中国古人类遗址年代学问题

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摘要 考古和年代学者们均已意识到在同一古人类遗址应用不同测年方法所得的年代可能存在较大差异, 但长期以来该问题却一直未被系统阐述和研究. 本研究对我国86处已发表古人类遗址的测年结果进行了统计和分析, 尝试厘清这个问题. 经统计发现U系测年法应用比例最大, 在各测年方法中占有突出地位; 37处遗址仅用了一种测年方法, 28处使用了两种以上(包括两种)方法, 不同方法测定同一遗址的年代结果存在差异, 其中17处差异较大. 同一遗址产生较大测年差异的原因可归纳为两大类: 一类是遗址埋藏学问题, 另一类是测年方法本身的差异. 本研究提出针对不同时期遗址, 采用不同方法组合的综合定年策略来解决测年差异问题, 从而获得古人类遗址的准确年代, 并建议应用该定年策略来重新评估我国一些重要古人类遗址的年代.

关键词 古人类遗址, 第四纪测年方法, 测年差异, 综合定年策略

中国发现了东亚地区最为丰富的古人类化石记录^[1,2], 然而这些化石的年代学研究却相对薄弱. 第四纪年代学属于第四纪地质学研究范畴, 也是古人类与旧石器考古学研究的重要内容, 但我国专门从事旧石器时代遗址年代学研究的科研人员较少, 相应的大型测年仪器和实验室不足, 再加上考古学与年代学之间学科交流不畅, 也为古人类遗址准确定年带来困难, 总体来看我国旧石器时代遗址的测年研究仍相对滞后. 本研究参考200多篇已发表有关我国古人类遗址(有古人类化石出土的遗址)年代的中、英文论文和专著, 对这些测年结果进行了总结与再分析, 共涉及86处遗址(图1), 以增进对我国现有古人类遗址年代的认知和理解.

1 测年结果总结与再分析

根据我国86处古人类遗址的测年结果, 我们系统总结了各遗址的测年方法、测年材料、年代结果和参

考文献等内容(表S1). 图2(a)归纳出各测年方法的应用情况, 图2(b)对应用不同测年方法数的遗址进行了分类, 并对28处应用两种以上方法遗址的测年结果一致性和不一致性进行了统计.

从图2(a)可以看到, 古人类遗址常用的测年方法主要包括: 铀系(U系)、碳十四(^{14}C)、电子自旋共振(ESR)、热释光(TL)、古地磁、铝铍埋藏($^{26}\text{Al}/^{10}\text{Be}$)、常规光释光(OSL)、ESR/U系、气候地层(黄土-古土壤地层)、红外后高温红外释光(pIRIR)、热转移光释光(TT-OSL)、红外释光(IRSL)和地貌-沉积推断法. 其中U系测年法的应用比例最高, 达到了47%; ^{14}C 的应用比例次之, 达到26%; ESR测年的应用比例为13%; TL、古地磁和 $^{26}\text{Al}/^{10}\text{Be}$ 埋藏测年的应用比例均为8%; OSL和ESR/U系测年法的应用比例为7%; 气候地层法的应用比例为5%; pIRIR测年的应用比例为3%; 而TT-OSL、IRSL和地貌-沉积推断法(地貌法)的比例均为2%. 总体

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图1 (网络版彩色)我国古人类遗址分布图^[1]. 遗址按阿拉伯数字排列依次为: 1, 巢县; 2, 和县; 3, 华龙洞; 4, 田园洞; 5, 周口店第一地点; 6, 周口店第四地点; 7, 周口店山顶洞; 8, 兴隆洞; 9, 狐狸洞; 10, 猪仔笼洞; 11, 泾川; 12, 武山; 13, 马坝; 14, 蟠龙洞; 15, 罗沙岩; 16, 白莲洞; 17, 宝积岩; 18, 九楞山R5013; 19, 南山洞; 20, 来宾; 21, 荔浦; 22, 柳江; 23, 隆林德峨; 24, 隆林龙洞; 25, 隆林那来洞; 26, 么会洞; 27, 鸡母岩洞; 28, 陆那洞; 29, 定模洞; 30, 独山-1; 31, 咁前洞; 32, 智人洞; 33, 岩砾洞; 34, 穿洞; 35, 猫猫洞; 36, 盘县大洞; 37, 桐梓; 38, 老鸦洞; 39, 许家窑; 40, 南召; 41, 浙川; 42, 孙家洞; 43, 灵井; 44, 白龙洞; 45, 长阳; 46, 黄龙洞; 47, 建始龙骨洞; 48, 梅铺; 49, 郧县; 50, 福岩洞; 51, 燕儿洞; 52, 葫芦洞; 53, 莲花洞; 54, 神仙洞; 55, 高资; 56, 鸽子洞; 57, 建平; 58, 金牛山; 59, 庙后山; 60, 东洞; 61, 前阳; 62, 小孤山; 63, 萨拉乌苏; 64, 水洞沟; 65, 乌珠台; 66, 沂源; 67, 丁村; 68, 长武; 69, 大荔; 70, 黄龙; 71, 陈家窝; 72, 公王岭; 73, 龙牙洞; 74, 资阳; 75, 台湾左镇; 76, 澎湖-1; 77, 丽江; 78, 龙潭山第一地点; 79, 龙潭山第二地点; 80, 马鹿洞; 81, 仙人洞; 82, 元谋大那乌; 83, 元谋郭家包; 84, 过山洞; 85, 乌龟洞; 86, 夏河

Figure 1 (Color online) Location of Chinese human fossil sites^[1]. Sites are listed in Arabic numerals: 1, Chaoxian; 2, Hexian; 3, Hualongdong; 4, Tianyuan Cave; 5, Zhoukoudian Locality 1; 6, Zhoukoudian Locality 4; 7, Zhoukoudian Upper Cave; 8, Xinglong Cave; 9, Fox Cave; 10, Zhuzailong Cave; 11, Jingchuan; 12, Wushan; 13, Maba; 14, Panlong Cave; 15, Luoshayan; 16, Bailiandong; 17, Baojiyan Cave; 18, Jiulengshan R5013 Cave; 19, Nanshan Cave; 20, Laibin; 21, Lipu; 22, Liujiang; 23, Longling Cave; 24, Longdong Cave; 25, Nalaidong; 26, Mohui Cave; 27, Jimuyan Cave; 28, Luna Cave; 29, Dingmo Cave; 30, Dushan Cave 1; 31, Ganqian Cave; 32, Zhiren Cave; 33, Yanli Cave; 34, Chuandong Cave; 35, Maomaodong; 36, Panxian Dadong; 37, Tongzi; 38, Laoya Cave; 39, Xujiayao; 40, Nanzhao; 41, Xichuan; 42, Sunjiadong; 43, Lingjing; 44, Bailong Cave; 45, Changyang Cave; 46, Huanglong Cave; 47, Jianshi Longgu Cave; 48, Meipu; 49, Yunxian; 50, Fuyan Cave; 51, Yan'er Cave; 52, Hulu Cave; 53, Lianhua Cave; 54, Shenxian Cave; 55, Gaozi; 56, Gezi Cave; 57, Chienping; 58, Jinniushan; 59, Miaohoushan; 60, Dongdong Cave; 61, Qianyang Cave; 62, Xiaogushan; 63, Salawusu; 64, Shuidonggou; 65, Wuzhutai; 66, Yiyuan; 67, Dingcun; 68, Changwu; 69, Dali; 70, Huanglong; 71, Chenjiawo; 72, Gongwangling; 73, Longyadong; 74, Tzeyang; 75, Cho-chen; 76, Penghu-1; 77, Lijiang; 78, Longtanshan Locality 1; 79, Longtanshan Locality 2; 80, Maludong; 81, Xianren Cave; 82, Danawu Yuanmou; 83, Guojiabao Yuanmou; 84, Guoshandong Cave; 85, Wuguidong; 86, Xiahe

来看U系测年方法占主导地位,¹⁴C和各种释光测年的应用比例也较高。

图2(b)显示有2处遗址(2%)无任何年代记录、19处遗址(22%)只有生物地层记录且并未进行测年研究、37处遗址(43%)只用了一种测年方法、28处遗址(33%)应用了两种以上(包括两种)测年方法。在这28处应用两种以上测年方法的遗址中,11处测年结果基本一致,17处结果不一致(测年结果差异超过具体年代或年代范围的20%以上),测年结果不一致的遗址占比高达61%(图2(b))。若测年结果差异是由样品上、下位置不同而

引起,且年代结果按地层顺序增长,则属于一致。

2 测年结果差异原因

为什么有这么多古人类遗址存在测年结果差异?原因可归纳为两大类:一是遗址埋藏学问题;二是测年方法本身的差异。

2.1 遗址埋藏学问题

我国古人类遗址可分为旷野遗址和洞穴遗址两大类,洞穴遗址占比高达70%。当古人类化石出土时,化石

图2 (网络版彩色)古人类遗址测年方法总结。(a)各测年方法在86处古人类遗址的应用情况总结。(b)遗址应用测年方法数分类,以及28处应用两种以上(包括两种)测年方法遗址的结果一致性和不一致性统计

Figure 2 (Color online) Summary of dating methods used in human fossil sites. (a) Summary of every dating method used in 86 Chinese human fossil sites. (b) Classification of the quantity for dating methods used in human fossil sites, and consistency and inconsistency analysis in 28 sites utilized more than two (including two) methods

埋藏部位需要精准描述,测年材料需要与人类化石有明确的埋藏关系:与人类化石同层、位于上部覆盖层、或位于下部沉积层。对于在古人类化石发现很久之后所取样品,其与人类化石之间的关系可能已模糊,这种情况下较难判断该样品年龄能否代表古人类化石年代。

旷野遗址古人类化石埋藏一般比较简单,多为松散堆积地层,基本按地层层序保存和埋藏。虽然在一些旷野遗址也存在侵蚀面、地层扰动或缺失等情况,但通过野外剖面详细描述基本可以识别。而洞穴遗址堆积则比较复杂,剖面描述有时难以反映堆积过程。洞穴堆积物主要由松散堆积物、钙质胶结物、古人类遗存和动物化石等组成。洞穴遗址普遍存在古人类化石层受钙板层约束的结构,适合U系测年,这也解释了为什么U系测年法在我国古人类遗址中的应用比例高达47%(图2)。

从洞穴遗址的地层层序来看包含古人类化石的松散堆积物受到钙板约束,但在地质历史时期洞内堆积常因落水洞流水,或洞口洪水作用,而发生侵蚀和再堆积。洞穴的钙板堆积层易被固定,而松散堆积在流水(或洪水)作用下却是活动的,松散堆积物裹挟着古人类化

石会发生再次堆积,甚至可以发生在早已形成的钙板层之下,所以化石和松散堆积物的同层堆积可能是假象,钙板层对化石层的约束也可能是假象,这些地层关系在野外难以辨认清楚。所以上述遗址埋藏学问题均会造成测年结果差异。

2.2 测年方法差异

另一方面,测年方法本身的差异也会引发古人类遗址测年结果的分歧。测年方法的差异可以体现在各方法的基本原理、测年材料、测年范围(图3)、误差大小等多个方面。比如U系测年法主要利用纯净的碳酸盐结晶和动物化石两大类材料,测年范围一般小于80万年^[3~5]。碳酸盐晶体是一个封闭体系,U系测年精度较高,也相对准确^[3],而骨化石总体上不能构成封闭体系,骨化石所载铀系年代信息只具有有限的分辨率^[4]。 ^{14}C 法的测年材料主要为炭屑、动物或人类化石等,应用AMS加速器其测年范围可达5万年^[6,7]。炭屑的测年结果一般是可靠的,测量骨骼化石时,提取足量骨胶原也可以获得较为准确的年代。

OSL测年法的材料主要为松散堆积物中提纯的石英和长石颗粒,单片再生剂量法(SAR)的测年上限一般

图3 (网络版彩色)古人类遗址常用测年方法定年范围示意图

Figure 3 (Color online) Dating range of methods used in human fossil sites

在6~10万年^[8~10], TT-OSL的测年范围可达78万年^[11,12], pIRIR的测年范围也可达50万年^[13], 但TT-OSL和pIRIR法在实际应用中的测年能力一般未超过20~30万年^[14]. 石英和长石颗粒进入洞穴时的晒退情况, 以及洞穴埋藏环境剂量的不均一性均会影响测年结果. TL测年法测定古人类用火烧烤过的石制品年代已达40多万年^[15]. ESR以及ESR/U系测年法的材料主要为大型食草类哺乳动物牙齿的牙珐琅质部分, 测年范围可以达到两百多万年^[16~18], 洞穴地层堆积的不均一性、含水量变化等因素均会导致外部剂量率的不确定性, 对牙化石年代结果有一定影响.

古地磁定年法适用于风成黄土、河湖相沉积、洞穴遗址堆积等, 但该方法仅能获得地磁极性倒转界线(例如, M/B界线、Jaramillo上下界、Olduvai上下界等)的准确结果, 对极性倒转界线之间层位的定年精度有限^[19,20]. $^{26}\text{Al}/^{10}\text{Be}$ 埋藏测年法的材料为石英粗砂或石英质、脉石英质砾石等, 测年范围大约为25万年~500万年^[21~23], 该方法要求样品沉积历史相对简单, 即从基岩区剥蚀后被快速搬运和埋藏, 没有经历复杂埋藏过程, 且要求样品埋藏深度超过10 m. 气候地层定年法主要应用在风成黄土堆积区遗址, 地层记录需有气候旋回, 其测年范围适合整个第四纪^[14,24,25], 但定年精度只局限

于冰期-间冰期尺度.

各测年方法的理想结果是接近或等于所测材料的真实年代, 但受系统不封闭、环境剂量不稳定、含水量变化、样品污染等多种因素影响, 测年结果与真实年代的差距要远大于预想. 还需强调一点, 由于受不同时代客观条件的局限, 一些测年方法在二十世纪七八十年代之前的准度和精度远低于现有水平, 所以同一方法的测年结果也可能存在较大差异.

3 讨论与建议

遗址的埋藏学问题和测年方法不同会引起测年结果差异, 且测年差异在古人类遗址中普遍存在, 似乎难以避免. 如图4所示, 在应用多种测年方法的遗址中, 测年结果一致的有隆林德峨、前阳洞、小孤山、神仙洞、智人洞、柳江、盘县大洞、大荔、金牛山、龙牙洞和白龙洞遗址; 而测年结果不一致的有水洞沟、田园洞、龙潭山第一地点、黄龙洞、萨拉乌苏、白莲洞、丁村、周口店第四地点、马鹿洞、许家窑、和县、葫芦洞、沂源、周口店第一地点、郧县、元谋和公王岭遗址.

早更新世代表性的人类遗址包括元谋和公王岭. 元谋遗址测年结果包括古地磁年代0.70^[26]和1.70 Ma^[27]、

图4 我国28处应用两种以上测年方法古人类遗址的测年结果对比与差异

Figure 4 Analysis and comparison of the dating results from 28 human fossil sites using more than two (including two) dating methods

ESR年代1.10~1.60 Ma^[28], 以及化石层上部砾石的²⁶Al/¹⁰Be埋藏年龄1.54 Ma^[29]. 虽然测年结果存在较大差异, 但考虑古地磁年代1.70 Ma^[27]与²⁶Al/¹⁰Be埋藏约束年龄1.54 Ma^[29]和早更新世生物地层数据^[30]相吻合, 所以将1.70 Ma作为元谋人化石年代是合理的. 公王岭遗址的古地磁年代测定为1.15^[24]和1.62~1.63 Ma^[31], 化石层下部²⁶Al/¹⁰Be埋藏年代为1.8 Ma^[23], 以及生物地层为早更新世^[32]. 两个古地磁结果差别较大, 但古地磁数据应该都是正确的, ²⁶Al/¹⁰Be埋藏年代和生物地层结果也没问题. 所以公王岭测年结果的分歧可能归因于遗址埋藏学问题: 蓝田猿人化石出土层位是黄土-古土壤序列中的L15粉砂层^[24], 还是S22和S23古土壤层^[31]? 总体来看, 对于早更新世遗址古地磁定年方法最为常用, 且最可靠^[20], 但由于其对极性倒转界限之间层位的定年精度有限, 所以需结合²⁶Al/¹⁰Be埋藏、气候地层、ESR、ESR/U系等其他测年方法.

中更新世遗址可用测年方法较多. 中更新世早期, 例如郧县, 遗址早期的古地磁定年结果分别为830~870^[33]和936 ka^[34], ESR定年结果为581±93 ka^[35]. 近些年气候地层法的结果分别为S8古土壤层0.79~0.80 Ma^[36]和L9黄土层0.98~1.01 Ma^[37], ESR/U系组合定年结果为1.1 Ma^[17]. 但我们最新的高密度古地磁定年结

果却大于1.4 Ma(未发表). 所以郧县人测年结果差异也较大, 仍需增加测年方法检验, 比如²⁶Al/¹⁰Be埋藏法. 中更新世中期, 例如白龙洞, 遗址²⁶Al/¹⁰Be埋藏测年结果为760 ka^[38]、ESR/U系定年结果是509 ka^[39]、古地磁定年结果接近并小于780 ka^[40], 考虑古地磁和埋藏年代均出自化石层下部, 这3种定年方法所得年代基本一致, 所以白龙洞化石年代在509~780 ka之间是比较可信的. 中更新世晚期, 例如大荔遗址, 气候地层法结果为大约270 ka、TT-OSL和pIRIR测年结果为258~268 ka^[41]、ESR/U系测年法结果为281 ka^[16], 考虑测年误差, 3种测年方法结果一致, 所以大荔遗址的测年结果是可信的. 再比如长阳遗址, 动物化石U系年代为194~196^[42]和143~196 ka^[43], 次生碳酸盐U系年代为233~257 ka^[43], 虽然测年结果差异不大, 但均为U系法测年, 所以尚需其他方法检验. 综上所述, 中更新世遗址可选择古地磁、气候地层、²⁶Al/¹⁰Be埋藏、U系、ESR/U系、ESR、TT-OSL和pIRIR等多个测年方法, 根据遗址保存测年材料, 应用3种以上方法进行交叉检验, 可获得准确年代.

关于晚更新世遗址, 例如黄龙洞, 遗址动物化石U系年代为95^[44]和35~72 ka^[45], 碳酸盐U系年代为103~104^[44]和81~101 ka^[46], ESR年代为44 ka^[47], 我们最

新的炭屑样品AMS ^{14}C 年代为33.3~35.1 ka(未发表), 生物地层记录为中更新世或晚更新世, 测年结果差异较大。综合来看U系测年结果偏老, 而ESR、 ^{14}C 年龄均偏年轻, 但也有年轻U系年代, 因此推断黄龙洞遗址发生过侵蚀和再堆积, 如前文所述钙板层的U系年代约束可能是假象, 所以黄龙洞人类化石可能偏年轻, 还需OSL等测年方法进一步检验。再如马鹿洞, 遗址动物化石U系年代为112~177 ka^[48], 炭屑 ^{14}C 年代为11.5~14.3 ka^[49], 存在很大分歧。该洞穴堆积也较复杂, 尚需OSL等测年方法的检验以进一步理解洞穴堆积过程^[50]。

此外, 晚更新世洞穴遗址多基于碳酸盐钙板和动物化石U系测年, 例如陆那洞^[50]、莲花洞^[51]、仙人洞^[52]等。也有少数遗址基于 ^{14}C 测年, 例如穿洞^[53], 以及基于OSL测年, 例如岩砾洞^[54]。这些遗址都需要增加测年方法做进一步检验。我们认为晚更新世遗址基于U系、 ^{14}C 和OSL这3种测年方法综合定年是必要的, 甚至需增加TT-OSL、pIRIR和ESR/U系等测年方法。而晚更新世晚期遗址, 尽量应用 ^{14}C 直接测年和古DNA分析以获得可靠年龄, 比如 ^{14}C 直接测定萨拉乌苏^[55]等遗址的人化石表明其属于全新世而非更新世, 但这些测量毕竟是破坏性的, 需谨慎应用。

综合以上古人类遗址测年情况分析, 使用多种测年方法可以避免因一种方法而造成的偶然性错误, 合理的多方法组合定年有利于排除错误年代。尤其在中更新世和晚更新世洞穴遗址中, 经过3种方法交叉检验结果一致最可信, 仅用一种测年方法的结果尚需验证, 而我国却有43%的古人类遗址只用了一种测年方法(图2(b))。根据我国86处古人类遗址测年情况, 部分遗址已有多种测年方法应用, 经交叉检验排除错误年代可获得准确结论, 比如: 元谋、周口店、白龙洞、大荔、盘

县大洞、金牛山、许家窑、田园洞、水洞沟、小孤山等遗址。而部分遗址还需增加测年方法进一步检验, 比如: 郧县、华龙洞、马坝、和县、长阳、咁前洞、兴隆洞、陆那洞、黄龙洞、福岩洞、乌龟洞、仙人洞、桐梓、猫猫洞、穿洞、马鹿洞等遗址。且尚有21处遗址没有测年研究, 比如梅铺龙骨洞、鸡母岩洞、宝积岩洞、过山洞、猪仔笼洞等, 大多数遗址的化石发现记录已不清楚, 或不具备合适的测年材料, 所以需对这些遗址进行详细摸底和再调查工作, 如能测得部分遗址年代, 也是很有意义的。

4 结论

埋藏学问题和测年方法不同会造成古人类遗址测年结果差异, 遗址埋藏学问题需要通过多方法测年来发现和修正, 而测年方法本身差异问题则更需要多方法测年来综合评估和判断。我们建议用不同方法组合的综合定年策略: 早更新世古人类遗址应主要依靠古地磁定年, 再结合 $^{26}\text{Al}/^{10}\text{Be}$ 埋藏、气候地层和ESR测年等方法来获得相对准确的古人类化石年龄; 中更新世遗址需要基于古地磁、气候地层、 $^{26}\text{Al}/^{10}\text{Be}$ 埋藏、U系、ESR/U系、ESR、TT-OSL和pIRIR等多种测年方法, 并根据遗址测年材料保存情况, 选择3种以上方法进行交叉检验; 晚更新世遗址基于U系、 ^{14}C 、OSL三种方法综合定年是必要的; 晚更新世晚期遗址可以谨慎地开展 ^{14}C 直接测年和古DNA分析。

准确的古人类化石年龄是建立我国正确古人类演化理论的基础, 因此需对新发现古人类化石采用多方法综合定年策略, 并建议应用该策略来检验和评估我国一些重要古人类遗址的年代, 这是提高我国古人类遗址年代准确性必要的一步。

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补充材料

表S1 我国86处古人类遗址的名称、遗址类型、测年结果、测年方法、采样位置、参考文献统计

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Summary for “中国古人类遗址年代学问题”

Chronological problems in Chinese human fossil sites

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Archeologists and chronologists have realized that dating age divergence exists in some human fossil sites. However, this problem has not been systematically elaborated and studied to date. This paper makes statistics and analysis on the dating results of 86 published Chinese human fossil sites and attempts to clarify this problem. We find that the U-series dating method has the largest proportion of application and occupies a prominent position in each dating method, 37 sites use one dating method, and 28 sites utilize more than two (including two) methods. Dating age divergence uses different methods in the same site, of which 17 sites are with large age divergence. We assume that the following are the reasons for the large dating age divergence in the same site: The taphonomy problems and the difference of the dating method itself. In summary, the problem of the dating age divergence in the same site is common.

The taphonomy problems of human fossil sites must be discovered and corrected through multiple dating methods. The difference of the dating method itself also needs the combination of multiple dating methods for evaluation and judgment. We suggest the following multiple dating strategies: Early Pleistocene human fossil sites should mainly rely on paleomagnetic dating, and $^{26}\text{Al}/^{10}\text{Be}$ burial dating, climatic stratigraphy, and ESR dating methods should be combined to obtain a relatively accurate human fossil age. Middle Pleistocene sites should be based on paleomagnetic dating, climatic stratigraphy, $^{26}\text{Al}/^{10}\text{Be}$ burial dating, U series, ESR/U series, TT-OSL, and pIRIR dating methods. Three or more dating methods must be selected for cross-examination. Late Pleistocene site dating must be performed on the basis of U series, ^{14}C , and OSL dating methods. ^{14}C dating and DNA analysis can be cautiously conducted in Late Pleistocene sites.

The use of multiple dating methods can avoid accidental errors caused by only one dating method, especially in the cave sites of Middle and Late Pleistocene. The summary of the dating results for 86 Chinese human fossil sites shows that some sites have applied multiple dating methods. After cross-checking, the following sites obtained reliable ages: Yuanmou, Zhoukoudian Localities, Bailong Cave, Dali, Panxian Dadong, Jinniushan, Xujiayao, Tianyuan Cave, Shuidonggou, and Xiaogushan. Certain sites should be further checked by adding dating methods, such as, Yunxian, Hualongdong, Maba, Changyang, Hexian, Ganqian Cave, Xinglong Cave, Luna Cave, Huanglong Cave, Fuyan Cave, Wuguidong Cave, Xianren Cave, Tongzi Cave, Mao-Mao-dong Cave, Chuandong, and Maludong. Twenty-one sites, such as, Meipu Longgu Cave, Jimuyan Cave, Baojiyan Cave, Guoshandong Cave, and Zhuzailong Cave, still have no dating research. We must make a detailed investigation and reinvestigation because the fossil discovery records of these sites may be unclear, or they may have unsuitable dating materials. Obtaining some ages from these sites is significant.

The accurate age of human fossil is the basis for establishing the correct theory of human evolution in China. Multiple dating strategies should be adopted for the newly discovered human fossil sites. Such strategies should be used to check and evaluate the age of some important Chinese human fossil sites that have been previously discovered. Doing so can further improve the reliability of the dating results for Chinese human fossil sites.

human fossil site, quaternary dating methods, dating age divergence, multiple dating strategydoi: [10.1360/TB-2020-0149](https://doi.org/10.1360/TB-2020-0149)