

印度纳尔玛达地区发现的粗壮智人化石 及其与亚洲直立人的连续性

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摘要: 1999年,在印度西部的纳尔玛达(Narmada)河的一条支流——奥尔桑(Orsang)河谷发现了一具孤立的智人头骨,这对于了解印度人类进化历史和南亚直立人与最古老的亚洲智人(或AMH,解剖学上现代的人)之间的联系有着重要的意义。化石是在古老的河流沉积物中发现的。对主体沉积和颅内沉积物的红外光释光(IRSL)测年结果显示,其年代为3—5万年。然而,对化石的直接测年(放射性碳加速器质谱测年AMS)结果表明,其年代最小为4981—5579年前。头骨被归类为圆颅型智人。头骨上最引人注意的特征是颅外有亚洲直立人头后部很发达的角圆枕。头骨最宽处在下部(颞骨)如直立人,这样的情况从来不见于智人。这可能是由于乳突的气窦化而形成的。乳突上脊发育,从破损的眉间区(20mm)可以看到很宽的额窦。所有这些粗壮的特征都表明 Orsang 头骨和晚期亚洲直立人之间具有遗传连续性。

关键词: 智人; 直立人; 角圆枕; 头盖骨; 纳尔玛达低盆地; 印度西部

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1 引言

最近,亚洲人类的进化引起了广泛的争论^[1-4]。其中受到最多关注的问题是亚洲晚期直立人和亚洲最古老的解剖学上的现代人之间是否存在着遗传连续性。不幸的是,在印度只发现了晚更新世的直立人纳尔玛达亚种(*Homo erectus narmadensis*)的一个头骨^[5-7],可能属于古老型智人^[8],或者未定种名的人属(*Homo sp. Indet*)^[9],其分类地位还有争议。Orsang 头骨于1999年发现,被鉴定为智人,具有可能为亚洲直立人和早全新世亚洲智人之间的生物学关系提供新的线索。

本文呈现了 Orsang 头骨的外部形态和生物测量的结果,与130个从更新世的人类头骨进行比较,并对其年代进行探讨。CT扫描颅骨后部骨骼,为可见于直立人的角圆枕和颅骨最大宽出现在较低位置的特征提供新的思路。比较结果支持 Orsang 个体基因组中含有亚洲直立人基因,其年代接近晚更新世或早全新世的观点。在这里,异乎寻常地存在于 Orsang

头骨的近祖形态特征比年代数据更加重要,因为这些特征支持印度本地人群从亚洲晚期直立人衍生而来的理论,并进一步支持了吴新智平行进化附带杂交的理论^[2]。

2 历史背景

人们从一个半世纪以前就知道纳尔玛达中部河谷的第四纪沉积中含有中更新世到晚更新世动物群^[10, 11]和伴存的旧石器时代早期的工具。这些沉积被重新分类为不同的组^[12], 古地磁测年结果为 0.73 Ma^[13, 14]。距今约 75,000 年前的位于出露的地层的基底的是最年轻的多岩火山灰^[15, 16]。Sonakia^[5]发现的直立人的破碎头骨标本是在印度发现的第一例,也是唯一的直立人化石。这个头骨于 1982 年被发现于 Hathnora, Madhya Pradesh 的纳尔玛达河谷(图 1B)。这是到现在为止印度次大陆上发现的最古老的人类遗骨,而且是原位埋藏,可以精确地确定地层,其中的古生物化石和文化的状况,在地质年表上都属于中更新世(大约 50 万年前)。接着又发现了一批人类化石——包括一件右侧锁骨^[17]。后来又在同一地点发现另外两件人类化石和一颗 *Equus namadicus* 的上颌齿^[18]。此人类头骨发现于印度 Madhya Pradesh 的纳尔玛达山谷中部的中更新世沉积物中,被归为一个新的分类单元——直立人纳尔玛达种(*Homo erectus narmadensis*)^[8]。纳尔玛达山谷低处与此头骨年代相当的第四纪沉积形成了 Gujarat 广阔冲积平原的一部分,研究者们对这些沉积的地层,沉积特征,沉积环境以及古环境方面^[19-22]进行了深入的研究。然而,到现在为止还没有在这些沉积物里发现人类化石的报道。本文报道了由第一作者及其巴洛达萨亚基劳王公大学(Maharaja Sayajirao University of Baroda)地质系的同事们于 1999 年 12 月发现的人类头盖骨化石。这件头骨化石是在 Ratanpur(Lat. 22°10'N, Long. 73°30'E)的 Orsang 河第四纪冲积物中原位发现的(图 1:A, C)。我们在这里讨论头骨化石的产出状态和形态特征及其对人类进化研究的启示作用。

3 区域地质构造

奥尔桑河发源于最南面的阿拉瓦利山脉(Aravalli Range),阿拉瓦利山脉由各种类型的构造变质岩和火山侵入岩组成^[23]。在山地露出地表的主要岩层属于阿拉瓦利超群,特别是上面的部分(尚庞统),其下层是花岗岩,片麻岩,还包括千枚岩,片岩和石英岩。接下来是德里超群和后德里侵入体(前寒武纪时期形成,由石英岩,云母片岩,石灰石,片麻岩和花岗岩组成)。中生代的地层以下暗色岩层(infratrappean)(石灰石, Nimar beds 的沙岩)和德干组的玄武岩流^[23]为代表。在山地内,奥尔桑河在一个 WSW - ENE 方向的广阔河道中流动。这条河在桑克达附近流入古加拉特冲积平原,这里的河道由于受到坎贝地下裂谷盆地东部边缘隐藏断层的影响,显著地向南转向,最终与纳尔玛达河交汇于钱朵德(Chandod)^[24]。奥尔桑河道的冲积相特点在于河流两岸垂直陡崖冲积相沉积的连续性。这些悬崖暴露出第四纪晚期的河相沉积,其上为风成沉积,可以与古加拉特冲积平原其他主要河谷(也就是萨巴尔马提河,默希河和纳尔玛达河)的悬崖剖面暴露出来的地层序列相连接^[25, 26]。

纳尔玛达河是印度半岛上最大的河流。其河道的一个主要部分位于古加拉特省以东,在这里转向,流过由属于晚白垩 - 始新世的基性熔岩流形成的德干组和冲积相沉积区。真正的纳尔

玛达冲积盆地位于古加拉特省境内的河流下游处。纳尔玛达河谷晚更新世沉积的中上部以蕴含丰富的哺乳动物群而闻名,包括一个在 Hathnora 发现的人类头骨,指示当时的气候条件比现在湿润^[10]。

4 勒登布尔剖面

被发现的人类头盖骨化石嵌入勒登布尔的奥尔桑河的垂直悬崖剖面中,部分可见(图 1:C 和图 2)。它嵌在左岸第四纪冲积的地层内但部分暴露(图 2:A, B, C)。由于这个头盖骨是在疏松的沉积中发现的,容易进行挖掘(图 2:D)。颅内充满了半压实的冲积沉积。颅盖上的一些部位被棕色的浸渍染色,由于暴露在空气中,下部的一块被冲蚀掉了。

勒登布尔剖面的连续延伸使我们可以确认其侧向延伸的岩性。为了绘制垂直岩性柱,我们检查了勒登布尔以南奥尔桑河左岸 600m 长的完整悬崖剖面延伸的岩石学和沉积学特性。在剖面的两末端分别有两个深的冲沟,作为本文所研究的剖面的界限。发现头骨的地点位于悬崖剖面上端的冲沟下游约 150m 处。悬崖高于河床约 20~23m (图 2:A)。剖面的底部是一层 2.5m 厚(图 2:A)的高度钙结化的粘质粉土层。在岩石学上它主要由粉土以及粘土和沙土组成。内部层理不可见,可能由大量的钙结化导致,存在的钙结岩(层状、瘤状和管状)可以证明这一点。头盖骨发现于此沉积的上部。上覆不整合接触的薄砾石层(10cm)。砂砾层在下游方向变得稀薄,事实上砂砾层只存在于悬崖剖面的上部。由于占主体的层状钙结岩的存在,此层硬化并形成了一个向河心突出的区域,头盖骨就是在这里被发现的。砂砾层的上层是水平分层的 1.5m 厚的砂质粘土。钙质结砾岩在本层中明显缺失。上层是一个 4m 厚的明显的红土壤。这层土壤的特点是颜色为红色和丰富的成土钙结岩结节发育。这些钙结岩结节在上部丰富,向下逐渐减少。在某些地方可以发现层状钙结岩。岩石学上,土壤是由砂质粘土组成的。红土壤在萨巴尔马提,默希和纳尔玛达河谷出露的晚第四纪地层序列中是一个显著的标志地层,并被前人用作流域间和流域内相对应的标志^[21, 22, 27, 28]。在奥尔桑河也是这样,红土壤在 Aritha 和伯哈德尔布尔(Bahadarpur)发育良好。根据从伯哈德尔布尔红土壤中提取的石英矿物得到的光释光年龄为大约 5 万年前^[25, 26]。红土壤被覆盖在约 1m 厚的粉砂层之下,再向上是一个约 4m 厚的深成土化河流相粉砂。土壤为棕色,显示出大量成土钙质砂砾岩结节的发育。

此上为 2m 厚水平层理的粉砂层,是最上层的冲积序列的标志。冲积序列被 5m 厚的风成沉积覆盖,最上 0.8m 已强烈成土化,形成现在的地表土(图 2:A)。勒登布尔的风成序列由无结构的同质粉砂组成。风成沉积与末次冰期最盛期(LGM)的全球干旱期广泛相关。风成沉积也分布在其他地区如奥尔桑谷^[25, 26]和古加拉特冲积平原的河流流域^[26-28]。

5 年代学和古环境

本文对从主体沉积和颅腔内提取出的粗粒长石进行了 IRSL 测年。从主体沉积中采集了两份样本,颅骨内的沉积物是在实验室内采取的。在实验室中使用多片附加剂量法(Multiple Aliquot Additive Dose, MAAD)方法进行分析。研究结果显示与头骨同水平的主体地层的年代为 38 ± 5 ka and 45 ± 7 ka。颅内的沉积物产生的年龄为 30 ± 7 ka and 27 ± 4 ka (表 1)。这个年龄与从 Ratanpur 上游的 Aritha 和 Bahadarpur 相关地层中获得的石英的年龄^[25, 26]相比偏小,这是因为

从长石中得到的荧光信号可能有着反常的褪色现象(athermal-rapid loss of stored signal from deeper traps at ambient temperature),由于褪色现象的存在,估计每 10 年中荧光信号会减少 2%—10%^[30]。因此,表 1 中的年代应该被认为是最小值。

作者还使用了¹⁴C 加速器质谱的方法(AMS)对头骨进行测年。样品提取自头骨化石右侧顶部骨骼,这里的组织已破损,取样量为几毫克。这种方法给出的年代数据为 4981—5579 cal yr. BP。我们认为碳放射性方法测得的年代值偏小。因为头骨破损处的微孔中很有可能被常年的雨水渗透,导致碳酸盐的分散和重聚,使得年轻的放射性碳污染样本。虽然上述观点纯属推论,但头骨的形态特征提供了很大的支持,显示此头骨可能比测年得到的年代更加古老,这一点将在后文详述。

根据产生了包括人类头骨在内的丰富的脊椎动物群的相关的冲积成的沉积物可以推断 Narmada 河谷中心区域当时为湿润到亚湿润气候^[10]。印度洋离岸风数据也显示在 3—5 万年前夏季风有所加强^[32]。

在 Ratanpur 并未发现与人类化石相关的考古学遗存。然而,曾经有报道称 Orsang 河及其支流 Sukhi 河的沉积物中发现过意味着人类存在的工具。这样的制品曾在多个旧石器时代早期(阿舍利)和旧石器时代中期以及一些细石器(中石器时代?)地点被发现,特别是在中游河段。在 Sankheda 的上游,旧石器时代早期和中期地点在两个河谷北缘沿岸的山麓上都有发现。在这些山麓上,石制品大多处在半初级状态,而位于淤积层的却经常被再加工过。在 Orsang 的中部地层序列中,阿舍利制品被埋在不整合地位于由基层斑杂粘土之上的胶结砂砾岩组成的的基底沉积轮回上层的疏松的,多卵石的砂砾层中。旧石器时代中期较早的材料出现在红土壤的顶部,这在区域尺度上非常著名,其上层的薄砂砾层中也存在^[33, 34]。细粒的风成砂上部形成了地层序列的最后一个单元,其中产生了大量细石器。为了做出小石片和细石叶^[33, 34],这些细石器的制作都倾向于选择最好的原材料如燧石,碧玉或玛瑙。这些石器组合的特点以及它们所代表的文化序列与邻近的 Gujarat 和 Rajasthan 南部所出产的相一致,也说明了在晚更新世时期这里的条件适宜人类居住。

6 头骨形态

头骨的形态特征的研究是本文作者之一(Anne Dambricourt Malassé)在巴洛达大学(Baroda University)进行的,比较解剖学的工作是在巴黎自然历史博物馆中完成的。颅腔内部充满了沉积物,因此只有外部解剖结构是可见的。脑颅除了额鳞的右侧暴露在空气中的一侧有一处相对近期造成的损伤以外,其余部分很完整。左侧眉弓,眉间和额骨左前部的突起保存完好。而下颌骨、上颌骨、颧骨和鼻骨以及筛骨和蝶骨体缺失。枕骨斜坡、岩部椎体以及枕骨髁和外枕部,听道以及颞下颌关节仍在原位但边缘已经不再分明。右侧茎突根部可见,颅底的这些部位脆弱,经常受损。此头骨的良好保存状况说明头骨被埋葬后并没有经历很多扰动(图 3:a, b, c)。

从头骨穹隆的总体构造,额骨的弯曲度以及颞鳞的轮廓,乳突向前下方生长,枕骨鳞部位置低和倾斜的位置,以及颞突和听道的相对位置等特征可以判定这个头骨属于智人(解剖学上的现代人, AMH)(图 4)。

右侧面观可通过损伤处看到宽阔的额窦,表现为内外骨板之间有一个约为 2cm 的间隙(图 5),但正面观和上面观仅局限于眉间区域(图 3;图 6)。眉间上凹和眶后缩狭在上面观中均不可

见。底面观可见两侧颞骨岩部的长轴比较接近冠状面,如见于典型智人头骨者。

颅骨最大宽的位置较低,这在智人中从未见过;顶骨壁张开与颞鳞接近(图7)。发育的乳突上脊增加了颅骨最大宽。后面观可见乳突与顶骨隆凸并不呈现在智人中常见的垂直关系,可能由于颞骨乳突像直立人那样气窦发达使得颞骨和顶骨之间隆起,而导致乳突和顶骨隆凸构成倾斜的关系。X光检查会在可能存在的乳突气窦系统的发育上给出更多的细节。

骨缝愈合的程度很高,特别是人字缝和矢状缝,说明此头骨属于一个成年个体。从损伤处可以看出各骨片(额骨、顶骨、颞骨和颧骨)都较薄。存在前凶后凹陷。两侧乳突发育完好,平放于桌面时可支持颅骨,这表示此头骨可能属于一个男性个体。颅骨左侧表面的一些肌肉腱膜附着痕迹十分明显,特别是颞肌的附着痕迹在垂直方向上延长并且粗糙,还有二腹肌的后腹引起的痕迹也很明显,而右侧则不显示这些特征。这样的不对称可以与在上面观和下面观中观察到的相比较(图3)。

组成颅骨穹隆的各骨片均为膜成骨,它们的构造是神经和激素的生长共同决定的。此头骨与直立人,特别是直立人纳尔玛达亚种(表2)之间在测量值上的相似性并非对应于生长发育的同源(growth homologies)小脑向前和向下发育的特征是解剖学上现代的人AMH典型具有的性状,这是很清楚的。

另外,值得一提的还有一些显著的解剖学特征。项平面和小脑窝的颅外表面短,其上的枕外隆凸点上区平坦而垂直;侧面观显示出重要的“扁枕”(图4)无枕骨圆枕。不过枕外隆凸(枕外隆凸点),上项线和乳突上脊都较发育。

颅底的研究考虑到了蝶枕联合的弯曲程度,当弯曲程度过大时,小脑幕向前方和下方移动,并限制了枕骨鳞部向后生长^[35-37]。颅骨的最大长减小,颅后点与枕外隆凸点重合,导致“扁枕”。X光检查与颅骨整形外科研究可以对小脑窝底部的缩短给出更多的解释。

观察到的一个标志性特征是角圆枕(或星点突),即顶骨鳞部外颅密质骨在星点区的加厚(图8)。两个血管孔限制了本应位于枕骨上方的凹凸。在直立人中,这个隆起通常与一个明显的上颞线形成连续体,而Orsang头骨上未见明显的上颞线。当将颅骨大体上按法兰克福平面摆放时,角圆枕的位置与颧弓相平齐,而不是像直立人纳尔玛达亚种一样位于颧弓上方。这是由于智人特有的小脑窝向下方和前方生长所导致的(图9)。

由于没有X光或CT扫描图像,所以目前还不可能总结出这样的从未在AMH中见过的性状组合的来源。这可能是由于常见于亚洲直立人的乳突气窦化所导致的。但也不能排除颅中窝这种特别的发育形式与“扁枕”之间的联系。这两个假说都需要CT扫描分析的验证。在额窦与多少与气窦化的蝶窦相连的筛骨气窦系统相通的情况下,我们提议在未来的研究中对下述理论进行验证:颞骨区的颅骨最大宽和颅底生长情况不只是由蝶枕联合(小脑窝缩短)控制,同样也可能受制于蝶窦(侧向膨胀^[38])和颞骨岩部的气窦化。蝶骨被毁坏,不过CT扫描可以提供颞骨岩部以上颞骨内表面的轮廓,来检验两侧颞骨颅内表面的距离是否异常增大。

7 生物测量分析

生物测量数据(表2)以支持其属于晚更新世-全新世的新数据证实了其解剖学鉴定支持此标本的年代为晚更新世-早全新世。正如我们所知,早期解剖学上现代的人(更新世,原

克罗马农人 Proto-cromagnoids) 脑量约为 1400—1600ml, 例如 Taforalt 的 Iberomaurusian 人(来自北非的克罗马农人, 晚更新世/早全新世, 即 12ka BP) 的脑量大于全新世人类^[39], 但是在新石器时代增加了的圆头化过程, 在中石器时代(9000ka BP) 以前未发现过^[40]。由于此头骨缺少某些 Martin and Saller^[41] 测量方法中的关键部位, 一些明显的距离数据是在其他头骨系列上的同源解剖标志点之间进行测量而得到的。颅骨最大长(眉间点-颅后点 170mm) 和最大宽(146mm) 与广义直立人的测量值一致, 这些数据如果没有颅骨形态构造和形态发生过程而独立存在的话就没有意义, 首先因为颅后点与枕外隆突点合为一点, 其次最大宽为两颞最大宽而不是两顶骨最大宽。

根据 Martin 和 Saller^[41], 当颅腔存在如人属化石中过度的对称侧向延伸时, 颅侧点不可能位于外耳道之上的整个邻近区域。不过对于 Orsang 头骨有些特别, 因为“扁枕”可能与由于蝶颞枕区的特定神经生长有关的颅腔的侧向延伸相关。将颅侧点位于 i) 颞骨和 ii) 顶骨这两种情况都考虑在内时, 分类情况是不同的。在第一种情况下, 即颅骨最大宽在颞骨之间, 那么其水平颅指数会将头骨归为特圆颅型; 在第二种情况下, 即位于顶骨之间, 则归为中颅型。颅骨最大高(前凶点-颅底点, 132mm) 和两颞宽(146mm) 的比值(90.4) 着重显示了此头骨的宽的一面。最后, 高/长比值显示此颅骨长(170mm) 突出地大于颅骨高(132mm)。

颅容量是根据 Martin 的方程根据颅外测量值进行计算的: $0.00037 \text{ (长)} \times \text{宽 (颅侧点 - 颅侧点)} \times \text{高 (颅底点 - 前凶点)} + 328 \pm 73$ 。像前面看到的那样, 在智人中两侧颅侧点位于顶骨。对于 Orsang 头骨, 颞区原本的横向轮廓使得针对此头骨的讨论是开放的。如果最宽处位于颞骨, 那么其脑量达到了 1540 ml; 如果最宽处位于顶骨, 那么其颅容量将接近 1400ml (1390ml)。左侧颞骨的颞下颌关节窝与暴露在空气中的右侧相比保存得更加完好; 二者不对称, 左侧更宽更深, 尺寸都较大。枕骨大孔不对称而且宽(指数为 85.7)。

总结起来, 此头骨神经颅较低, 长而宽, 生物测量学方面的独特性来自于颅后部呈“扁枕”状态的独特特征, 小脑窝缩短和颞骨凸出。由于这种独特的轮廓, 有必要区分两种形态分类: i) 颅骨最大宽位于颞骨处, 则此头骨为特圆颅型, 脑量较大(1540ml); ii) 颅骨最大宽位于顶骨处, 则此头骨为中圆颅型, 脑量较小(1390ml)。如前文提到的, 最高的脑量与旧石器时代末期中石器时代初期的人群(12ka BP) 更加相符, 与其发育良好的外颅特征相一致, 特别是强烈的眉间气窦化。然而此头骨归类为特圆颅型, 又使其与中石器时代的捕猎-采集者(9000ka BP) 和/或新石器时代人群更加接近。这种明显的矛盾可以通过引入颅整形术(cranial orthopaedics) 方法来解决。总体的颅面平衡似乎正常, 除了穹窿轮廓, 短的颅底和由早期穹窿颅缝愈合和蝶枕连接的过度弯曲导致的胎儿期或孕产期发生的不对称变形。

更多的结论只有使用 CT 扫描或 X 光将 Orsang 头骨形态和其他史前或历史人群进行生物动力学分析比较之后才能得出。此项分析对阐明地区性效应对包括或多或少弯曲的蝶枕区在内的复杂中轴骨产生的影响有所帮助^[42, 43]。

这里采用的初步方法可以用来研究 Orsang 头骨具有过渡性中石器时代形态, 比起可能有颅底变型的新石器时代纤细人群更接近克罗马农人。这样的变形可能是由于特定的胎儿期或孕产期生长发生的蝶枕联合弯曲导致的。最大宽位于颞骨区可能是由于 i) 乳突气室系统气窦化, ii) 脑部的不正常横向生长, iii) 这两个因素与蝶骨生长和脑垂体内分泌影响着密切关系。

8 比较解剖学分析

作者将 Orsang 头骨的形态与巴黎古人类研究所的标本(模型和原件, $n = 104$)以及已经在文献中被描述过的标本($n = 21$)进行了对比(表 3)。

气窦化外侧扩张超过眶上切迹,然而形成眶外缘的颧突仍然保持纤细。上述的这种气窦化导致鼻根很宽,侧面观可见眶上弓突出(图 10)。

Taforalt(Tafoughalt, Morocco, 11—12 ka BP)27 个成人头骨中的一些保存在巴黎古人类研究所,其特点是眉间区气窦大,强的乳突上脊和枕骨突起。不过其中并没有标本发展出角圆枕,也未发育出这么强烈的眉间区气窦。

角圆枕是 Orsang 头骨的一个重要特征,我们在 130 个更新世头骨上分析了这个性状的时间和空间分布,其中包括能人,匠人,鲁道夫人,罗德西亚人,格鲁吉亚人,直立人,先驱人(*H. antecessor*),海德堡人,尼安德特人以及早期现代智人,其中大部分在巴黎古人类研究所中有收藏(模型或原件),其他的标本在文献中有描述(表 3)。星点区保存足够完整的化石标本都被纳入考虑范围。比较结果如下:

早更新世(2.5Ma—780ka), $n = 19$, 11 个来自非洲,4 个来自欧洲,4 个印度尼西亚。角圆枕在非洲头骨上没有发现。而在 8 个出自亚欧大陆的可以观察到。

中更新世(780ka—120ka), $n = 27$, 10 个来自非洲,12 个来自欧洲,5 个来自中国。非洲的标本中只有一例即罗德西亚人(Kabwe)发展出了这种特征,而在欧洲的 5 个标本和中国的 5 个标本中都可以观察到。

晚更新世(120ka—10ka), $n = 83$, 31 个来自非洲,25 个来自欧洲,7 个来自近东,19 个来自亚洲。基于上述比较,两个人群被区分了出来,一个是人属化石种(尼安德特人,直立人,弗洛勒斯人), $n = 24$, 4 个来自近东,10 个来自欧洲,20 个来自亚洲。角圆枕仅在亚洲标本中可见。第二个人群是 AMH($n = 58$),其中 31 件非洲标本,15 件欧洲标本,3 件近东标本,9 件亚洲标本。角圆枕只在亚洲标本中可见。

在早更新世,角圆枕仅可见于亚欧大陆头骨上。中更新世角圆枕特征在欧洲消失,而在南亚仍被继承了下来,即在印度,中国和印度尼西亚。尼安德特人,非洲和近东的早期解剖学上的现代人(AMH)标本的顶骨都没有发展出这样的突起。晚更新世,此特征在亚洲的地理分布范围似乎有所缩小,在中国北部和韩国北部的 5 件标本中未能观察到。然而印度尼西亚从 Ngandong-Sambunmacan 组到弗洛勒斯人,南部中国(四川,云南,贵州)和印度中部(Hathnora)的标本中都可以见到角圆枕的存在。在全新世中期,此特征在印度的一个新石器地点发现的 Tekka Lakota (Karnataka, collection of Deccan College^[3])头骨上存在。角圆枕的这种强烈的地域性说明一些亚洲人群是独立在基因流之外的。它意味着,正如印度尼西亚的 *Homo floresiensis* (c. a. 18 ka)所显示的,本地演化在至少 180 万年前的地区多样性分化中发挥了十分重要的作用。中更新世的 Kabwe 头骨是一个独特的案例,它支持基因流动和/或人类从南亚到东非的迁徙,暗示着当时阿拉伯-非洲基因流动的巨大弓形地理区。

9 对人类进化的启示

最古老的人类石器记录发现于东非的 Kada Gona and Ounda Gona (2.55 Ma), Omo (2.5 Ma), 近东 (Yiron 峡谷北部 2.4 Ma), 法国也有这种可能性 (Saint Eble 2.4—2.2 Ma)^[44-46]。亚洲最早的石器记录为距今 220 万年的中国安徽人字洞, 180 万年前的四川龙骨坡^[47]和 166 万年前河北马圈沟^[48, 49]。这些发现揭示了人类在 200 多万年以前的居住地扩张情况。人类在印度的第一次定居很可能与中国一样古老, 但可能由于这里缺乏适宜发生石化作用的条件, 极少留下人类化石。相反, 石制品更有代表性, 发现于多种沉积中, 特别是在印度次大陆印度西北部的冲积沉积和塌陷沉积^[50, 51]。这里最古老的石制品记录位于 Potwar 高原 (巴基斯坦), 印度河的支流 Soan 谷中, 距今 190 万年^[52, 53]。

在 180 万年前, 人类在旧大陆已经广泛分布, 他们具有与解剖学上的现代人相当不同的区域特征。Spoor *et al.*^[54]认为他们属于一个独特的广义直立人类型。在非洲存在着两个人属物种: 一种是最原始的能人^[55-57]从 240 万年前开始出现, 另一种是直立人^[54]从 190 万年前开始出现。在东南亚则是直立人 (1.8—1.6 Ma, Modjokerto), 欧洲南部为 Dmanisi (Georgia) 的 4 个头骨, 距今 181 万年^[58]。这意味着人属至少从三百万年前就已经出现了^[45, 54, 59]。然而距今 1.8 万年的 *Homo floresiensis* (Indonesia) 也为人类进化世系显著长时间发展的可能性提供了证据 (包括胚胎发育数据^[3, 41])。相同的证据来自最近对与哈萨克斯坦毗邻的阿尔泰山 Denisova 洞, 距今 4 万年的人类化石的 mtDNA 研究, 发现这代表着一种 100 万年前^[60]从尼安德特人和现代人共同祖先谱系分支出来并单独进化的一个人类物种^[4, 61-64]。在埃塞俄比亚的新构造运动地区有着记录的早期智人 (Omo Kibish 195 ka and Herto 160 ka) 是从这个根据其原始的胚胎型式可以鉴定为很古老的共同主干中的一个进步的物种 (有着增大的大脑和小脑新皮层) 中产生出来的。

最近中国南部与 Ratanpur 位于同一纬度的广西崇左智人洞^[65]发现的下颌骨弥补了亚洲大陆上进步的直立人和 AMH 之间的时间断层, 于是其与 4 万年前的田园洞人类遗迹^[66]之间有一个时间断层。印度次大陆只出产了来自斯里兰卡的 Fa-Hein 和 Batadoma-lena 洞中的一系列化石, 使用¹⁴C 方法得到的测年数据分别为 *ca.* 25 and *ca.* 33 ka and to *ca.* 28 ka^[67-69]。较其为晚的有 Bjimbetka 的中石器时代人类骨骼和为旧石器时代晚期和历史时期人群^[70]之间的连续性提供了证据, 后继的是 4600 BP 的 Harappan。

James and Petraglia^[71]争论现代智人于 7 万年前从非洲到达印度。他们举出了化石, 人工制品和遗传学证据来得出这一结论。这些证据显示早期人类经过中东移民到印度, 并在 4.5—6 万年前到达澳大利亚^[72]。但是智人洞的 AMH 下颌骨与这一假说相矛盾。在 Narmada 山谷中部 (Madhya Pradesh) 的冲积沉积中发现的头盖骨被归为直立人^[7], 后来又被认为是直立人纳尔玛达亚种^[8]。颅骨的穹窿很高, 不过颅底没有经过完整的复原, 不可能与智人进行“枕骨开合”幅度的比较, 尽管这是分类学, 个体发生学和系统发生学上最重要的标准^[4, 61, 62, 73-75]。

在 Orsang 头骨眶上脊的中矢面破损处很容易测量出, 其眉间有发达的气窦, 其颅骨后部表面构造很发达由此可以判断这个头骨接近晚更新世粗壮的智人, 比与新石器时期的纤细型人群接近的程度更大。此外, 由于它具有发达的角圆枕, 可能乳突部的气窦化和乳突的

朝向导致颅骨最大宽位于颞骨下部,证明了其遗传物质中有着亚洲直立人的基因。

Dmanissi 成人期骨骼也发展出了角圆枕。在与包括早期现代智人的 130 个更新世颅骨化石进行的比较中,清晰地显示出欧亚大陆人类辐射发生之后,角圆枕在亚洲 200 万年的人类的遗传物质中得到固定。如果我们有限的古生物学标本可以反映过去,这个特征在早更新世期间在非洲从来没有出现过,而在欧亚大陆的所有头骨中都存在。后来它在中更新世的欧洲消失了尼安德特人和无论在近东还是非洲的最早的智人也没有发展出这一特征。Kabwe 并不是一个 AMH,它是唯一一个能够仍然能够反映从亚洲到东非的基因流的标本。而相反的是,亚洲人群(印度,中国和东南亚)保留了并且将编码角圆枕生长因子的基因传承了下来。在印度中部,这种传承一直延续到新石器时代(Tekka Lakata, Karnataka)。在现生人群中角圆枕(或是现代人中的星点突),仍然在某些蒙古人种和澳大利亚人种中可见,并且其他骨骼加厚,如乳突后突和乳突上结节具有高出现率^[76, 77]。

Orsang 头骨的颅外面特征的粗壮性与新石器时代的颅骨不同,这说明其年代可能是晚更新世-早全新世。另一方面,它与非洲和中东智人(Herto, Omo 2, Qafzeh, Skhul)中没有,但在最晚的南亚直立人中非偶然地存在的近祖特征(颅骨最大宽出现在颅骨较低位置以及角圆枕)之间存在的联系,以及如 Taforalt 人群那样存在眉间额窦,在 Orsang 的祖先中是有居住在 Narmada 盆地中的亚洲晚期直立人,比如大脑量的直立人纳尔玛达亚种。

10 结论

从出露于 Gujarat, Orsang 山谷 Ratanpur 中晚更新世序列中发掘出的一具人类头骨化石是对印度次大陆原有的人类化石增加了宝贵的标本。其地层框架以及相关沉积物的测年,指示这里的条件对人类的存在有利,这与印度中部和西部当时的地区古环境条件有关系的。Orsang 头骨具有强烈的眉间气窦,明显的颅骨后部表面结构发达,最大宽度在颞骨下部水平,乳突的朝向,比起新石器时代人群与晚更新世-早全新世的粗壮型智人(旧石器时代末期-中石器时代初期-中石器时代人群)更接近。与来自非洲,近东和亚欧大陆的 130 个头骨比较的结果显示角圆枕的发育是从亚洲直立人继承而来的。角圆枕的进步的地区化在从亚欧大陆到亚洲都可以观察到的事实说明一些亚洲直立人群是在至少 180 万年前从非洲和欧洲独立进化而来的。所有的数据都显示亚洲直立人和中石器时代亚洲智人之间的系统发生关系。AMH 和人属中最古老的人种之间的进化水平与其同源基因以及它们的突变效应有关^[3, 4, 61, 62, 78-80],所以现代解剖特征是通过杂交产生的^[2, 81, 82]并且有可能是至今未知的复杂基因调控过程。最近的古生物学数据已经不再支持非洲 AMH 在 7—9 万年前来到亚洲以及土著人群灭绝的理论,这些古生物学数据包括中国南部崇左的距今 11 万年的下颌骨以及晚更新世-早全新世印度中部的,具有早期亚欧大陆形态特征角圆枕的 Orsang 头骨化石。

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(中文翻译:中国科学院古脊椎动物与古人类研究所 崔娅铭)

**Discovery of a Robust Fossil *Homo sapiens* in India
(Orsang River Valley, Lower Narmada Basin, Gujarat) :
Possible Continuity with Asian *Homo erectus***

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Abstract: The discovery in 1999 of an isolated skull of *Homo sapiens* in the Orsang River valley, a tributary of the Narmada River in western India, is significant for understanding human evolution in India and the links between South Asian *Homo erectus* and the oldest Asian *Homo sapiens* (or AMH, anatomically modern human). The fossil was found in an old fluvial deposit. Infrared stimulated luminescence (IRSL) dating of the host sediments and of those within the endocranium provided an age ranging from 50 to 30 ka. However, direct dating (AMS radiocarbon) of the bone gave a minimum age of 4981-5579 cal BP. The skull is found to refer to a brachycranial *Homo sapiens*. and The most interesting features observed are the exocranial, a well developed torus angularis in the posterior part of the Asian *Homo erectus*, the greatest width in the lower part of the cranium (temporal) as in *Homo erectus*, which may be due to pneumatization of the mastoid process. The supramastoid crest is developed and very broad frontal sinuses are visible located in the broken glabellar area (20mm). All together, these robust features suggest a genetic continuity between Orsang skull and the late Asian *Homo erectus*.

Key words: *Homo sapiens*; *Homo erectus*; torus angularis; calvarium; lower Narmada basin; western India.

1 Introduction

Human evolution in Asia has been a matter of recent debate^[1-4]. The most interesting concerns have however been the genetic continuity between late Asian *Homo erectus* and oldest Anatomically Modern Human recorded in Asia. Unfortunately, only one skull of *Homo erectus*

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narmadensis^[5-7], either archaic *Homo sapiens*^[8] or *Homo* sp. indet^[9] of late Pleistocene is known from India. The taxonomical description of which has been debatable. The Orsang skull discovered in 1999 is identified as *Homo sapiens* with features which may throw new light on the biological relationships between Asian *Homo erectus* and early Holocene Asian *Homo sapiens*.

In this paper, we present results on the external anatomy and biometry of the Orsang skull, compare it with 130 skulls from lower to late Pleistocene and debate its age. CT scan will further help understand features in the post-cranial part and also shed light on torus angularis and the greatest width in the lower position as observed in *Homo erectus*. The comparative study supports the presence of Asian *Homo erectus* genes in the Orsang genome and an age close to late Pleistocene/early Holocene. The age in this case is less important than the exceptional association of plesiomorphic features which support evidence of endemic populations derived from late Asian *Homo erectus*. This further supports the Wu Xinzhi theory of parallel evolution of human by hybridization^[2].

2 Historical Context

The Quaternary deposits in Central Narmada Valley is well known since over a century and a half for its middle to late Pleistocene mammalian fauna^[10, 11] and associated rich assemblages of the lower Palaeolithic implements. These deposits were reclassified into different formations^[12] and palaeomagnetically dated to ca. 0.73 Ma BP^[13, 14]. The Youngest Toba Ash occurring at the base of the exposed sequences is dated to ca. 75,000 BP^[15, 16]. The broken skull specimen of *Homo erectus*, the first and only of its kind in India discovered by Sonakia^[5] is one of such rare discovery. This skull was discovered in 1982 in the middle of the Narmada valley at Hathnora, Madhya Pradesh (Fig. 1; B). It is the most ancient human remnant so far discovered in Indian subcontinent and it was discovered in situ which allow a precise determination of its stratigraphic, palaeontological and cultural context all attributable to the middle Pleistocene (around 500,000 years ago). This was followed by discovery of second human fossil comprising a right clavicle^[17] and two hominin fossils along with an upper tooth of *Equus namadicus* from the same site^[18]. The human calvaria found in a middle Pleistocene deposit in the central Narmada valley of Madhya Pradesh, India, was assigned to the new taxon *Homo erectus narmadensis*^[8]. Quaternary deposits of comparable age in lower Narmada valley which form part of the extensive alluvial plain in Gujarat have been studied in great details with respect to their stratigraphy, sedimentary characteristics, depositional environments and paleoenvironment^[19-22]. However, no fossil remains have been reported so far from these deposits. The present study reports the discovery of fossil human calvaria by the first author and his colleagues at the Department of Geology, The M. S. University of Baroda in December 1999. The fossil was found in situ at Ratanpur (Lat. 22°10'N, Long. 73°30'E) in the Quaternary alluvial sediments of the Orsang River, which is a major tributary of the Narmada River in Gujarat (Fig. 1; A, C). We discuss here the field setting and morphological characteristics of the fossil skull and its implication in human evolution.

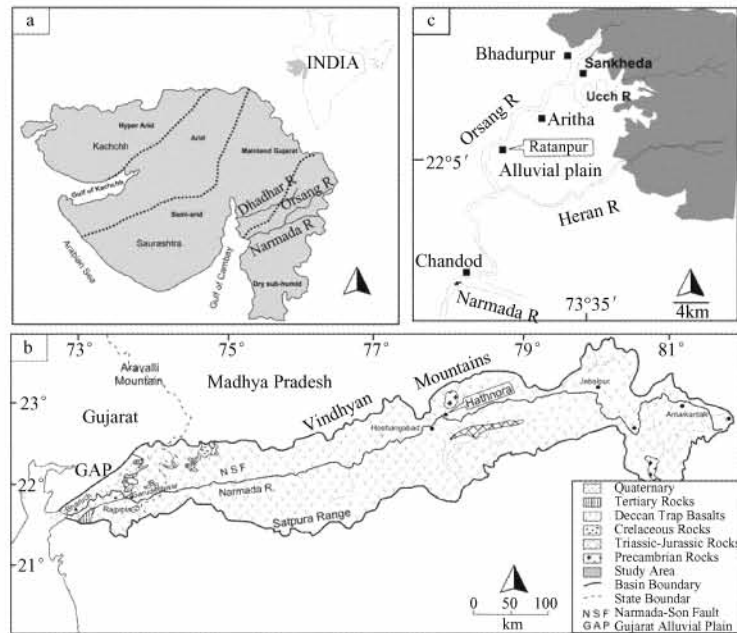


Fig. 1 a. Map of Gujarat showing major climatic zones and the location of Orsang River, b. Map of Narmada River giving a regional geological setup. Location of Hathnora is also seen from where the first fossil skull was reported. c. Map of Orsang River showing the location of Ratanpur from where fossil skull was recovered.

3 Regional Setting

The Orsang River arises from the southernmost part of the Aravalli mountain ranges that consists of various types of structurally deformed metamorphic and igneous intrusive rocks^[23]. Major rock formations exposed in the upland zone belong to the Aravalli Supergroup of rocks, especially the upper part (Champaner series), resting on granites and gneisses and including phyllites, schists and quartzites. They are followed by the rocks of Delhi Supergroup and post-Delhi intrusives consisting of quartzites, mica schists, limestones, gneisses and granites of Precambrian age. The Mesozoic is represented by intratrappean rocks (limestones, sandstones of Nimar beds) and basaltic flows of the Deccan Trap Formation^[23]. Within the uplands, the Orsang River flows in a channel broadly oriented in WSW-ENE direction. The river enters the Gujarat alluvial plain around Sankheda where the channel prominently swings towards south due to the influence of buried faults at the eastern margin of the subsurface Cambay rift basin^[24], finally meeting the Narmada River at Chandod. The channel of the Orsang River in its alluvial part is characterised by continuous line of vertical cliffs of alluvial sediments on either banks. The cliffs expose late Quaternary fluvial sediments capped by aeolian sediments which are stratigraphically correlatable to sequences exposed in the cliff sections of other major river valleys of Gujarat alluvial plain viz. the Sabarmati, the Mahi and the Narmada River^[25, 26].

The Narmada River is the largest river of peninsular India. A major part of the course of the Narmada River lies to the east of Gujarat state where it flows alternately through rocky areas comprising Late Cretaceous-Eocene basaltic lava flows belonging to the Deccan Trap Formation and alluvial sediments. The true alluvial basin of the Narmada is encountered in its lower part within the state of Gujarat. The late Pleistocene sediments of the central and upper part of the Narmada valley is well known for its rich mammalian faunal remains, including a human skull found at Hathnora indicating conditions humidier than present^[10].

4 The Ratanpur Section

The fossil human calvarium discovered was embedded but partially visible in the vertical cliff section of the Orsang River at Ratanpur (Fig. 1:C; Fig. 2). It was found embedded but partly exposed in the Quaternary alluvial sediments on the left bank cliff section (Fig. 2:A, B and C). Since the calvarium was found in the unconsolidated alluvial sediments, it was easily excavated (Fig. 2:D). The endocranium was filled with semi-compacted alluvial sediments. The vault is tinted at places with brown impregnation, while a sector of the lower part is washed-out due to recent exposure to the air.

The exposed sediment succession at Ratanpur, was carefully logged to establish its stratigraphic relationship with other previously studied sections and understand the palaeoenvironmental conditions in the context of the calvarium discovered. The continuous extension of the cliff section allowed for confirmation of the lateral extension of the lithologies. For preparing the vertical litholog, we examined lithological and sedimentological characteristics of the ~ 600 m long extension of the unbroken cliff section along the left bank of the Orsang River to the south of Ratanpur. Two deep gullies at either end of the section formed the limits of the section studied. The site from where the calvarium was recovered is located at 150 m downstream of the gully at the upper end of the cliff section. The cliff height ranges from 20-23 m above the river bed (Fig. 2:A). At the base of the section is a highly calcretised clayey silt which is about 2.5 m thick (Fig. 2:A). Lithologically it comprises mainly silt with clay and sand. Internal stratification is not visible probably because of the extensive calcretisation evidenced by the presence of calcretes (bedded, nodular and tubular). The calvarium was found in the upper part of this deposit. This is overlain by thin (10 cm) gravel with an erosional contact. The gravel thins out in the downstream direction is in fact limited to the upper part of the cliff section only. Owing to the dominance of bedded calcrete, the horizon is indurated and forms a bench which is protruded towards the river in which the calvarium was found. The gravel is overlain by 1.5 m thick horizontally stratified sandy silts. The calcretes are conspicuously absent in this horizon. Overlying this is a 4 m thick prominent rubified soil (red soil). The soil is characterised by distinct red colour and profuse development of pedogenic calcrete nodules. The calcrete nodules are abundant in the upper part and are seen to gradually decrease downwards. Bedded calcretes are also observed at places. Lithologically, the soil consists of sandy silts. The red soil is identified as a prominent marker horizon in the exposed late Quaternary sequences of the Sabarmati, Mahi and the Narmada River valleys and has been used by previous workers for inter-

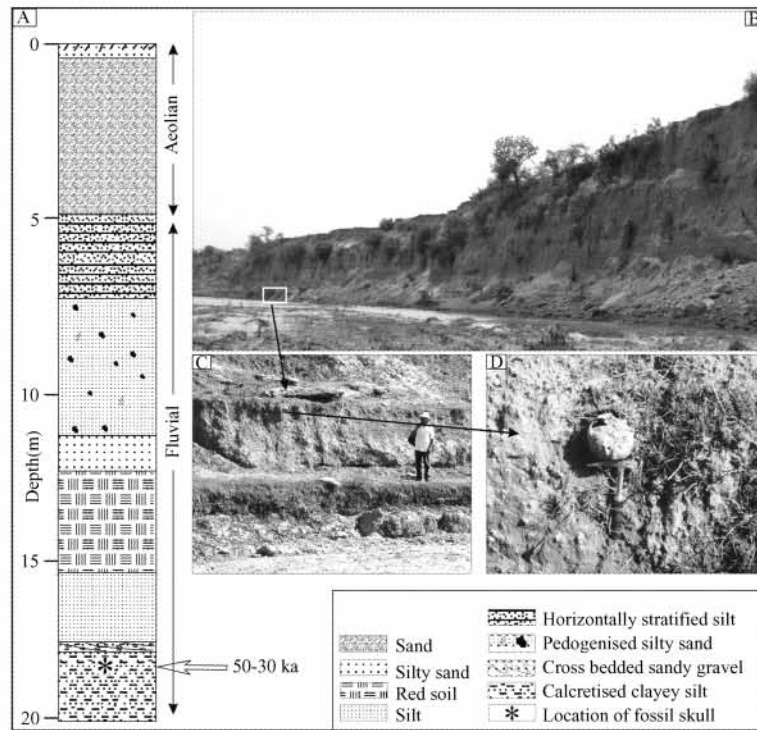


Fig. 2 A. Lithology of the exposed Quaternary sediment succession at Ratanpur. The horizon from where the fossil skull was found and its IRSL date is also shown. Upstream view of the cliff section at Ratanpur. The box indicates the place from where the fossil skull was discovered. C. Close view of the fossil skull bearing sediments at Ratanpur. D. Photograph showing the position of skull in which it was found. Photograph was taken after it was excavated.

basinal and intra-basinal correlations^[21, 22, 27, 28]. In Orsang River also, the red soil is found to be well developed at Aritha and Bhadurpur. Optical age obtained on quartz mineral extract from the red soil at Bhadurpur gave an age of around 50ka BP^[25, 26]. The red soil is overlain by 1m thick silty sand which is followed by a thick (4 m) horizon of deeply pedogenised fluvial silty sand. The soil is of brown colour and shows extensive development of nodular pedogenic calcretes. Overlying this is 2 m thick horizontally stratified silts that mark the uppermost part of the fluvial sequence. The fluvial sequence is capped by 5 m thick aeolian sediments of which the top 0.8 m is deeply pedogenised that forms the present day surficial soil (Fig. 2A). The aeolian sequence at Ratanpur is found to be consisting of structureless and homogenous silty sand. The aeolian sediments broadly correlate with the global arid phase of the Last Glacial Maximum (LGM). The aeolian activity well recorded at other places in Orsang valley^[25, 26] and in other river basins of the Gujarat alluvial plain^[26-28].

5 Chronology and Palaeoenvironment

Infra red stimulated luminescence (IRSL) dating was attempted on the coarse grained feldspar extracted from the host sediments and those within the skull cavity. Two samples were taken from the host sediments of the skull. The sediments within the skull were sampled in the laboratory. These were analyzed using the Multiple Aliquot Additive Dose (MAAD) protocol. In MAAD identical discs with their natural luminescence are given incremental beta dose and luminescence versus applied dose growth curve is plotted. Extrapolation of this curve to zero or residual luminescence (in the case of sediments) provides the paleodose. In the present study, a minimum of 4-6 discs per dose points are taken and irradiation going up to six times to anticipated paleodose were given^[29] to achieve an optimum precision. The palaeodose was obtained by extrapolating the signal value to zero taking due cognizance of the mathematical function of the luminescence versus dose growth curve.

Studies have shown that luminescence signal from feldspar, may exhibit anomalous fading (athermal-rapid loss of stored signal from deeper traps at ambient temperature). An estimated loss of 2 to 10% in luminescence signal per decade due to fading has been observed^[30]. In view of this, the ages given in Table 1 should be considered as the minimum ages. The host sediments at the same level as that of the skull gave an age of 38 ± 5 ka BP and 45 ± 7 ka BP. The sediments inside the skull yielded an age of 30 ± 7 ka BP and 27 ± 4 ka BP (Table 1). Compared to the quartz ages obtained on the correlatable sections at Aritha and Bahadurpur^[25, 26] located in the upstream of Ratanpur, the feldspar ages are underestimated due to the reason discussed above.

Table 1 Dose rate and IRSL age data

| Sample No. | Sample dated | U (ppm) | Th (ppm) | K (%) | ED (Gy) | Dose rate (Gy/ka) | Age (ka) |
|------------|----------------|----------------|----------------|----------------|--------------|-------------------|------------|
| RTNSFA | Skull sediment | 3.75 ± 1.0 | 20.5 ± 3.0 | 1.81 ± 0.1 | 126 ± 26 | 4.2 ± 0.4 | 30 ± 7 |
| RTNSF | Skull sediment | 3.75 ± 1.0 | 20.5 ± 3.0 | 1.81 ± 0.1 | 112 ± 15 | 4.2 ± 0.4 | 27 ± 4 |
| RTN1AF | Host sediment | 3.18 ± 1.0 | 16.3 ± 3.0 | 1.66 ± 0.1 | 140 ± 12 | 3.7 ± 0.4 | 38 ± 5 |
| RTN1F | Host sediment | 3.18 ± 1.0 | 16.3 ± 3.0 | 1.66 ± 0.1 | 166 ± 22 | 3.7 ± 0.4 | 45 ± 7 |

Cosmic ray dose 150 ± 30 $\mu\text{Gy/a}$, Water content $15 \pm 5\%$

¹⁴C dating of the skull using AMS method was also attempted. For this, the bone sample of a few milligrams was removed from the right side of the nuchal bone, where the tissues were already damaged. This method gave a minimum age of 4981-5579 cal BP. We consider that the radiocarbon age is underestimated. The reason being the skull was embedded in a protruded bench developed on the bedded calcrete horizon; hence it is possible that dissolution and re-precipitation of carbonate due to percolating rain waters over the years can contaminate the sample with young radioactive carbon in the micro pores of the skull bone. The above inference, although speculative at this stage, draws strength from the morphological characteristics of the skull, described later in the text, which suggests that the skull is possibly of greater antiquity. The

aeolian sediments at Aritha and Bahadurpur have yielded identical age of 21 ± 2 ka BP while the horizontally stratified fluvial silts below it at Bahadurpur have been dated to 23 ± 2 ka BP^[25]. Overall, the chronological data of the present study and by Juyal *et al.*^[25] suggests the continuation of active fluvial aggradation until the onset of arid phase of the Last Glacial Maximum.

The fluvial sequence exposed at Ratanpur is dominated by fine grained sedimentary facies. The basin received sediments from the Precambrian highlands in the north and northeast with some contribution from the basaltic hills in the east. Lithological characteristics indicate the existence of a fluvial system that carried mostly silts and sands and deposited them in flood plain environment as indicated by the prevalence of fine grained sediments with horizontal lamination and buried soils. The presence of palaeosols in the fluvial deposits indicates periods of pedogenesis with continued alluvial deposition. The fluvial sequence at Ratanpur appears to have been deposited mostly during the 50-30 ka period (MIS 3), which has been identified as a period of enhanced precipitation attributed to strengthening of the SW monsoon^[25, 26]. Enhanced fluvial aggradation during this period is also reported from the Sabarmati, Mahi and lower Narmada valleys^[22, 26, 31]. Humid to sub humid conditions in the central Narmada valley have been inferred from the correlatable alluvial deposits that yielded rich assemblage of vertebrate fauna including a human skull^[10]. Offshore data from the Indian Ocean also suggest strengthening of summer monsoon between 50-30 ka BP^[32].

No archaeological artefact was found in association with the human fossil at Ratanpur. However, tools signifying the presence of man have been reported earlier from the sediments of Orsang River and its tributary, the Sukhi River. These have been found at many lower Palaeolithic (Acheulian) and Middle Palaeolithic sites, especially in the middle reaches, as well as microlithic (Mesolithic?) sites. Upstream of Sankheda, lower and middle Palaeolithic sites occur in the piedmonts all along the northern margin of both valleys. In these piedmonts, the lithic artefacts are mostly in semi-primary situation while in the alluvium they are usually reworked. In the middle Orsang stratigraphical sequence, Acheulian artefacts are imbedded in the loose pebbly gravel that unconformably rests on the basal deposition cycle composed of cemented gravel above the basal mottled clay. Early middle Palaeolithic material occurs at the top of the red soil, well known at regional scale, and in the overlying thin gravel bed^[33, 34]. The upper part of the fine aeolian sands, that forms the last unit of the stratigraphical sequence has yielded large quantities of microliths pointing to selection of the finest raw materials such as chert, jasper or agate in order to produce small flakes and bladelets^[33, 34]. The characters of the lithic assemblages and the cultural sequence they represent tally well with that of the neighbouring regions of Gujarat and southern Rajasthan and also suggest favourable conditions for the existence of man during the late Pleistocene.

6 Morphology of the Skull

The morphological characters of the skull were studied by one of us (Anne Dambricourt

Malassé) in Baroda University while comparative anatomy was done at the National Museum of Natural History of Paris (France). As the skull cavity was full of sediments only its external anatomy was observable. The cerebral cranium is complete apart from the frontal squama in its right portion that shows a relatively recent break on the side exposed to the air. The supraorbital arch of the left orbit is preserved, with the glabella and the left external angular process of frontal bone. However, the mandible, the maxilla, the malar and nasal bones, as well as the ethmoid and body of the sphenoid are missing. The clivus, the petrous pyramid, the occipital condyles and the exo-occipital, the auditory canals and the temporo-mandibular articulations are also in place but blunt. The root of the styloid apophysis is visible on the right side. These parts of the base are fragile and often damaged. Their good state of preservation indicates that the skull underwent little movement since its burial (Fig. 3; a, b, c).

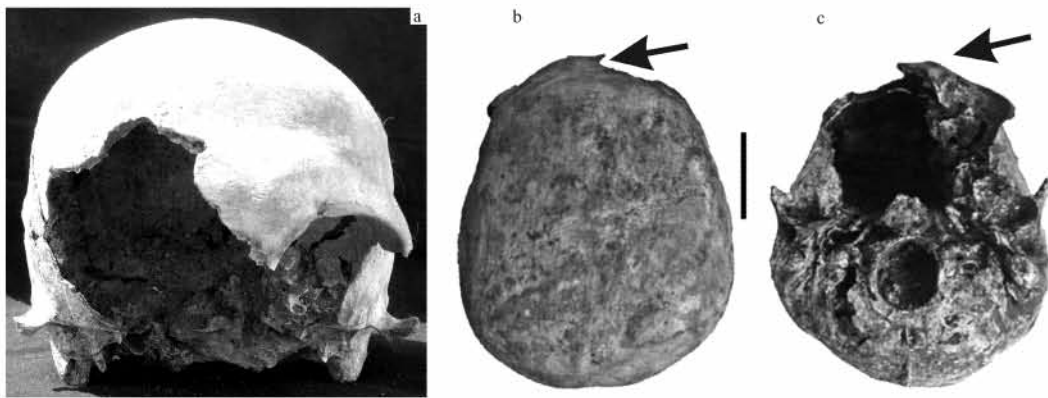


Fig. 3 Orsang skull: a) frontal view, b) and c) upper and basal view showing the sagittal asymmetry, black arrow indicates the glabellar sinuses (scale 5 cm)

The calvarium belongs to *Homo sapiens* (in the sense of anatomically modern human, AMH) as shown by the general conformation of the vault, the curve of the frontal, the general contour of the temporal squama, the development of the mastoid process downward and forward, the low and tipped position of the occipital squama, as well as the relative positions of the zygomatic process and the auditory canal (Fig. 4).

Broad frontal sinuses are visible in right lateral view as shown by a break in this part, which shows a gap of about two centimetres between the inner and outer compact tables of the bone (Fig. 5), but they are limited to the glabellar area as seen in the frontal and superior view (Fig. 3; Fig. 6) without supra-glabellar depression, no post-orbital constriction is visible in superior view. In basal view the frontalisation of both petrous bones is typically that of *Homo sapiens*.

The maximal width is in the lower part of the skull that was never observed before in *Homo sapiens*; the parietal wall flares while closer to the temporal squama (Fig. 7). This large breadth is increased by the development of the supramastoid crest. In posterior view, the mastoid processes are not in a vertical alignment with the parietal eminences, resulting from the temporo-parietal bulge probably caused by a pneumatization of the mastoid portion of the temporal bone as

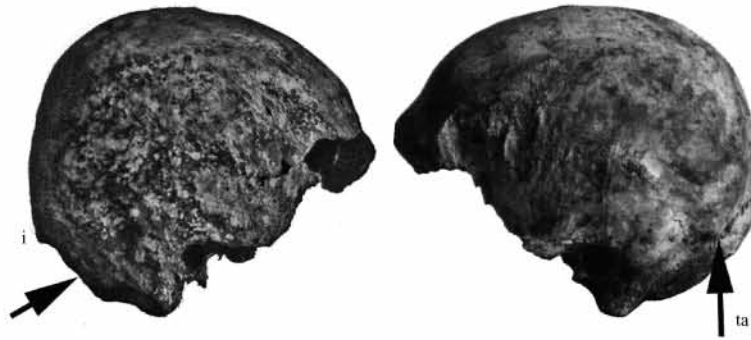


Fig. 4 Orsang skull; left and right lateral view showing the planoccipitaly. The right side of the skull is altered by exposure to air. The arrow on the left indicates the short exocranial part of the cerebellar fossa, i; inion. The arrow on the right indicates the torus angularis(ta).

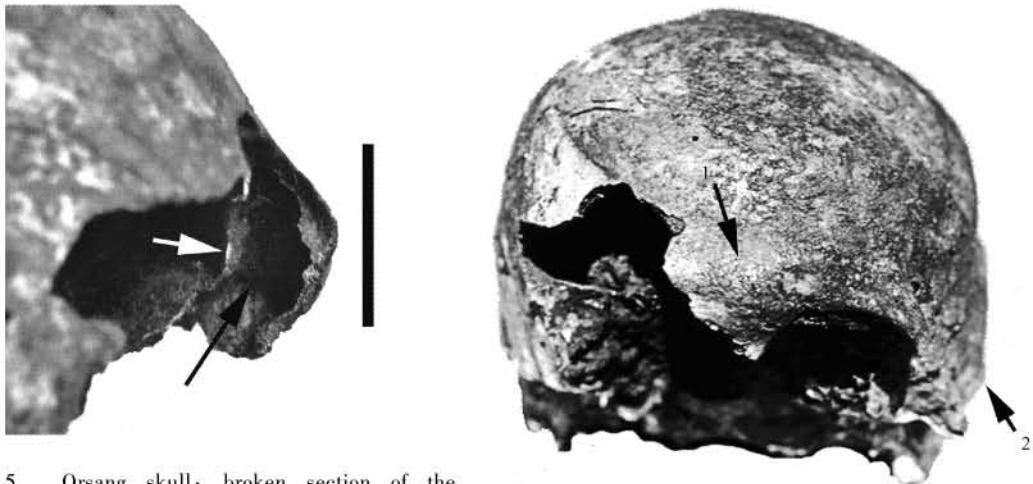


Fig. 5 Orsang skull; broken section of the glabellar sinuses in right lateral view. The white arrow indicates the endocranial compact bone, the black arrow shows the sinus cavity(scale 3 cm)

Fig. 6 Orsang skull in frontal view, arrows: 1 the strong pneumatization of the glabellar area, 2 the maximal breadth at the temporal level.

in *Homo erectus*. X-ray investigation will give more details on possible development of mastoid air cell system.

The degree of synostosis of the cranial sutures is high, particularly for the lambdoid and sagittal sutures attesting a mature adult stage. The bones (frontal, parietal, temporal, malar) are rather thin as shown by their section visible on the breaks. There is a post-bregmatic depression. The two mastoid processes are quite well developed and support the skull when it is placed on a table; this character argues in favour of a male individual. Some marks of the muscular aponeurosis are well distinct on the left side of the cranium, especially those of the temporal muscle which are elongated vertically and rough, and those of the posterior belly of the digastric muscle. However the right side does not show these features. This asymmetry could be compared

to the one seen in inferior and superior views (Fig. 3).

The bones of the vault are of membranous formation, their conformation result from a combination of neural and hormonal growths. Similarities in measurements with *Homo erectus* especially with *Homo erectus narmadensis* (Table 2) do not correspond to growth homologies and it is clear that the forward and downward development of the cerebellum is typically that of AMH (anatomically modern human).

Besides these, other features worth noting are the remarkable anatomical characteristics. The nuchal plane and the exocranial surface of the cerebellar fossa is short, and above them the supra-iniac zone is flat and vertical; the profile presents an important planoccipitaly (Fig. 4). There is no torus occipitalis; nevertheless the external occipital protuberance (inion), the superior nuchal line and the supramastoid crest are developed.

The study of the skull base takes into consideration the flexion of the spheno-occipital synchondrosis. When the flexion is too active, it brings the tentorium cerebelli forward and downward and hence limits the backward growth of the occipital squama as known in cranio-facial orthodontics (biodynamics of spheno-temporo-occipital growth)^[35-37]. The maximal length tends to reduce so that the opisthocranion can merge to the inion, with planoccipitaly as a result. X-rays investigation with such a cranial orthopaedic approach could give more explanation for the shortening of the cerebellar fossa bottom.

A characteristic feature observed is the torus angularis (or asteriac process) a thickening of the exocranial compact bone of the parietal squama, located in the asteriac area (Fig. 8). Two vascular orifices delimit the relief which tends to overhang the occipital bone. In *Homo erectus*, this protuberance is more developed in continuity with a marked superior temporal line not visible on the Orsang skull. In the approximate Frankfurt plane, its position is at the level of the zygomatic process and not above as in *Homo erectus narmadensis*, because of the downward and forward growth of the cerebellar fossa, specific of the *Homo sapiens* grade (Fig. 9).

Without X ray or CT scan view, it is not possible to conclude on the origin of this association of features never observed in anatomically modern human. This can be probably made by a pneumatization of the mastoid process classically observed in Asian *Homo erectus* but one can not exclude a peculiar development of the middle cerebral fossa in relation with the planoccipitaly. So both hypotheses a) pneumatization and b) biodynamics of spheno-temporo-occipital growth, need a CT scan analysis. While frontal sinuses are in connection with ethmoidal air cell system connected with the more or less pneumatized sphenoidal sinus, we propose in a future study to test the correlation between the maximum width in the temporal area and a growth of the skull base governed not only by the spheno-occipital synchondrosis (shortening of the cerebellar fossa) but also by a possible pneumatization of both sphenoidal sinuses (lateral inflation^[38]) and petrous



Fig. 7 Orsang skull in posterior view.

The arrows indicate the supramastoid crest

Table 2 Orsang skull measurements in millimeters (number in the left column correspond to Martin and Seller^[41])

| ORSANG Cranium | Notes |
|--|--|
| 1 maximum length glabella-opisthocranion | 170 inion and opisthocranion coinciding |
| 8 maximum breadth | 146 location; supramastoid crest |
| bi-parietal breadth | 128 between the two parietal bosses |
| 17 basi-bregmatic height | 132 |
| 20 auriculo-bregmatic height | 105 |
| horizontal cranial index | |
| temporal 100xl/L | 85.29 hyperbrachycranium |
| parietal 100xl/L | 75.29 mesocranium |
| index of height/length | |
| auriculo-bregmatic height/max. cranial length | 61.76 orthocranium (low vault) |
| basi-bregmatic height/max. cranial length | 77.64 low skull |
| index of height/breadth | |
| auriculo-bregmatic height/max. cranial breadth | 71.91 wide vault |
| basi-bregmatic height/max. cranial breadth | 90.41 wide vault |
| cranial capacity | 1390, 75 ml + -73 |
| frontal sagittal curvature | |
| 26 nasion-bregma arc | 116 |
| 29 nasion-bregma chord | 104 |
| Index | 89.65 |
| divergence of the frontal | |
| 9 minimum frontal breadth | 110 by symmetry |
| 10 maximum frontal breadth | 112,5 |
| index of divergence | 97.77 |
| nasion-inion arc | 297 |
| Parietal; length of sagittal arc/temporal arc | |
| 27 Sagittal arc of parietal | 122 |
| arc of parietal with temporal edge | 105 |
| curvature index | 116.19 high index probably caused by the planoccipitaly |
| upper temporal line to temporal edge | 37 (between the highest point of the superior temporal curve and the highest point of the superior temporal line) |
| stephanion-bregma chord | superior stephanion; 60 mm; inferior stephanion; 67 mm |
| upper stephanion arc | 112 |
| upper stephanion chord | 103 |
| nasion-frontomalar suture | 47 (in horizontal plane) |
| bizygomatic breadth | 128 anterior zygomatic tubercle |
| bi-asterion breadth | 109 |
| 11 bi-porion breadth | 132 |
| bi-pterion breadth | 100 |
| bi-mastoid breadth | 106 |
| porion-asterion length | left: 45 right: 44 |
| length between the summit of the mastoid process and the centre of the carotid canal | 28 |
| 7 Foramen magnum | |
| length | 35 |
| width | 30 |
| index | 85.71 wide foramen magnum |

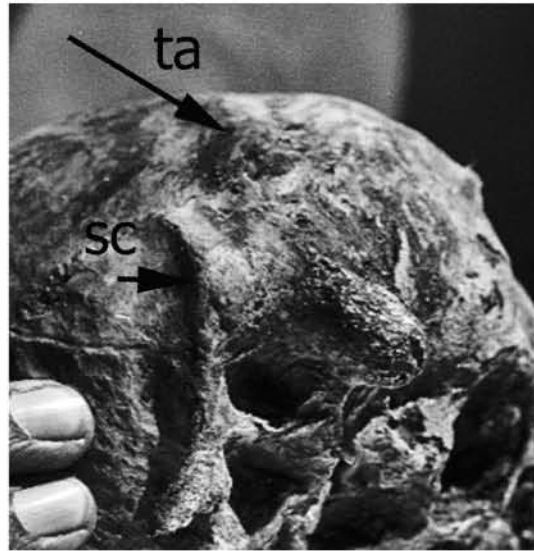


Fig. 8 Orsang skull; the left temporal and parietal bones. The arrows indicate sc; the supramastoid crest, ta; the torus angularis.



Fig. 9 Comparison between *Homo erectus narmadensis* (Hathnora) (left) and Orsang (right) in the Frankfurt plane, centred on the porion (scale approximately comparable). The arrow indicates the torus angularis.

bones. The sphenoid is destroyed; nevertheless CT scan can provide the profile of the inner surface of the temporal bone, just above the petrous pyramid, to verify if the distance between the two endocranial temporal surfaces is abnormally enlarged.

7 Biometrical Analysis

The biometrical measurements (Table 2) confirm the anatomical diagnosis with new data supporting the late Pleistocene-early Holocene age. As we know, the early Anatomically Modern Humans (Pleistocene, Proto-cromagnoids) developed cranial capacity around 1400-1600 ml,

greater than Holocene people 39, for instance as in Iberomaurusian people of Taforalt (Cromagnoids from North Africa, late Pleistocene/early Holocene; i. e. 12 ka BP). But the process of brachycephalisation which increased during Neolithic period, is not visible before Mesolithic^[40]; i. e. 9000 ka BP. Since the skull is lacking major parts to apply Martin and Saller^[41] measures, critical distances are taken with homologous anatomical points for comparison with other skull series. The maximum length (glabella-opisthocranion 170 mm) and the maximum width (146 mm) correspond to *Homo erectus s. l.* biometric homologues, as the opisthocranion merges to the inion and the maximum width is bitemporal not biparietal, therefore these values have no meaning isolated from the cranial conformation and morphogenetic trajectories.

According to Martin and Saller^[41], euryon cannot be located on the entire adjacent region above the external auditory meatus when symmetrical lateral expansion is excessive as in Homo fossil species. Nevertheless with Orsang skull, the case is peculiar because of the planoccipitaly which could be correlated to the lateral expansion of cranial cavity due to specific neural growth in the spheno-temporo-occipital area. Taking into account both cases, i) euryon on temporal bone and ii) euryon on parietal bone, the skull is classified differently. In the first case, i. e. the greatest breadth is bitemporal, the horizontal cephalic index classifies the skull in the category of hyperbrachycephaly. In the second case, i. e. the greatest breadth is biparietal the skull classifies in mesocranium category. The ratio between the maximum height (basion-bregma, 132 mm) and the bitemporal (146 mm), is 90,4, the cranium is wider than high that accentuates the broad aspect of the skull. Finally the height/length ratio shows a sharply longer skull (170 mm) than high (132 mm).

The cranial capacity is estimated according to Martin's equation based on the exocranial measures: $0.00037 (\text{length} \times \text{width} (\text{euryon-euryon} \times \text{basion-bregma height}) + 328 \pm 73$. As seen previously, in *Homo sapiens* the distance between the two euryons is located on the parietal bones. With Orsang skull, discussion is open because of its original transversal profile in the temporal area. Taken on temporal bone the value gives a capacity of 1540 ml. Taken on parietal bone, the capacity would approach 1400 ml (1390 ml). The glenoid fossa of the temporal; the left TMJ (temporo-mandibular joint) has been better protected than the right one, which was exposed to air; they are asymmetrical, the left being appreciably wider and deeper. They are large-sized. The foramen magnum is asymmetrical and wide (index = 85,7).

To conclude, the neurocranium is low, long and wide, the biometric originality lies in the particular development of the posterior part with the planoccipitaly, the shortening of the cerebellar fossa and the temporal convexity. Because of this original profile, it is necessary to distinguish two morphological categories: i) the greatest breadth is bitemporal, the skull developed hyperbrachycephaly with a high cranial capacity (1540 ml), ii) the greatest breadth is biparietal, the skull is mesocranium with a less cranial capacity (1390 ml). As mentioned above, the highest cranial capacity corresponds more to the Epipaleolithic people (12ka BP), that is in accordance with the well developed exocranial features, especially the strong glabellar pneumatization. Nevertheless the skull classified itself in hyperbrachycephaly category which

makes Orsang skull closer to Mesolithic hunters-gatherers (9000ka BP) and/or Neolithic people. This apparent contradiction can be solved by introducing the cranial orthopaedics approach. The general cranio-facial equilibrium seems normal, but the profile of the vault, the short base and the symmetry evocate deformities caused during foetal or circumnata growth by early cranial suture synostoses of the vault and excessive flexion of the sphenoccipital synchondrosis.

More conclusions will be drawn with CT scan or X ray investigation comparing Orsang skull morphology with the biodynamical analysis applied to prehistorical or historical population. The analysis will help in illustrating endemic effects on the complete axial skeleton including the sphenoccipital region less or more flexed^[42, 43].

This preliminary approach allows concluding that Orsang skull has a transitional Mesolithic morphology closer to Cromagnoid people than to the gracile Neolithic with a probable basiscranial deformity. This deformity can be due to specific sphenoccipital synchondrosis flexion during foetal or circumnata growth. The widest length in the temporal area can probably be i) by pneumatization of the mastoid air cell system, ii) by abnormal transversal growth of the encephalon, iii) these two factors in close relation with sphenoidal growth including hypophysis with endocrine consequences.

8 Comparative Anatomy

The morphology of the Orsang skull has been compared with the specimens kept in the Institut de Paléontologie Humaine of Paris (casts and originals, $n = 104$), and those described earlier in literature ($n = 21$) (Table 3).

Laterally the pneumatization extends beyond the supraorbital notch whereas the zygomatic process forming the external orbital edge remains gracile. This pneumatization as seen above causes a very wide nasal root and a protrusive profile of the supra-orbital arch (Fig. 10).

Some of the 27 adult skulls of Tafouhalt (Tafoughalt, Morocco, 11-12 ka BP) kept at the Institut de Paléontologie Humaine, are characterized by big glabellar pneumatization, strong supramastoid crest and occipital protuberance; nevertheless none of them developed a torus angularis neither such an important pneumatization of the glabellar sinuses.

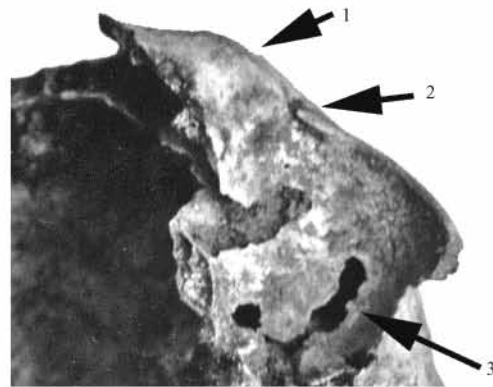


Fig. 10 Orsang skull, inferior view of the glabellar sinuses. Arrows: 1 the pneumatized glabella, 2 the supraorbital notch, 3 ceiling of the orbital cavity.

Tab. 3 Distribution of torus angularis in the Pleistocene African and Eurasian populations

| Lower Pleistocene (2.5Ma-780ka BP) | Torus angularis | Sources | Taxon |
|---------------------------------------|-----------------|---------|------------------------------|
| AFRICA | | | |
| 1. KNM ER 1470 | no | cast | <i>Homo rudolfensis</i> |
| 2. KNM ER 1813 | no | cast | <i>Homo ergaster</i> |
| 3. KNM ER 3883 | no | cast | <i>Homo erectus</i> |
| 4. KNM ER 3733 | no | cast | <i>Homo ergaster</i> |
| 5. KNM-ER 42700 | no | 1 | <i>Homo erectus</i> |
| 6. Omo Shungura L. 894. 1 | no | 2 | <i>Homo erectus</i> |
| 7. Olduvai Hominid 9 | pseudo | cast | <i>Homo erectus</i> |
| 8. KNM WT 15 000 | no | cast | <i>Homo ergaster</i> |
| 9. Bouri | no | 3 | <i>Homo erectus</i> |
| 10. UA 31 Buia | no | 4 | <i>Homo erectus</i> |
| 11. Atlanthrope 4 | no | 5 | <i>Homo erectus</i> |
| EUROPE | | | |
| 12. Dmanisi D 2700 ado ♀ | weak | 6 | <i>Homo georgicus</i> |
| 13. Dmanisi D 2280 | yes | 6 | <i>Homo georgicus</i> |
| 14. Dmanisi D 2282 ado ♀ | weak | 6 | <i>Homo georgicus</i> |
| 15. Dmanisi D 3744 old | yes | 6 | <i>Homo georgicus</i> |
| INDONESIA | | | |
| 16. Sangiran 2 | yes | cast | <i>Homo erectus</i> |
| 17. Sangiran 4 | yes | cast | <i>Homo erectus</i> |
| 18. Sangiran 10 | yes | 7 | <i>Homo erectus</i> |
| 19. Sangiran 17 | yes | cast | <i>Homo erectus</i> |
| Middle Pleistocene(780 ka-120 ka) | | | |
| AFRICA | | | |
| 20. KNM-ER 3884 | no | cast | <i>Homo erectus</i> |
| 21. Ndutu 1 | no | cast | <i>Homo erectus</i> |
| 22. LH 18-Ngaloba | no | cast | <i>Homo erectus</i> |
| 23. Kabwe | yes | cast | <i>Homo rhodesiensis</i> |
| 24. Omo Kibish 1 | no | 8 | <i>Homo sapiens</i> |
| 25. Omo Kibish 2 | no | 8 | <i>Homo erectus</i> |
| 26. Herto | no | 9 | <i>Homo sapiens</i> |
| 27. Eliye 1Springs169 | no | 10 | <i>Homo heidelbergensis</i> |
| 28. Saldanha | no | cast | <i>Homo heidelbergensis</i> |
| 29. Djebel Irhoud 2 | no | cast | <i>Homo sapiens</i> |
| 30. Djebel Irhoud 1 | no | cast | <i>Homo heidelbergensis</i> |
| EUROPE | | | |
| 31. Ceprano | yes | 11 | <i>Homo heidelbergensis</i> |
| 32. Tautavel | yes | cast | <i>Homo heidelbergensis</i> |
| 33. Castel di Guido | yes | 12 | <i>Homo heidelbergensis</i> |
| 34. Reilingen | yes | 13 | <i>Homo heidelbergensis</i> |
| 35. Atapuerca 4 | yes | 14. | <i>Homo heidelbergensis</i> |
| 36. Atapuerca 5 | no | 14 | <i>Homo heidelbergensis</i> |
| 37. Swanscombe | no | cast | <i>Homo heidelbergensis</i> |
| 38. Biache Saint Vaast | no | 15 | <i>Homo heidelbergensis</i> |
| 39. Krapina | no | cast | <i>Homo neanderthalensis</i> |
| 40. La Chaise BD 17 | no | 15 | <i>Homo neanderthalensis</i> |
| 41. La Chaise S25 | no | 15 | <i>Homo neanderthalensis</i> |

(Tab. 3 Continued)

| Lower Pleistocene (2. 5Ma-780ka BP) | Torus angularis | Sources | Taxon |
|--|-----------------|----------|------------------------------|
| CHINA | | | |
| 42. Sinanthropus III | yes | cast | <i>Homo erectus</i> |
| 43. Sinanthropus X | yes | cast | <i>Homo erectus</i> |
| 44. Sinanthropus XI | suspected | cast | <i>Homo erectus</i> |
| 45. Sinanthropus XII | yes | cast | <i>Homo erectus</i> |
| 46. Hexian | yes | cast | <i>Homo erectus</i> |
| 47. Dali | yes | cast, 16 | <i>Homo erectus</i> |
| INDIA | | | |
| 48. Hathnora | yes | cast | <i>Homo erectus</i> |
| Upper Pleistocene(120 ka-10 ka) | | | |
| AFRICA | | | |
| 49. Singa 1 (Sudan) | no | 17 | <i>Homo sapiens</i> |
| 50. Kanjera (Kenya) | no | cast | <i>Homo sapiens</i> |
| 51. Gambles Cave (Kenya) | no | cast | <i>Homo sapiens</i> |
| 52. Rhunda (Kenya) | no | cast | <i>Homo sapiens</i> |
| 53. Taforal (n = 27) | no | original | <i>Homo sapiens</i> |
| NEAR EAST | | | |
| 54. Amud | no | cast | <i>Homo neanderthalensis</i> |
| 55. Tabun | no | cast | <i>Homo neanderthalensis</i> |
| 56. Shanidar 1 | no | 18 | <i>Homo neanderthalensis</i> |
| 57. Shanidar 2 | no | 18 | <i>Homo neanderthalensis</i> |
| 58. Qafzeh 6 | no | original | <i>Homo sapiens</i> |
| 59. Qafzeh 9 | no | 19 | <i>Homo sapiens</i> |
| 60. Skhul V | no | cast | <i>Homo sapiens</i> |
| EUROPE | | | |
| 61. Spy 1 | no | cast | <i>Homo neanderthalensis</i> |
| 62. Spy 2 | no | cast | <i>Homo neanderthalensis</i> |
| 63. Mont Circeé | no | cast | <i>Homo neanderthalensis</i> |
| 64. La Ferrassie | no | cast | <i>Homo neanderthalensis</i> |
| 65. La Chapelle-aux-St | no | original | <i>Homo neanderthalensis</i> |
| 66. Gibraltar | no | cast | <i>Homo neanderthalensis</i> |
| 67. Neanderthal 1 | no | cast | <i>Homo neanderthalensis</i> |
| 68. Saccopastore 2 | no | cast | <i>Homo neanderthalensis</i> |
| 69. La Quina | no | cast | <i>Homo neanderthalensis</i> |
| 70. Cova Negra | no | cast | <i>Homo neanderthalensis</i> |
| 71. Cro-magnon I | no | cast | <i>Homo sapiens</i> |
| 72. Cro-magnon 3 | no | original | <i>Homo sapiens</i> |
| 73. Cueva del Barranc Blanc | no | cast | <i>Homo sapiens</i> |
| 74. Grimaldi | no | cast | <i>Homo sapiens</i> |
| 75. Predmost ♀ | no | cast | <i>Homo sapiens</i> |
| 76. Predmost ♂ | no | cast | <i>Homo sapiens</i> |
| 77. Mladec V | no | cast | <i>Homo sapiens</i> |
| 78. Mladec VI | no | cast | <i>Homo sapiens</i> |
| 79. Brno III | no | cast | <i>Homo sapiens</i> |
| 80. Dolni Vestonice I | no | cast | <i>Homo sapiens</i> |
| 81. Dolni Vestonice III | no | cast | <i>Homo sapiens</i> |
| 82. Ofnet K1802 | no | cast | <i>Homo sapiens</i> |
| 83. Ofnet K1806 | no | cast | <i>Homo sapiens</i> |

(Tab. 3 Continued)

| Lower Pleistocene (2.5 Ma-780 ka BP) | Torus angularis | Sources | Taxon |
|---|-----------------|--------------|--------------------------|
| 84. Ofnet K1818 | no | cast | <i>Homo sapiens</i> |
| 85. Kostenki XIV | no | cast | <i>Homo sapiens</i> |
| North KOREA | | | |
| 86 Ryong gok 1 | no | cast | <i>Homo sapiens</i> |
| 87 Ryong gok 2 | no | cast | <i>Homo sapiens</i> |
| North CHINA | | | |
| 88 Zhoukoudian UC 101 | no | cast | <i>Homo sapiens</i> |
| 89 Zhoukoudian UC 102 | no | cast | <i>Homo sapiens</i> |
| 90 Zhoukoudian UC 103 | no | cast | <i>Homo sapiens</i> |
| South CHINA | | | |
| 91 Ziyang | yes | 16 | <i>Homo sapiens</i> |
| 92 Chuandong | yes | 16 | <i>Homo sapiens</i> |
| 93 Wanrengang | yes | original, 20 | <i>Homo sapiens</i> |
| INDONESIA | | | |
| 94 Sambungmacan 1 | yes | cast | <i>Homo erectus</i> |
| 95 Sambungmacan 3 | yes | cast | <i>Homo erectus</i> |
| 96 Sambungmacan 4 | yes | cast | <i>Homo erectus</i> |
| 97 Ngawi | yes | 21 | <i>Homo erectus</i> |
| 98 Ngandong 6 | yes | cast | <i>Homo erectus</i> |
| 99 Ngandong 7 | no | cast | <i>Homo erectus</i> |
| 100 Ngandong 8 | no | cast | <i>Homo erectus</i> |
| 101 Ngandong 10 | yes | cast | <i>Homo erectus</i> |
| 102 Ngandong 11 | yes | cast | <i>Homo erectus</i> |
| 103 Ngandong 12 | yes | cast | <i>Homo erectus</i> |
| 104 Flores | yes | cast | <i>Homo floresiensis</i> |

1: Spoor *et al.* [54]; 2: Tobias [83]; 3: Berhane *et al.* [84]; 4: Abbate *et al.* [85]; 5: Arambourg [86]; 6: Lumley and Lordkipanidze [58]; 7: Grimaud and Jacob [87]; 8: Day [88]; 9: White *et al.* [89]; 10: Brauer and Leakey [90]; 11: Mallegni *et al.* [91]; 12: Mallegni *et al.* [92]; 13: Dean *et al.* [93]; 14: Arsuaga *et al.* [94]; 15: Rougier [95]; 16: Wu [2]; 17: Stringer *et al.* [96]; 18: Trinkaus [97]; 19: Vandermeersch [98]; 20: Zhang *et al.* [99]; personal observation courtesy from Prof. Ji Xueping; 21: Widiyanto and Zeitoun [100].

The torus angularis is a significant feature of the Orsang skull. We analyzed its frequency in space and time on the basis of 130 skulls of Pleistocene fossil species, *H. habilis*, *H. ergaster*, *H. rudolfensis*, *H. rhodensis*, *H. georgicus*, *H. erectus*, *H. antecessor*, *H. heidelbergensis*, *H. neanderthalensis* and early modern *Homo sapiens*, most of them available in the Institut de Paléontologie Humaine of Paris (casts and originals), while others are described in published literature (Table 3). The fossil specimens sufficiently well preserved in the asteriac area have been taken into account. The results of the comparison are as follows.

Early Pleistocene (2.5 Ma-780 ka), $n = 19$, 11 Africans, 4 Europeans, 4 Indonesians. The torus angularis does not appear on the African skulls. However it is visible on the 8 Eurasians.

Middle Pleistocene (780 ka-120 ka), $n = 27$, 10 Africans, 12 Europeans, 5 Chinese. In Africa only one cranium developed this relief, *Homo rhodensis* (Kabwe); it is visible on 5 skulls in Europe and 5 other specimens in China.

Upper Pleistocene (120 ka-10 ka), $n = 83$, 31 Africans, 25 Europeans, 7 Near Eastern, 19

Asian. Based on the above comparison, two groups are distinguished. The first group is the one with fossil species of Homo (*H. neanderthalensis*, *H. erectus*, *H. floresiensis*) $n = 24$, 4 Near Eastern, 10 Europeans, 20 Asians. The torus angularis is visible only in Asians. The second group with the AMH ($n = 58$) 31 Africans, 15 Europeans, 3 Near Eastern, 9 Asians. The torus angularis is visible only in Asians.

During lower Pleistocene, the torus angularis developed only in the Eurasian skulls. During middle Pleistocene it disappeared from Europe but is still transmitted in South Asia, i. e. in India, China and Indonesia. No *Homo neanderthalensis*, no African neither Near Eastern early anatomically modern humans (AMH) developed this parietal protuberance. During upper Pleistocene, its Asian geographical expansion seems to decrease as it is not visible on the 5 skulls from North China and North Korea. However, its occurrence is still visible in Indonesia from the Ngandong-Sambunmacan group till *Homo floresiensis*, in South China (Sichuan, Yunnan, Guizhou) and in Central India (Hathnora). During middle Holocene, it is noticed on an Indian Neolithic cranium from Tekka Lakota (Karnataka, collection of Deccan College)^[3]. The strong regionalisation of the torus angularis suggests that some Asian populations were isolated from genetic flows which mean that endemism played an important role for the differentiation of geographical diversities during at least 1.8 Ma years as shown by late *Homo floresiensis* in Indonesia (ca. 18ka BP). The middle Pleistocene skull of Kabwe (*Homo rhodensiensis*) appears as an isolated case which supports evidences of gene flows, and/or human migrations, from South Asia to East Africa, that implies a big geographical arch of Arabo-African gene flows at that time.

9 Implication for Human Evolution

The oldest human artefacts were recorded in East Africa at Kada Gona and Ounda Gona (2.55 Ma), Omo (2.5 Ma), in Near East (North of the Yiron Rift 2.4 Ma) and possibly in France (Saint Eble 2.4-2.2 Ma)^[44-46]. Earliest Asian artifacts were recorded in China dated ca. 2.2Ma BP in Renzidong (Anhui), 1.8Ma BP in Longguppo (Sichuan)^[47] and 1.66Ma BP in Majuangou (Hebei)^[48, 49]. These discoveries reveal the extension of the human settlement more than 2 million years ago. The first settlements in India are very probably as old as in China but the extreme rarity of fossil *Homo* specimens is probably due to the scarcity of contexts favourable to the fossilisation. However, artefacts are much better represented, in various types of sediments, especially in alluvial and colluvial deposits of the North-Western Indian subcontinent^[50, 51], where the oldest artefacts were recorded in the Potwar Plateau (Pakistan), in the Soan valley, a tributary of the Indus River, and dated to 1.9Ma BP^[52, 53].

At 1.8 million years, the human diversity was already well dispersed in the Old World, with regional features which belong to the same anatomical pattern *Homo* quite distinct from anatomically modern human. For Spoor *et al.*^[54] they belong to a unique *erectus s. l.* pattern. In Africa are the two species, *Homo habilis* which should be the most primitive^[55-57] living since 2.4Ma BP and *Homo erectus* (1.9Ma BP)^[54]. In South East Asia *Homo erectus* (1.8-1.6 Ma BP, Modjokerto) and in southern Europe the four skulls from Dmanissi (Georgia) are dated to

1.81 Ma BP^[58]. This implies that the *Homo* genus emerged at least 3 million years ago^[45, 54, 59] whereas the *Homo floresiensis* (Indonesia) dated to 18 ka. BP provides evidence for the remarkable longevity of the primitive ontogenetic pattern (including embryonic data^[3, 4]). The same evidence is given by recent studies on mt DNA coming from the Denisova cave, in the Altai Mountains bordering Kazakhstan and dated to c. a. 40 ka. They reveal the existence of a species coming from a human lineage which evolved separately from the common ancestors of both *Homo neanderthalensis* and *Homo sapiens* since ca. 1 Ma BP^[60]. Early *Homo sapiens* recorded in the particularly privileged tectonic areas of Ethiopia (Omo Kibish 195 ka and Herto 160 ka BP) emerged from an evolved species (i. e. enlarged cerebral and cerebellum neocortex) of this very ancient common trunk identified by its primitive embryonic pattern^[4, 61-64].

In continental Asia, the time gap between evolved *Homo erectus* and anatomically modern human fills recently with the discovery of the Chongzuo mandible (Zhiren cave) in South China dated to 110 ka BP^[65], located at the same latitude to that of Ratanpur. Then there is a gap with human remains from Tianyuan Cave dated to 40 ka BP^[66]. The Indian subcontinent has produced just one set of fossils found in Sri Lanka from Fa-Hein and Batadoma-lena caves, respectively dated by ¹⁴C method to between ca. 25 and ca. 33 ka and to ca. 28 ka BP^[67-69]. Later on Mesolithic skeletons in Bhimbetka provide evidence for population continuity between late Palaeolithic and historical periods^[70] followed by the Harappan period dated to 4600 BP.

James and Petraglia^[71] argue that modern *Homo sapiens* arrived in India from Africa about 70 ka ago. They arrived to this conclusion by bringing together fossils, artefacts, and genetic data. The evidence points to an early human migration through the Middle East into India, arriving in Australia by 45 ka to 60 ka ago^[72]. But the AMH mandible of Zhirendong contradicts this hypothesis. The calvarium found in a fluvial deposit of the central Narmada Valley (Madhya Pradesh), is assigned to *Homo erectus*^[7] then to a subspecies *Homo erectus narmadensis*^[8]. The vault of the skull is high; nevertheless without a complete reconstitution of the base, it is not possible to compare the amplitude of the “occipital bascule” with *Homo sapiens*, though it is a taxonomical, ontogenetical and phylogenetical criterion of first importance^[4, 61, 62, 73-75].

With its conspicuously developed glabellar pneumatization, easily measured in the midsagittal plane of the broken supraorbital ridge, and its well marked post-cranial superstructures, the skull from Orsang valley is closer to the robust *Homo sapiens* of the late Pleistocene, than to the gracile Neolithic population. Besides, with its well developed torus angularis, the maximal width at the level of the lower temporal, probably due to the pneumatization of the mastoid, the orientation of its mastoid process, this skull attests to the presence of Asian *Homo erectus* genes in its hereditary material.

The torus angularis develops at the adult stage as shown in Dmanissi. The comparison of 130 Pleistocene fossil skulls including early modern *Homo sapiens*, clearly shows the genetic fixation of the torus angularis in Asia 2 million years after the Eurasian radiation. As far as limited paleontological record reflects the past, this feature never appeared in Africa during lower Pleistocene while it is present on all the Eurasian skulls. Later during middle Pleistocene it

disappeared in Europe with *Homo neanderthalensis* and no earliest *Homo sapiens* developed it, neither in Near East nor in Africa. Kabwe which is not an AMH, is the only one exception which also reflects genetic flows from Asia to eastern Africa. However, during the same time, Asian population kept and transmitted the genes coding for the growth factor of the torus angularis, in India, China and South East Asia. The transmission is found in Central India until the Neolithic (Tekka Lakata, Karnataka). For living populations the torus angularis (or process asteriacus in modern man), is still visible in certain Mongoloid and Australoid population with high incidence of other bone thickenings like retromastoid process and supramastoid tubercle^[76, 77].

The robustness of the exocranial features of Orsang calvarium which is different from Neolithic skulls suggests that its age is probably late Pleistocene-early Holocene. On other hand, the association of plesiomorphic characters absent on African and Middle-Eastern *Homo sapiens* (Herto, Omo 2, Qafzeh, Skhul) (the greatest width at the lower level of the cranium and the torus angularis) but systematically present on the youngest South Asian *Homo erectus*, the pneumatization of the glabellar sinuses as in the Epipalaeolithic population of Tavoralt, suggests that among ancestors of Orsang were late Asian *Homo erectus* living in the Narmada basin, such as the large brained *Homo erectus narmadensis*.

10 Conclusions

The discovery of a fossil human skull excavated from the late Pleistocene sequence exposed at Ratanpur in Orsang valley, Gujarat, is a valuable addition to previous human fossils from the Indian subcontinent. The stratigraphic framework, and dating of the associated deposits, point to favourable conditions for the existence of man, which correlate with the regional palaeoenvironmental conditions existing in western India and central India at that time. With strong glabellar pneumatization, well marked post-cranial superstructures, the maximal width at the level of the lower temporal and the orientation of its mastoid process, the skull is closer to the robust *Homo sapiens* of the late Pleistocene-early Holocene (Epipaleolithic-Mesolithic people) rather than Neolithic population. Comparison with 130 skulls from African, Near Eastern and Eurasian Pleistocene allow concluding that the well developed torus angularis is inherited from Asian *Homo erectus* genes. A progressive regionalisation of the torus angularis is observed from Eurasia to Asia indicating that some Asian *Homo erectus* population evolved independently from Africa and Europe during at least 1.8 million years. All together the data points to phylogenetic links between Asian *Homo erectus* and Mesolithic Asian *Homo sapiens*. The evolutionary level between Anatomically Modern Human and oldest species of Homo genus concerns the homeotic genes with their saltationist effects^[3, 4, 61, 62, 78-80], so modern anatomy emerged by hybridization^[2, 81, 82] and probably by complex genetic regulatory processes still unknown. The paradigm of replacement by African anatomically modern humans arriving in Asia around 90-70 ka with complete extinction of autochthonous populations, is no more supported by the recent paleontological data. The mandible of Chongzuo in South China dated to 110 ka, and late Pleistocene/early Holocene skulls such as Orsang in Central India, with early Eurasian feature,

never observed in Africa (the torus angularis), support the multiregionalism hypothesis of AMH emergence from late *Homo erectus* in Asia as well as from late *Homo rhodesiensis* in Africa, both *erectus* and *rhodesiensis* reflecting regional variability of the same genetic background.

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