiens (Thobold 1860, 81), in Narmada valley and Indian sub-continent.

The study of cyclic Toba ash fall and using phytogeographic data, 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 (325m) and occurrences of fossil of skull cap of Homo erectus (Sonakia1984) at 83 m & human cranium Homo sapiens (Thebold 1960,1981) (transported) have rarest occurrences of human fossils in Narmada valley and subcontinent which also confirm the intensive impact of volcanic ash fall on these hominines and their consequential mass extinction caused by mega dislocation in ecology and environment by volcanic eruption.

Toba Eruption and Its Impact on Environment:-

In Narmada valley and Indian sub continent the Environment and climate during late pleistocene has been significantly affected after Toba eruption, according to Rampino et al. (1988) the size of Toba at 74 ka could have induced a volcanic winter, similar to predicted nuclear winter scenarios, as modeled by Turco et al. (1983, 1990). The injection of vast amounts of gaseous aerosols and volcanic dust and matrix into the atmosphere, which follow large volcanic eruptions, is predicted to have detrimental and decisive consequences for changes of global climate. Past historical eruptions, such as Tambora in 1815 (Stothers, 1984) and Pinatubo in 1991 (Mc Cormick et al., 1995), have provided evidence of post-eruption climatic deterioration and climatic. With the eruption of Toba having been far larger than both of these historical eruptions, its consequences are therefore assumed to have been far more devastating. The imprints of divesting impacts in the area of study and specific on human population are matter of scientific concerned and yet to be investigated. The studies conducted of Ash bed associated with Quaternary deposits of Narmada Valley consist of sediments of two domain viz. deposits of interglacial domain (Boulder conglomerate-Hathona formation) and fluvial deposit of paleo-domain of Narmada. The boulder conglomerate is fossil ferrous horizon of Narmada and has yielded skull cap of Homo erectu Sonakia (1984). (Khan & Sonakia 1991) .It is marker horizon and represents interglacial phase in the history of Quaternary sedimentation in Narmada Valley. The occurrence of ash bed reported from Quaternary sediments o f Narmada are associated with two horizons of ash beds of middle and upper Pleistocene age (Khan et.al.1991).

These ash beds are designated as NAB-I and NAB-II consisting of five layers designated as (L1 to L5) in ascending antiquity in the valley.The Ash bed NAB-1 (L1- to L-3) is associated with upper gritty units of boulder conglomerate (Hathnora formation) and is identified at an elevation of about 290m. Above m.s.l. The Ash bed NAB-II (L-4 to L5) is associated with upper units of clay silt deposits of paleo-domain of Narmada (Shahganjg formation) and is identified at an elevation of 310m. above msl.The study of grain morphology of glass matrix, their- relation with other minerals shape, size, texture of lithic fragments and association of other ashy sediments of pyroclastic origin suggest that sediments were brought from distant source by Aeolian agonies, during the different phases of sedimentation in Narmada Valley. It is observed that in stratigraphic coloumn two horizons of Ash bed occurred at the vertical distance of about 20 m. which indicate that there were two phases of settling volcanic ash in Narmada valley and Indian subcontinent as a whole with significant time break. The element of time break is in terms of sedimentation perceptible appears to be related with global climatic changes induced by the super volcanic eruption. These ash beds are used as tool in correlation of different quaternary deposits and archeological sites in the valley. The occurrences of two horizons of Ash bed and their deposition by settling of volcanic dust with time gape suggest induced and defused atmospheric conditions in Narmada valley for a very long time after volcanic eruption.

The atmosphere contaminated by volcanic ash volcanic matrix and huge amount of gases and dust particles had definitely affected the atmosphere and climate had have led to temporarily darkened skies in the Narmada valley and Indian subcontinent for very long time. Ash, however, it has had short stay in the atmosphere depending of particles load, wind direction and velocity, moisture density, and volcanic coloumn of eruption and its shrinkage, land barriers, temperature association of gases and longevity of sulphuric acid aerosols. The association of sulphuric acid predicted to have had the most damaging repercussions for Indian subcontinents and global climate. Dense concentrations of H2SO4 aerosols in the stratosphere had been the main causecative factor to prevent radiation reaching the Earth from the Sun. (Rampino et al., 1988). This process results in cooling of both the atmosphere and the surface of the Earth.

Toba in Indian Subcontinent with special reference to Narmada Valley:-

The occurrence of ash bed reported from Quaternary sediments o f Narmada are associated with two horizons of ash beds of middle and upper Pleistocene age (Khan et.al.1991). These ash beds are designated as NAB-I and NAB-II consisting of five layers designated as (L1 to L5) in ascending antiquity in the valley.The Ash bed NAB-1 (L1- to L-3) is associated with upper gritty units of boulder conglomerate (Hethnora formation) and is identified at an elevation of about 290m. Above m.s.l.l The Ash bed NAB-II (L-4 to L5) is associated with upper units of clay silt deposits of palco-domain of Narmada (Shahganjg formation) and is identified at an elevation of 310 m. above m.s.l.The study of grain morphology of glass matrix, their- relation with other minerals shape, size, texture of lithic fragments and association of other ashy sediments of pyroclastic origin suggest that sediments were brought from distant source by Aeolian agonies, during the different phases of sedimentation in Narmada Valley. It is observed that in stratigraphic coloumn two horizons of Ash bed occurred at the vertical distance of about 20 m. which indicate that there were two phases of settling volcanic ash in Narmada valley and Indian subcontinent as a whole with significant time break. The element of time break is in terms of sedimentation perceptible appears to be related with global climatic changes induced by the super volcanic eruption. These ash beds are used as tool in correlation of different quaternary deposits and archeological sites in the valley. The occurrences of two horizons of Ash bed and their deposition by settling of volcanic dust with time gape suggest induced and defused atmospheric conditions for a very long time after volcanic eruption

Having reviewed the theories surrounding the effects of the Toba eruption on both global climate and human populations in general, it is now possible to turn our attention to evidence provided in the specific context of the Indian subcontinent. By way of background, it is important to recognize that ca. 800 km3 of fine-grained volcanic ash was injected into the stratosphere during the 74 ka Toba eruption. The ash was carried by prevailing winds in all directions, apart from to the south-east. As a result, large areas of southern and southeastern Asia were covered in tephra, from the Arabian Sea in the west to the South China Sea in the East (Figure 1). YTT has been documented in marine cores from the northeast Indian Ocean and Bay of Bengal (Ninkovich et al., 1978a, 1978b; Dehn et al., 1991) and more recently from the Central Indian Ocean Basin (Pattan et al., 1999, 2002), Arabian Sea (Schulz et al.

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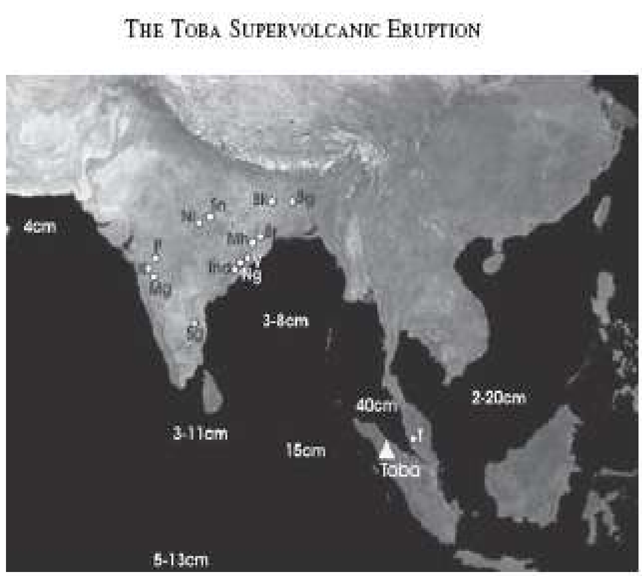


Figure 1. Marine and terrestrial distribution of the Youngest Toba Tuff in southern and south-east Asia. The thickness of marine ash layers at various localities is indicated (in white, in centimetres). The white circles in India, Bangladesh and Malaysia indicate the location of terrestrial tephra sites. The letters correspond to the following localities; K=Kukdi, P=Purna, Mg=Morgaon, Sg=Sagileru, Ind=Indravati, Ng=Nagavali, V=Vansadhara, Mh=Mahanadi, Br=Brahmani, Bg=Bogra, Bk=Barakar, Sn=Son, Nr=Narmada, T=Tampan

1998, 2002; Pattan et al., 2001) and South China Sea (Bühring et al., 2000; Song et al., 2000). The thickness of the YTT bed in these deep-sea cores ranges from ~2 to ~40 cm and does not appear to reduce significantly with increasing distance from the Toba caldera. However, marine ash layers, as with terrestrial tephra beds, can experience reworking and bioturbation and thus some may not preserve a precise record of air-fall thickness.

Terrestrial YTT deposits have been identified in India (Rose and Chesner, 1987; Khan et.al.1991) Acharyya and Basu, 1993; Shane et al., 1995; Westgate et al., 1998), Malaysia (Ninkovich et al., 1978a; Rose and Chesner, 1987; Shane et al., 1995) and possibly in Bangladesh (Acharyya and Basu, 1993; Acharyya et al.,2000). Of these, Indian YTT occurrences are far more numerous and extensive, having been documented in river valleys throughout the subcontinent (Table 1). Well-described Toba ash localities include those from the Middle Son and Central Narmada valleys in Madhya Pradesh, the Kukdi river in Maharashtra, and the Indravati, Nagavali, Vansadhara, The documentation of occurrences of YTT deposits in India has been relatively recent. Williams and Royce (1982) reported the first discovery of volcanic ash in India, encountered during explorations in the Middle Son valley in 1980. This was followed by further discoveries of tephra deposits in the Middle Son valley, as well as in the central

Table 1. A summary of Indian tephra localities, indicating the nature of the tephra deposits, those that have been identified as YTT and dated by absolute means, and those that have been found in association with Paleolithic artifacts

River Valley	*Tephra Locality*	*Tephra Thickness (m)*	*Extension of Tephra (km)*	*Geochemically Characterized as YTT?*	*Absolute Dates*	*Archaeology-tephra Associations?*
Middle Son	Ghogara	1.5	30	Yes[a,b,c,d]	No	Yes (Middle and Upper Paleolithic)
	Ramnagar	0.5				
	Nakjhar	0.7				
	Khutiali	1.5				
Central Narmada	Pawlaghat	0.24–0.4	20	Yes[b,c,d]	121 ± 22 ka[d]	Yes (Middle and Upper Paleolithic)
	Guruwara	0.8				
	Devakachar	<1				
	Hirapur	<1				
Kukdi	10 sections near Bori	0.2–1	3.5	Yes[b,c,d]	1.4 Ma[e]; 0.54 Ma, 0.64 Ma, 0.023 Ma[f]; 0.67 Ma[g].	Yes (Lower Paleolithic)
Vansadhara	Goguparu	1.25	2	Yes[b]	No	Yes (Lower Paleolithic, but stratigraphic association between ash and artifacts is unclear)
	Kareni	3–5				
Nagavali	Rayagada	1.5–6	17	Not analysed	No	Not reported
Mahanadi	Kumbia	2.1	45	Yes[d]	No	Not reported
	Krushnamohonpur	2				
	Pitamohul	3				
	Sonepur	1.5–2.5				
Brahmani	Samal	2.5	2.5	Not analysed	No	Not reported
Indravati	Damkelar	0.2–0.3	0.5	Not analysed	No	Not reported
Sagileru	(not specified)	0.3–2	90	Not analysed	No	Not reported
Barakar	Opposite Barakar town	1.83	0.1	Yes[b]	No	Not reported
Purna	e.g. "Gandhigram Place"	Not specified	Not specified	Yes[c,d]	84 ± 16 ka[d]	Yes Paleolithic (Acheulean?)[c]
Kartha	Morgaon	0.17	0.54	Not analysed	No	Yes Lower Paleolithic (Acheulean)
(Andhra Pradesh?)	"Karnool area"[d]	Not specified	Not specified	Yes	No	Not reported

aRose and Chesner (1987);

Khan et.al (1991)* In Narsighpur- Sardapur Sardarpur-Hathnora & Guruwara and Pawlaghat section

bAcharyya and Basu (1993);

cShane et al. (1995);

dWestgate et al. (1998);

eKorisettar et al. (1989);

fHorn et al. (1993);

gMishra et al. (1995)

Narmada valley (Basu et al., 1987, Khan et.al 1991), the Kukdi river valley (Korisettar et al., 1988), and in the Vansadhara, Nagavali, Mahanadi, Brahmani and Indravati river basins of Orissa (DevdasandMeshram,1991).Around the same time a tephra layer was recorded from the Barakar river basin in West Bengal- Bihar (Basu and Biswas, 1990), and along the Sagileru river valley in Andhra Pradesh where an extensive tephra bed is traceable for 90 km (Anonymous,1991;AcharyyaandBasu, 1993).

None of these tephra deposits were identified as YTT until 1987 when Rose and Chesner compared the Middle Son tephra with YTT samples from Lake Toba and marine cores. They concluded that the Son tephra was evidence of an extensive co-ignimbrite ashfall (Rose and Chesner, 1987). Further, the true extent of YTT distribution in India was not realized until the work of Khan et.al (1991) who has identified well defined two level of Ash bed for the first time in vertical column of Quaternary deposits at diffent level and well defined different micro layers in the wom of Narmada.These ash beds are designated as NAB-I and NAB-II consisting of five layers designated as (L1 to L5) in ascending antiquity in the valley.The Ash bed NAB-1 consist of three layers (L1- to L-3) is associated with upper gritty units of boulder conglomerate (Hethnora formation) and is identified at an elevation of about 290 m above m.s.l. The Ash bed NAB-II (L-4 to L5) is associated with upper units of clay silt deposits of palco-domain of Narmada (Shahganjg formation) and is identified at an elevation of 310 m. above m.s.l.

These layers have distinct and diagnostic chemical composition and associated quartz grains have distinct imprints of morphological elements. (Table No---------). Acharyya and Basu (1993). They geochemically characterized tephras from five Indian river valleys (Kukdi, Narmada, Son, Vansadhara, Barakar), identifying all of them as YTT. Their work was later confirmed and built upon by two separate studies. First, by Shane et al. (1995) who analyzed tephras from the Kukdi, Narmada, Purna and Son valleys, Second, by Westgate et al. (1998) who confirmed the presence of YTT in the Vansadhara, Mahanadi, Middle Son, Central Narmada, Purna, and Kukdi river valleys, as well as in the Karnool area. They also obtained fission-track dates for ash samples from the Purna and Narmada basins, giving dates of 84±16 ka and 121±22 ka respectively (Westgate et al., 1998). It appears that samples of volcanic ash from the Indravati, Brahmani, Nagavali and Sagileru river valleys have not been geochemically characterized, although it is assumed by Acharyya and Basu (1993) that these are all deposits of YTT.

Impacts of volcanic Ash-Fall on Late Pleistocene Hominines in the Indian Subcontinent:-

The Toba eruption of 74 ka was clearly an mega event of great magnitude, far greater than any known historical eruption (Table 2; Figure 3), suggesting it had devastating impact and repercussions as it has change global climate and environment. There are Questions and quarries from many quarters, however, as to the scale of these repercussions is concerned these were of size able magnitude and has influenced late pleistocene Hominess in Narmada valley and Indian subcontinent. The effects of Toba may or may not have been far-reaching such that the eruption can be said to have had an impact on a global scale. Perhaps impacts were on a more regional scale, for example, at the level of Southeast Asia or the Indian subcontinent as a whole. Alternatively, the hazardous effects of Toba may have been localized, whereby individual habitats or ecosystems were affected, yet other areas in a region remained unscathed.

These questions necessitate consideration of two separate aspects of the eruption; first, the consequences of possible rapid global climatic deterioration and second, the direct effects of the ash-fall on hominines and their environments in India. An additional issue that needs to be addressed is the identification of those hominines that inhabited India ∼74 ka and thus those who may have been affected by Toba. In this regard, numerous questions need to be asked. How many hominines species occupied India at the time of the eruption, one species or more? Was H. sapiens present in the subcontinent?∼74 ka, or did initial colonization occur at a later date?Unfortunately, hominine fossil evidence from the Indian subcontinent is limited and cannot currently provide answers to these questions. Only a few specimens are known, none of which belong to the time-frame of the Toba eruption. The oldest fossil from India is represented by the Narmada hominine (see Achreya, this volume), dated to not less than 236 ka (Cameron et al., 2004), or to some time in between 150 and 250 ka (Kennedy, 2001:167). Modern human remains have been discovered in an undated Late Paleolithic context at Bhimbetka rock shelter III-A-28 (Wakankar, 2002:5) and from three cave sites in Sri Lanka, dating from 27.7 ka (Kennedy 1999, 2001).

S. C. Jones

Table 2. Eruptive volumes (DRE) of a number of well-known volcanic eruptions

Volcanic Eruption	*Date of Eruption*	*Location*	*Dense Rock Equivalent (DRE) in km³*	*Reference*
Fish Canyon Tuff	27.8 Ma	La Garita caldera, Colorado (USA)	4500	Mason et al., 2004
YTT	74 ka	Toba caldera, Sumatra	2800	Rose and Chesner, 1987
Huckleberry Ridge Tuff	2 Ma	Yellowstone, Wyoming (USA)	2200	Mason et al., 2004
OTT[a]	788 ka	Toba caldera, Sumatra	800–1000	Lee et al., 2004
Oruanui	26.5 ka	Taupo, New Zealand	530	Mason et al., 2004
OTT[b]	840 ka	Toba caldera, Sumatra	500	Diehl et al., 1987; Chesner, 1998
Bishop Tuff	700 ka	Long Valley, California (USA)	450	Mason et al., 2004
Campanian Ignimbrite	33.5 ka	Campi Flegrei, Bay of Naples, Italy	80	Rosi et al., 1996
MTT	501 ka	Toba caldera, Sumatra	60	Chesner, 1998
Tambora	1815 AD	Lesser Sunda Islands, Indonesia	50	Self et al., 1996
Krakatau	1883 AD	Sunda Strait, Indonesia	10	Self et al., 1996
Pinatubo	1991 AD	Luzon, Philippines	5	Self et al., 1996
Vesuvius	79 AD	Bay of Naples, Italy	1.5	Gurioli et al., 2005
Mount St Helens	1980 AD	Washington (USA)	0.55	Carey and Sigurdsson, 1982

aThe background behind the estimates obtained by Lee et al. (2004) is discussed in the text. Their DRE estimate combines the estimate of 500km3 for terrestrial OTT, with an estimate of 310–590km3 for distal air-fall ash. The latter estimate is calculated using evidence from layer D in the Indian Ocean deep-sea core, ODP Site 758, and 3 marine cores in the South China Sea. Lee et al. (2004) believe that layer D and the South China Sea ash are OTT. bOTT date and volume estimates prior to the work of Lee et al. (2004). The date of 840 ka was obtained by Diehl et al. (1987), using 40Ar/39Ar.

Investigations of modern human genetic variation have been providing some important insights into the timing of modern human dispersals into the Indian subcontinent (see Endicott et al., this volume), yet it does not provide information on other hominine species that may have inhabited India at the time of the Toba event. A synthesis of modern genetic data illustrates that the initial colonization of India by H. sapiens took place after the Toba eruption via a southern dispersal route from Africa, through southern Arabia and into India. Various dates have been obtained for the colonization of India; ~50 to 60 ka

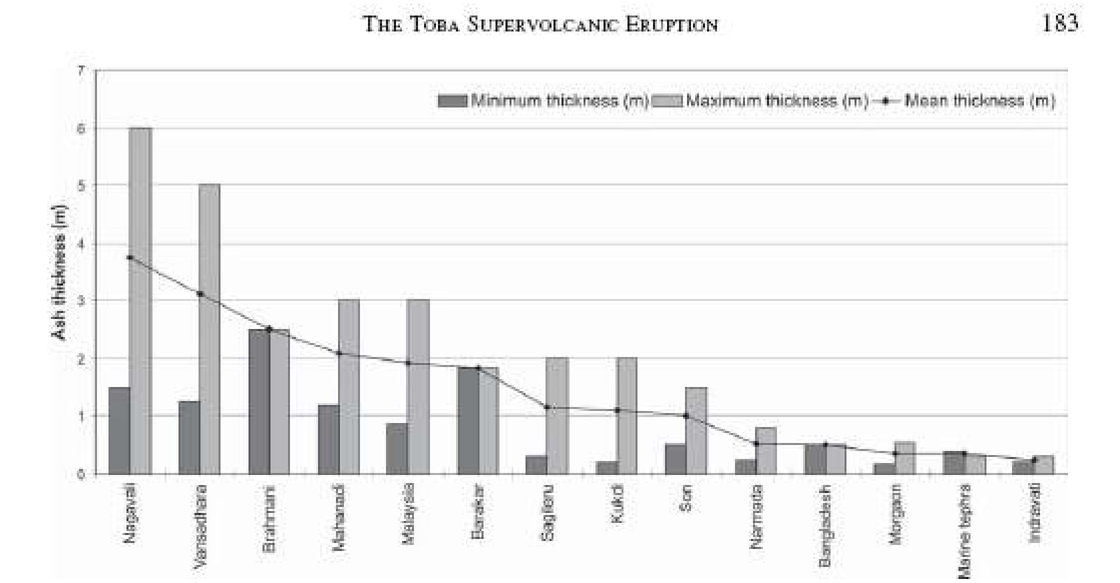


Figure 2. Thickness (in metres) of Toba ash deposits in the Indian Subcontinent

(Quintana-Murci et al., 1999), 45 to 50 ka (Underhill et al., 2001), 60 ka (Kivisild et al., 2003), 60 to 70 ka (Palanichamy et al., 2004), 65 ka (Macauley et al., 2005), and 50 to 70 ka (Thangaraj et al., 2005). It should be noted how close some of these quoted dates are to the age of the Toba eruption. Evidence for pre-Toba migrations to India is provided by Oppenheimer (2003) and possibly by Forster and Matsumura (2005), the latter giving a timeframe of between 85 and 55 ka for dispersals to India. Using phytogeographic data, Oppenheimer (2003) argues that H. sapiens occupied India before ∼74 ka and may have undergone “mass extinction” as a result of the Toba eruption (Oppenheimer, 2003).

A comprehensive review of the Late Pleistocene archaeological record of the Indian

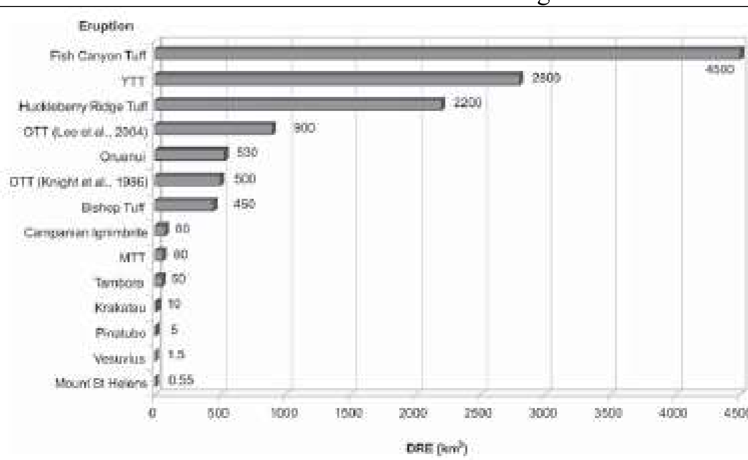


Figure 3. Eruptive volumes (Dense Rock Equivalent (DRE) in km3) of a number of well-known volcanic eruptions

Subcontinent has recently been provided by James and Petraglia (2005), with particular focus on the colonization of the subcontinent by H. sapiens. They argue that two distinct lithic industries characterize the Late Pleistocene in South Asia; an earlier Middle Paleolithic, beginning ∼150 ka (Misra, 1995),and a later technological complex (“Late Paleolithic”), beginning ∼45 ka. They find no evidence of a symbolic (or Upper Paleolithic) revolution in the

Indian record that can be said to be associated with the appearance of the first modern humans. Instead, they tentatively date the colonization of India by H. sapiens to ~70-50 ka and indicate that these early colonizers may have used Middle Paleolithic technologies. In this scenario, distinguishing assemblages created by H. sapiens from those made by other hominine species, who also produced Middle Paleolithic artifacts, is considered problematic (James and Petraglia, 2005). Therefore, in the broadest sense it is possible to predict that hominine in India were practicing Middle Paleolithic technologies at the time of the Toba eruption, however, it is not possible to discern which hominine species manufactured them.

Archaeological evidence from the Indian subcontinent can only provide evidence of the impacts of the Toba eruption on hominines if Paleolithic remains are preserved in either extremely well-dated contexts or in direct association with deposits of the Youngest Toba Tuff. Unfortunately, the former are currently a rarity in India; however, a number of sites exist in the Indian subcontinent where Toba tephra is preserved together with Paleolithic assemblages.

Quaternary deposits and Paleolithic site and Stone Age tools:-

In several river valleys preserve tephra deposits that are directly associated with stone artifacts that pre-date and post-date the eruption. While Indian YTT deposits are relatively well-described in the geological literature, the archaeological significance of any associations between ash and Paleolithic remains has yet to be explored. There is currently very little published information which describes these associations. The Central India Narmada River has conspicuously has straight, course as it is controlled by E-W lineament. It is bound by Vindhyachal in the north and Satpura range to the south; the area in between these two upland is found to be ideal for a study of Quaternary sedimentation as witnessed by the presence of multicyclic sequence of Quaternary terraces in the valley.These are well developed in the Central Narmada valley stretch over 300 km, from Jabalpur in the east Harda in the west. The width of the valley varies from 20 to 80 km. The Quaternary deposits are 400m thick, however, only the upper 50 m has been exposed in river section. The boulder conglomerate exposed at Hathnora (22°52'77°52') has yielded skull of early man (Homo erectus skull) of undisputed Middle Pleistocene hominine remains Sonokia (1984)

The Quaternary deposits of Narmada valley in the area Hominid Fossil locality Hathnora consists of 70 to 90 m of Narmada alluvium was deposited in single aggradational episode with minor pauses when dissection of the alluvium produced two terraces (NT1-NT2) The Sediments of gradational episode constitutes three lighostratigraphic units viz Boulder conglomerate, Sohagpur Formation. A Boulder bed of glacio-fluvial origin underlies the sediments of the alluvium phase. Thus the fossiliferous boulder conglomerates, the basal unit of the alluvium marks disconformities between the lower glacio – fluvial boulder layer and the upper fluvial sediments. The fossiliferous boulder conglomerate is considered to be middle Pleistocene age (Khan & Sonakia 1992). The Boulder Conglomerate (Hathnora Fomation) is thick wedge of semi consolidated fossiliferous sediments and concealed under thick deposits of clay and silt of the older alluvium in valley.

It may contain the richest vertebrate fossil assemblage and has yielded only known Hominid fossil from the Indian sub-continent (Sonakia 1984). The Boulder bed which yielded Hominid fossil for the first time reported to be of glacial & fluvial origin Khan & Sonakia (1992). The fossiliferous horizons is concealed wedge, it is exposed only at some places in valley by lateral dissection by superimposed drainage, lateral river cutting, dissection of quaternary blanket, and other erosinal activities. The concealed and hidden disposition of fossiliferous horizon and its mysterious intricacy in tectonic zone and due to failure to understand basin configuration has disappointed the geoscientists to add further to any new find of Human skull, in spite of keen interest and intensive and extensive work .This formation is associated with various stone tools and stone implements like scraper, cutter, axe, blade with unfinished tools and scrap material. The area around homonid fossil possesses sites of Stone Age. The gravel that yielded the Narmada Homo erectus carries heavy hand axes, cleavers and scrapers. The critical three dimensional study of the area around Hathnora (22°52'77°52') between Vindhyachal and Satpura mountains vast industry sites of the same palaeo lithic implements have been located along the edge and pediment slope of the Vindhyan and basaltic upland. These sites appear to have been inhabited by Narmada hominid and its contemporaries for generations together.

T**he Narmada Homo erectus and associatied Multi Layered Volcanic Ash:-**

The early human settlements have left widespread signatures on Indian River valley systems in the form of extensively large Paleolithic industry sites and with association of Stone Age tools, whereas the hominid fossil evidences are very rare and scanty. The skull cop of Homo eractus, the 'Narmada Man' (Fig 20) is the only example in the long stretch of Quaternary alluvial deposits occurring at varying topographic levels in the Narmada river valley of Central India. Some of the terraces are pretty rich in Paleolithic and Neolithic cultural materials, bearing testimony to the hunting and gathering abilities of early man. Elsewhere in the world, a century of discoveries precedes the discovery of the Indian fossil in 1982. The pioneering discoveries succeeded, with a couple of few finds from java in Indonesia and from China. Later, when the search involved the continents of Africa and Europe there was a spurt in the rate of discoveries and as a result, a large number of human fossils were discovered, thereby making the study of human evolution more logical and factual. It has to be mentioned here that initially discoveries of human fossils from Germany in Europe and from java in Asia, were very much neglected. The Indian fossil mentioned by Theobold (1881) was lost due to sheer curatorial negligence (Kennedy, 1980), whereas the Garman Neandethal specimen was initially misinterpreted.

It took time to describe the Narmada specimen in detail and it also invited controversies regarding its taxanomic. (De Lumly and Sonakia, 1985; Kennedy at al, 1991). Quaternary Tectonics Evolution, Sedimentation, and Paleo-anthropological Records of Impact of Ash fall on Pleistocene Hominines in Narmada Rift System (M.P.) Central India The Main Narmada rift is both symmetrical and asymmetrical in different segments along its length of about 1300 km. Several paleo- anthropological localities, archeological sites ranging in age from the Pliocene-Pleistocene times were discovered within these basins. The discovery of Human Skull Homo erectus form boulder conglomerate bed of Hathnora formation Khan (1992) by Sonakia (1984) De Lumley,. and Sonakia, (1985): in Sehore district M.P.India was first fossil skull of man from Indian sub-continent. It is correlated with Homo-eructs of China on Quaternary Platform is found to be the oldest homo-erectus in Asia Khan et.al (2013)

The known Pliocene–Pleistocene paleo-anthropological localities have given us information about ancestors who were habitants and sparsely concentrated in the Narmada rift valley. This is not a coincidence, because the volcanic and tectonic activities that were responsible for the formation of the rift basins and formed the loci of Quaternary sedimentation & created ideal environments for the proliferation of life and the preservation of faunal and floral remains. The Quaternary volcanic eruption, ash fall, repeated tectonic dislocation and were responsible for the quick burial and preservation of fossils during digenesis. The assemblages of sediments and granulometric parameters, digenetic processes involving silicification, calcification, feldspathization, clay formation, and pedogenesis all played vital roles in fossil preservation in the sediments. The various rock fabrics, ash bed, paleo- sole inter bedded with the fossiliferous sediments also provide temporal information about geologic processes, faunal evolution, paleo -environment, and early hominid behavior and lithic technology.

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 & Aziz 2015)).

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).

Khan (1984) carried out detailed geological, geomorphological and sedimentological studies and identified three prominent terraces in the Central sector of the Narmada. (Khan Sonakia 1992), studied Quaternary deposit in vertical column in relevance to occurrence of Human Skull and reported glacial and fluvio- glacial deposit in Narmada valley for the first time. The boulder bed which yielded Hominid fossil for the first time reported to be of glacial - fluvial origin Khan & Sonakia (1992). Beside occurrences of association of ash beds with fossileferous boulder conglomerate Khan & Rahate (1991) indicates some distant volcanic source. .

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. Magneto-statigraphic studies are being carried out by Rao, et.al (1997). 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).

In Narmada Rift system presence of the Katni Formation 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 and Jabalpur 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 from Mio-Pliocene Pleistocene time, has deposited complete sequence of glacial, fluvio-glacial lacustrine and fluvial deposits with changing environments and climate in time chronology. The present disposition of quaternary blankets in Son Narmada Tapti and Purna basin is due to post deposition Quaternary tectonics which is solely responsible for dislocation, faulting and shifting of different blocks and distorting quaternary blanket 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, 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 present work was initiated in 1982 and continued over a decade, during the tenure tremendous data on various aspects was of Quaternary geology, sedimentology, pedology, archaeology, tectonic, neotectonic Ash bed and other related studies were carried out and accordingly acquired and accrued tremendous data from the ground by systematic field work, by working on official assignment as part of government duty. The virgin and previously unknown areas of the rift basins were studied and inventory of paleoantoological and paleoanthropological Ash bed resources were made. The study indicated the potential of the Mio-Pliocene Pleistocene time and late and early Pleistocene Quaternary sediments of the Narmada Rift System for paleoantoological paleoanthropological Ash bed association its impact & research.

There is a strong link with association of Ash bed and ash fall environment and association of faunal and floral remains especially in the Pliocene–Pleistocene sedimentary strata. 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, environment, climatic and impact of ash fall in time and space.

The pale-oantoological information from these localities is remained closely associated with Quaternary sedimentary deposits boulder conglomerate and boulder bed and Ash 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 these deposits is that due repeated tectonic dislocation and faulting they are dislocated ad distorted and 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 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, which posses the complete sequence of all three domain in increasing antiquity from the bottom of the rift trench 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 LINEAMANT ZONE as single ecosystem for evolution of man in Indian subcontinent.

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

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 relevant 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. On the merits of correlation of startigraphic columns of Quaternary of Narmada Rift System , accumulation of sediment, rate of sedimentation, palaeo-environments, lithostratigraphy and biostratigraphic position of boulder conglomerate on unified Quaternary Platform, author consider it as one of the earliest and oldest Homo erectus in Asia. Khan et.al (2013).

The boulder conglomerate of fluvio-glacial origin which yielded human skull from Hathnora formation 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 quaternary sequence and depth of occurrence of skull cap , rate of sedimentation of Hominid locality Hathnora (22^{o}52'77^{o}52') (325 m) India, has been correlated with the Quaternary of Luochuan (90-120 m) Chenjiawo (50m) and Congwanling sequence (36 m) of China on unified coded model of Quaternary platform tied up and developed at mean sea level to ascertain the depth of occurrence and of age of skull cap of Narmada Homo erectus Sonakia (1984), at the rate of sedimentation (83 m) Khan et.al (1213) which indicates that the human skull Homo erectus of Narmada is oldest in Asia which lived survived and sustain prior volcanic eruption and ash fall..

The central Narmada valley possess rich Palaeolithic occurrences about 300 Lower Palaeolithic occurrences have been reported in different contexts. The present work deals with these assemblages and associated raw material sources in central Narmada valley. The Central Narmada valley is rich in various rock types which were used as raw material by various hominine populations. The Narmada River cut across Indian subcontinent negating its course along SONATA lineament zone dividing in to dividing the peninsular India into two geological provenances. Whereas, in the south, there are primarily the Gondwana Supergroup, Deccan Trap and the Mahakoshal Group. The Central part is occupied by thick sequence of Quaternary deposit. The main raw material types in the north of Narmada are quartzite and sandstone (Vindhyan Supergroup), whereas, in the south of Narmada, the main raw materials are quartzite (Gondwana Supergroup) and chert (Deccan Trap). Acheulean sites are mostly found along the foothills of Vindhyan as well as along the banks of the Narmada River and its tributaries. It is attempted that to correlate these material sources with occurrence of of Paleolithic sites to have a better understanding of past human activity and environment in which the hominine resided. The area become more interesting after the recovery of Homo eructus from boulder conglomerate from Hathnora by Sonakia (1982)

In Central Narmada valley and around Hominid Locality Hatnora 330 occurrences have been reported, which signifies its importance in palaeo-anthropological which have imprints of human activity. The sites are located along northen bank on pediment surface of Vindhyan. The Narmada and Son ad Tapti Rivers are three of of the most important geographic features that have shaped the course of Acheulean adaptations in this region of the subcontinent, The central sector of Narmada which embodies steeped sequence of alluvial which possess good quality of raw material.

Vindhyan Supper Group Of Rocks:-

The Vindhyan Super group is one of the largest and thickest Proterozoic sedimentary successions in the world, spanning an exposed area of 60,000 sq km and extending invisibly under the Gangetic Alluvium and Deccan Traps. It mainly consists of non-metamorphosed sandstone, shale, and limestone ranging in age from 1.72 to 0.75 billion years:The Vindhyan basin is a classic example of Proterozoic intracontinental basin that developed in the central part of the Indian shield along with several other basins such as Cuddapah, Chattisgarh, etc. The strata are exposed in three major sectors: Son valley, Bundelkhand and Rajasthan. Substantially thick Vindhyan rocks have also been recognized under the Gangetic alluvium.

The Vindhyan Basin, containing more than 5000 m thick sequence of sandstones, shales and limestones, occupies an area of about 1,62,000 sq.km of which about 80,000 Sq.km extends into the Ganga valley in the north and northeast beneath the Tertiary sediment of the Himalayan foredeep. In the southwest, the Vindhyan rocks are covered by Deccan volcanics. The basin is bounded by the Son-Narmada Geofracture in the south, the Great Boundary Fault in the west, the Monghyr-Saharsa Ridge in the east, and the Bundelkhand Massif and Indo-Gangetic Plains in the north. Bundelkhand Massif divides this basin into two parts – the Son Valley on the southeastern side and the Chambal Valley where exposures occur from Agra (Uttar Pradesh) to Chittorgarh (Rajasthan).

The southern margin of the Vindhyan basin is marked by a major ENE–WSW trending lineament termed Narmada–Son lineament south of which occurs the Satpura orogen. A NE–SW trending major lineament known as Great Boundary Fault separating the Aravalli–Delhi orogen from the Vindhyan, also marks the western margin of the Vindhyan basin in the Rajasthan sector. The Vindhyan strata define a broad, regional syncline trending ENE–WSW. The axis of the syncline is slightly curved and plunges gently towards west. The average dip of the southern limb is greater than that of the northern limb rendering the axial plane to dip southerly.

The Vindhyan Basin was formed as a result of a large crustal downwarp in the northern part of the Indian Platform, after the Delhi orogeny. The initial transgression of the sea from the north is inferred to have taken place in the eastern part of the basin over the Bijawars. The shallow sea appears to have established lagoonal conditions near the coastal part during the subsequent regressive phase. Initially, the Son-Narmada Lineament was dormant, but at the onset of Vindhyan sedimentation later, the fault system along this downwarp became active with the formation of the southern limit of Vindhyan deposition. After the deposition of Kajrahat Limestone, the Son-Narmada Lineament again became active resulting in emission of volcanic material, which was deposited as the Jardepahar Porcellanite. In the subsequent regression, the shore line shifted towards northwest. The Fawn Limestone was deposited over the shelf in a tidal flat environment. This was followed by shallowing of the basin as is evident from the overlying Glauconitic Sandstone. The fresh marine transgression resulted in the deposition of marine shales followed by Rohtas Limestone. The entire Vindhyan succession, maximum thickness estimated to be around 3 km, and comprising mainly sandstone, shale and limestone is assigned as the Vindhyan Supergroup.

The Supergroup is divisible into four groups:-

1. Semri Group,
2. Kaimur Group,
3. Rewa Group and
4. Bhander Group,

from bottom to top. Each group is again subdivided into several formations. The Semri Group in the Son valley rests unconformably on a variety of pre-Vindhyan rocks such as granites and metamorphics. In the Bundelkhand area, the group overlies the Bundelkand Granite Gneisses and Bijawar Group of metamorphics, whereas in the southern Son valley, Mahakoshal is the basement in most places; however, in some localities (e.g., Deoland, M.P.) the basement is granite. The Semri succession of the Bundelkhand area has two detached outcrops around Chitrakut and Bijawar respectively, and is only a few tens of meters thick.

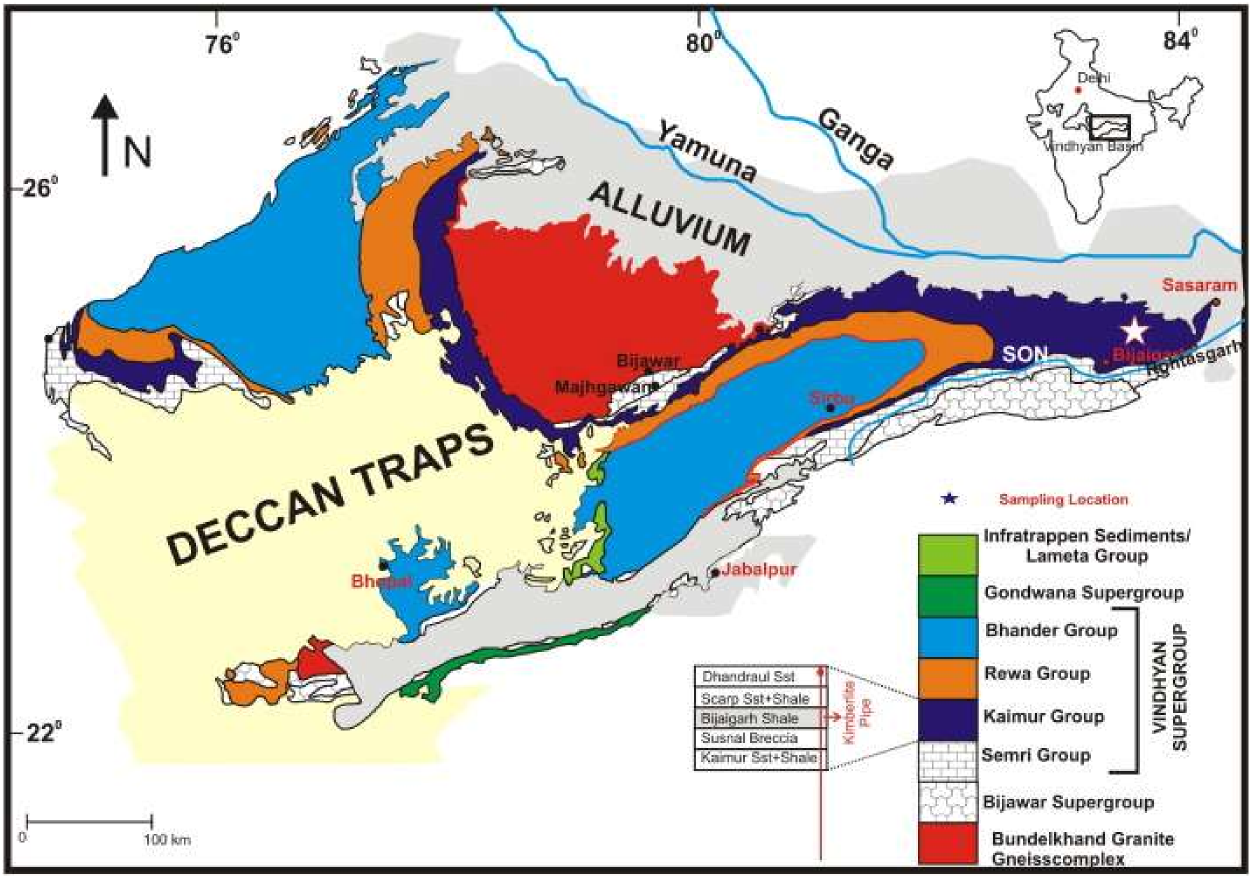
The Vindhyan supper Group of rocks in eastern extremity around Bhopal inliers and southern arm of these rocks on the obsequent slope embodies Bhimbetka shelter mostly the rock cavities of intermeddled Quartzite lime stone sandstone and shale which have been which were exposed to post erosinal and depositional activities to million and million years resulting circular hollow and cylindrical cavities of lime stone and shale interbedded strata both along and across bedding planes which have created natural shelters in Vindhyan rocks, These were occupied by migrants Hominess in event of volcanic eruption and dense atmospheric contamination and fall of ash in subcontinents.. The cluster of these rock shelter was discovered in 1957-58 by Dr V,SWakankar. The Rock Shelters of Bhimbetka are located about 45 km south east of Bhopal on the road to Hoshangabad. The site spread over 10 km in length and about 3 km in width has more than 700 rock shelters, of which over 400 have paintings. The earliest human activities are known from the numerous stone tools including hand axes, cleavers and also the pebble tools.

The latter pertinently was found in primary contexts. The continuity of human evolution from the Lower Palaeolithic Period is noticed by the smaller size of stone tools in the following Middle Palaeolithic Period besides new tools like scrapers. During the Upper Palaeolithic Period newer tool types like: blades, borers and bruins had also emerged. However, it is in the Mesolithiic Period that there is a clear change in the materials and tool typology. Earlier, the tools were largely made of quartzite and sandstone, whereas the tools being made in the Mesolithic Period were most often of chalcedony. The stone tools of this period include blades, triangles, trapezes, crescents besides quern and muller.

The Mesolithic culture at Bhimbetka continued much longer as understood by the presence of Chalcolithic potteries in otherwise Mesolithic contexts. By the Early Historic times it appears that interaction with the surrounding cultures became more pronounced. This is evidenced by the presence of rock-cut beds in a rock shelter on the top portion of an inselberg like outcrop not far from the later built temple at this site. In all respect it resembles the Sallekhana spots observed in South India.

The cave also has a small inscription of the Maurya/Sunga period. Within the general area of Bhimbetka Group of rock shelters small stupas have been found at Bhimbetka, near Bhoranwali, at Bineka, at Lakhajuar and midway between Lakhajuar and Bhimbetka. At Bineka besides the stupa enclosure wall and other structures were found. There are a large number of Shanka Lipi inscriptions in the Bhimbetka cluster of rock shelters.

However it is the rock paintings of Bhimbetka that steals the limelight. of particular interest to the tourist are the Auditorium Rock Shelter, Zoo Rock and Boar Rock in Bhimbetka Cluster. The earliest endeavor here other than for mere run of the mill activities for survival is the engravings of small cup like depressions at the end of the Auditorium Rock Shelter, which is dated to nearly 100000 years. Near the end of this tunnel there is a cluster of painting depicting a hunter, deer, tiger cattle and stylized peacock. Further ahead on the same path one comes across the Zoo Rock Shelter, which qualifies as the most densely painted rock shelter, paintings spanning from the Mesolithic to the Mediaeval. The paintings here include those of A Mesolithic boar painted in dark red, animals like: elephant, rhinoceros, boar, barasingha, spotted deer and cattle and snake, etc. Later paintings include battle scenes painted in red and an elephant painted in white. The Boar Rock, which is the last among the rock shelters accessible for tourist has a depiction of a mythical boar with horns that is many more times larger than the human being chased by it.



Co Nclusion:-

The study of the area in Central Narmada valley around Hathnora(22°52'77°52') between Vindhyachal and Satpura mountains vast industry sites of the same palaeo lithic implements have been located along the edge and pediment slope of the Vindhyan and basaltic upland. These sites appear to have been inhabited by Narmada hominid and its contemporaries for generations together the left over stone industry sites and unfinished material haphazardly indicate sudden dissemination and migration of hominines in search of shelter and safe places after volcanic eruption as also documented by the relicts of ruins Paleolithic and Mesolithic industrial site and scattered occurrence of stone implements around Hominid locality of Hathnora

The area possesses rich Palaeolithic occurrences about and 300 Lower Palaeolithic occurrences have been reported in different contexts. The present work deals with these assemblages and associated raw material sources in valley .These rock types were used as raw material by various hominines populations. The area appears to be thickly inhabitated and influence by human activity which was adversely affected by severe Toba volcanic eruption and hominines were forced to be migrated in struggle of survival to the safe places. The nearest safe place was Bhimbetka about twenty kilometers in the north located in consequent slope of Vindhyan rocks of Bhopal inliers which possess about 700 rock shelters of different size and dimention.The study of human activity in the area around Bhembetka indicates the hominines populations lived around 100000 years.

The 74,000 year-old super eruption of the Toba volcano, located in northern Sumatra, is recognized as one of Earth's largest known eruptions and was certainly the largest of the Quaternary period (Smith and Bailey, 1968). It is presumed that it have led to both global climatic and environmental deterioration and had a impact on decimation of modern human populations (Rampino et al., 1988; Rampino and Self, 1992, 1993a) (Rampino and Self, 1993b; Ambrose, 1998, 2003a, 2003b; Rampino and Ambrose, 2000). However, the severity of Toba's impact on climate and hominines has been contested and debated by scientist (Oppenheimer, 2002; Gathorne-Hardy and Harcourt-Smith, 2003). Geological, paleontological and archaeological evidence from the Indian subcontinent provides an excellent opportunity to address these issues. The intensity and scale of the Toba super eruption was multidimensional and its column of eruption was so vast that it forma canopy of volcanic matrix led to the deposition of a blanket of volcanic ash across the continents and river valleys over India, Malaysia, the Indian Ocean, and the Arabian and South China Seas. Resulting persistent terrestrial tephra deposits have been documented in a number of river valleys throughout India. (Khan et.al 1991 Acharyya and Basu, 1993; Shane et al., 1995; Westgate et al., 1998).

The occurrence of Bolder conglomerate and occurrence of haphazard and disserted sites of Palaeolithic sites indicates that area suffered dual hostility first the end of glacial activity with the stratigraphic column at the level of 83 m where the Homo eructs survived Sonakia (1984) both by glacial activity and volcanic eruption, whereas in the second hostility evolving human activity by volcanic eruption and dense smoke and dust and darkness. And consequent upon H Sapiens and associated were forced to migrate to safer places. In view of the recorded observation the concealed quaternary strata to the level of about 350 m below ground level further needs attention of geoscientist for the search of human remains in Narmada valley.

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 cap 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 Toba eruption of 74 ka was distinctly and clearly a mega event of very great magnitude and intensity, far greater than any known historical eruption, suggesting it had very devastating impact and repercussions. It has change the global climate environment and ecology.

The association of Ash bed NAB-I with Hathnora formation at the depth of 78 m in Quaternary column of Narmada and occurrences skull cape of Homo erectus of Narmada at the depth of 83 m assumed that Toba eruption might have taken place later than that of existence of Homo erectus which appeared and resided in the valley for long time before the fall of Toba ash. The association of Ash bed NAB-II at the depth of 72 m with the younger deposits indicates the second cyclic of fall of Toba ash which might have influenced the younger Hominines i.e. Homo erectus & Homo sapiens, in Narmada valley.

The occurrences of these skull caps with short range of their occurrences in the stratigraphic column of Narmada with the Ash beds horizon NAB-I and NAB-II and specially with the Hathnora formation one at the top at an average elevation of about 268-273 m above the mean sea level and other with younger deposits had revealed the close association with volcanic activity with their existence. The Toba Ash fall is also in very close range with the sequence of sedimentation and occurrences with both the skull caps, which certainly has its impact on the middle and late Pleistocene Hominines in Narmada valley and Indian subcontinent.

The Hominines residing in Central Narmada valley after eruption of Topa and sudden decline in climatic ecology rapidly migrated to the nearest rock shelter of Bhimbetka in the north leaving behind hapazrdly their tool making sites, raw material unfinished tool and other belonging behind.The Bhimbetka posses about 700 rock shelters.of different size and dimentions and shape within the periphery about eight kilometers. The relict of human activity, tools, rock paintings, are recorded in these shelter where they resided about 100000 years.

It is reported that remains of H. sapiens in the area of Bhembetaka north of hominid locality of Hathnora and relicts of rocker shelter and ancient human signature indicate the dispersal of Hominines after the eruption of volcanic matrix and its fall Waclhlakar, V.S., 2002.The association of skull cap Sonakia, A (1984) and Sankhyan (2007) described two new hominine fossils from Netankheri up stream of Hathnora in the Central Narmada valley. They include a partial left humeral diaphysis and a distal shaft fragment of the left femur associated with Hathnora formation Khan & Sonakia 1992. The analysis of quartz grain morphology of sediment columns of Hathnora and quartz grain morphology of paleo-sole across the quaternary strata of bore hole sampling across 556 m of rock basin revealed that Homo eructs of Narmada partly sustain in the glacial and fluvio-glacial environment as witnessed by Hathnora formation (Boulder & gravel bed) which marks the end of hostile climate and environment of sedimentation in Narmada valley Khan (2013).

The study of quartz grain and their micro structures of paleo- soil identified in concealed blanket of quaternary deposits display relatively heterogeneity in Sediment characteristics throughout across the Quaternary column of Hathnora section in central Narmada valley. The quartz grain of paleo-soil and sediments display diagnostic characteristics of glacial fluvio-glacial and fluvial concealed environment of sedimentation at different depth. The significant breaks in grain morphology of quartz grain surface texture and associated elements and granular matrix in the sequence of quaternary strata is recorded at 150, 350 and 350 and beyond which linked to long evolution of glacial fluvio-glacial and fluvial environment of sedimentation in time and space in increasing antiquity in the valley from the base Khan (2013).In view of the recorded observation the concealed quaternary strata to the level of about 350 m below ground level further needs attention of geoscientist for the search of human remains Ash bed in Narmada valley.

The atmosphere contaminated by volcanic ash volcanic matrix and huge amount of gases and dust particles had definitely affected the atmosphere and climate had have led to temporarily darkened skies in the Narmada valley and Indian subcontinent for very long time. The study of grain morphology of glass matrix, their- relation with other minerals shape, size, texture of lithic fragments and association of other ashy sediments of pyroclastic origin suggest that sediments were brought from distant source by Aeolian agencies during the different phases of sedimentation in Narmada Valley.

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