Kako bolje izkoristiti arheološko metodo izkopavanja v kasnejši analizi in razlagi izsledkov
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Izvleček

V prispevku avtor obravnava na značilnih primerih statistične in druge metode, ki jih uporablja pri analizi gradiva izkopavanj v Divjih babah I. Vse metode temeljijo na kontroli napake in zanesljivosti analiziranih podatkov. Avtor izkoristi prednosti arheološke terenske metode pred geološko terensko metodo in nakaže možnost za reševanje problema izohronih in diahronih najdb in procesov.

Abstract

In the contribution, the author deals with typical examples of statistical and other methods that he used in the analysis of material from excavations at Divje babe I. All the methods are based on control of error and reliability of the analysed data. The author makes use of the advantages of archaeological field methods over geological field methods and demonstrates the possibility of solving problems of isochronic and diachronic finds and processes.

1. UVOD

Če govorim o arheologiji kot samostojni vedi, moram v prvi vrsti opredeliti metodo oziroma metode, ki jih arheologija uporablja pri svojem delu. Pri tem hitro ugotovim, da so arheološke metode podobne, če ne enake, metodam drugih zgodovinskih ved *sensu lato*, kot sta npr. geologija in paleontologija.

Arheologija torej nima lastne metode, razen morda pri izkopavanju, ima pa veliko možnosti, da uporablja in kombinira različne metode, saj se pri svojem delu srečuje z zapletenimi vprašanji, ki zahtevajo prav tako zapleten pristop do reševanja.

V tem prispevku ne nameravam posegati zunaj okvira slovenske paleolitske problematike. Moj glavni namen je, da razložim nekatere (ne)standardne postopke, povezane z analizo gradiva druge faze izkopavanj v Divjih babah I v letih 1989-1999. Ker je bilo objavljenih že več različnih izsledkov (Turk et al. 2001, 2002), obstaja bojazen, da bodo ti izsledki razumljeni kot rezultat "hokus-pokus" metod, zlasti ker novi izsledki niso povsem skladni s starimi. Ne nazadnje je moj namen prispevati k razvoju paleolitske arheologije v Sloveniji.

Pri svojem delu sem spoznal, da kljub temu, da lahko veliko vem o stvareh, stvari in z njimi povezane procese ne znam razložiti, ker nimam ustreznega znanja. Znanost je tista, ki zna razložiti, kako stvari delujejo v smislu modela o vzroku in posledici. Za to mora imeti razvito znanstveno metodo, ki omogoča sprotno kontrolo kakovosti in zanesljivosti rezultatov in ki po možnosti uporablja eksperiment v širšem pomenu besede, kar pomeni, da preizkuša tudi različne metode, če jih že ne razvija. Nekaj tega želim pokazati na konkretnih primerih.

2. IZHODIŠČA, IDEJE IN DEFINICIJE

Kontrola kakovosti (natančnosti zbiranja in obdelave podatkov) in **zanesljivosti** izsledkov z ocenitvijo napake je bistveni del vsake znanstvene metode.

Natančnost zbiranja in obdelave podatkov je odvisna predvsem od metode, vloženega časa in značaja tistih, ki metodo izvajajo.

Razlaga rezultatov je predvsem funkcija raziskovalne metode in znanja posameznika.

Zanesljivost podatkov in zanesljivost sklepov, ki temeljijo na zanesljivosti podatkov, ni vedno odvisna od natančnosti, s katero so bili podatki zbrani in obdelani. Veliko število manj natančnih podatkov je lahko včasih bolj zanesljivo kot omejeno število zelo natančnih podatkov.

Potem je tu še **verodostojnost**, ki je stvar znanstvene etike. S podatki lahko ravnam na tak ali drugačen način, odvisno od cilja, ki ga zasledujem. Če je vse isto in je različno samo ravnanje, lahko dosežem različne cilje. Na tej točki delovanja se postavi vprašanje verodostojnosti znanstvenega dosežka.

Temelj znanosti je matematika. Matematika bi se morala uveljaviti tudi v slovenski arheologiji, vsaj preko statistične metode (glej Brodar 1962-1963), da bi lahko začeli razmišljati o znanstvenih metodah v arheologiji. Matematika in fizika sta pri nas, predvsem v paleolitski arheologiji, že dalj časa posredno prisotni v obliki radiometričnih metod datiranja (Osole 1974, 1983 in predvsem Nelson 1997; Lau et al. 1997, kjer sta na posameznem primeru razloženi dve različni metodi datiranja, ki sta dali različen rezultat). Žal je to bolj ali manj vse, vsaj kar zadeva paleolitsko arheologijo. Zato bi rad pokazal, kljub svojemu pomanjkljivemu znanju matematike, kakšne so dejanske možnosti za uporabo matematičnih metod, ki se ponujajo "čisti" arheologiji brez t. i. pomožnih strok, in sicer na primeru dveh na videz nepovezanih stvari:

1.) strukturnih agregatov, tj. fragmentov zemljene mase, velikih 0,5-3 mm, sestavljenih iz med seboj povezanih primarnih delcev (Ćirić 1986, 96 ss) in

2.) fosilnih ostankov, tj. kostnih fragmentov, večjih od 3 mm, ki pripadajo skoraj izključno jamskemu medvedu.

Eno in drugo sicer nima dosti skupnega z arheologijo, razen da se nahaja v paleolitskem najdišču, vendar zlasti najdbe kosti zelo dobro ponazarjajo značilno arheološko situacijo in njene dileme.

Preden preidem k stvari, moram pojasniti tudi nekaj vprašanj, ki zadevajo **kronologijo**.

Poznavanje časovnega zaporedja dogodkov je osnovni pogoj za razlago stvari in tega kako stvari delujejo v smislu vzroka in posledice.

Stvari se lahko spreminjajo glede na čas in prostor, in sicer izohrono (istočasno v prostoru odnosno "vzporedno s časom") ali diahrono (raznočasno v prostoru odnosno "poševno s časom"). Če se prostor povečuje, se lahko pri stvareh povečujejo tudi z njim povezane razlike, neodvisno od časa. Če se istočasno povečuje čas (zmanjšuje časovna ločljivost), se povečujejo tudi razlike med stvarmi v prostoru, tokrat odvisno od prostora in časa. V arheološki praksi spremljamo samo navidezne spremembe med stvarmi v času in prostoru, vse do točke, ko maksimalno povečamo **časovno ločljivost**, tj. zmanjšamo enote časa, kot so leto, desetletje, stoletje, tisočletje ... O manjših časovnih enotah v predzgodovinski arheologiji nima smisla govoriti.

Poenostavljeno povedano predstavlja čas v arheologiji vertikalno razsežnost, prostor pa horizontalno ali bočno (lateralno) razsežnost stvari. Neupoštevanje prostora in z njim povezane prostorske variabilnosti ima lahko v arheologiji in v sorodnih strokah hude posledice. Žal se arheologi tega pri svojem delu vedno ne zavedamo ali pa preveč zaupamo zakoreninjeni predpostavki o izohronosti podobnih stvari in procesov.

V arheološki prostorski enoti, ki se jo ne da več deliti (npr. kvadrant; vzorec, vzet iz profila ipd.), se čas in prostor navidezno poenotita, zato razlike, povezane s časom, ne morem ločiti od razlik, povezanih s prostorom. Navidezno zato, ker je vse odvisno od deljivosti prostorske enote, medtem ko časovna ločljivost, ki sicer vpliva na neenotnost prostora, v takem primeru navidezno ne vpliva na prostor. Na večjem prostoru sta čas in prostor tudi pri majhni časovni ločljivosti ločena, zato lahko razlike, povezane s časom, ločim od razlik, povezanih s prostorom. Kako to storim, bo razvidno kasneje na primeru agregatov in kostnih fragmentov.

Pojem časa ima v arheologiji več pomenov (Siiriäinen 1992). V mojem primeru sta pomembna samo dva pomena, ki sem ju označil kot **časovni horizont** in kot **sedimentacijski nivo**. Časovni horizont predstavlja dogajanje v točno določenem fizičnem času, ki ga lahko okvirno določim z različnimi radiometričnimi metodami. Vsi dogodki, ki se zgodijo v istem fizičnem času, so istočasni. Sedimentacijski nivo, ki je sestavljen iz vodoravnih režnjev tako, da upošteva vpad (nagib) plasti, predstavlja relativni čas. Vse kar se je zgodilo v določeni debelini sedimenta, pripada določenemu sedimentacijskemu nivoju. Dogodki, zajeti v sedimentacijskem nivoju, niso nujno istočasni v smislu absolutnega fizičnega časa. Zato sedimentacijskih nivojev in časovnih horizontov ne morem enostavno enačiti med seboj. Zaželeno je, da so sedimentacijski nivoji čim tanjši, ker se tako poveča časovna ločljivost v paketu sedimentov.

Več sedimentacijskih nivojev sestavlja **plast**, ki je osnovna depozicijska enota. Plast je homogena celota, ki je (teoretično) nastala pod stalnimi fizikalno-kemičnimi pogoji pri enotnih procesih in njihovem enotnem zaporedju. Plast je ločena od talnine in krovnine na podlagi ene (ali več) osnovnih značilnosti sedimentnih kamnin. Na značaj plasti vpivajo fizikalni, kemični, biološki (vključno antropološki), geološki in diagenetski pogoji. Plastnost nastaja v sedimentu praviloma tedaj, ko pride do sprememb v materialu, ki se odlaga. Praznine med plastmi (hiati), ki vplivajo na popolnost kronološkega zapisa, nastanejo zaradi prekinitve pri sedimentaciji, erozije, kemičnih sprememb ali sprememb pogojev pri sedimentaciji.

Zato so na terenu ugotovljene t. i. **geološke plasti** samo začasni delovni pripomoček kronološke narave in nimajo bistveno večje teže od umetnih režnjev, stratigrafskih enot in podobnih stratigrafskih pripomočkov, dokler ne ugotovim prave narave vsake posamezne plasti ali skupin plasti. To je le redko mogoče na terenu, kjer plasti *ad hoc* razmejujem in označujem.

Tako plasti kot sedimentacijski nivoji običajno pripadajo različno dolgim časovnim horizontom. To pomeni, da hitrost sedimentiranja ni enakomerna oziroma da sedimentacija je, ali pa jo ni, odvisno od različnih notranjih in zunanjih pogojev v najdišču. **Hitrost sedimentiranja** je torej zelo pomembna spremenljivka, odvisna od pogojev za sedimentacijo.

3. METODA IN MATERIAL

Vse analize in grafični pikazi rezultatov so bili narejeni s pomočjo programa *Stat.Soft.Inc.* (2001). *STATISTICA* (*data analysis software system*). *version* 6. *www statsoft.com.* Matrik s podatki ne podajam, ker bi zavzeli preveč prostora.

Večina podatkov za agregate in kostne fragmente je bilo zbranih med izkopavanjem po kvadratih velikosti 1x1 m in po vodoravnih režnjih debeline 12 cm na površini, ki je bila v začetku izkopavanja velika 83 m^2. Debelina režnja je bila določena optimalno glede na teksturo sedimentov v režnjih, od katerih je več kot polovica režnjev vsebovala od 51 % do skoraj 100 % dolomitnih kosov, večjih od 10 cm, ostali režnji pa od nekaj odstotkov do 50 %. Ker velikost kvadratov in debelino režnjev med izkopavanjem nisem spreminjal, so kostni fragmenti prostorninsko uteženi. Zaradi različnih deležev dolomitnih kosov, večjih od 10 cm, se je od režnja do režnja spreminjala prostornina, ki je bila dejansko na voljo kostnim fragmentom. Zato je masa kostnih fragmentov obratno sorazmerna s prostornino dolomitnih kosov, večjih od 10 cm, kar dokazujejo negativni, relativno visoki, statistično značilni korelacijski koeficienti. Če sem kostne fragmente utežil s prostornino dolomitnih kosov, večjih od 10 cm, so se povečale absolutne vrednosti kostnih fragmentov, relativni odnosi med njimi pa se niso spremenili. Zato sklepam, da tekstura sedimenta bistveno ne vpliva na časovno-prostorski vzorec kostnih fragmentov v sedimentu.

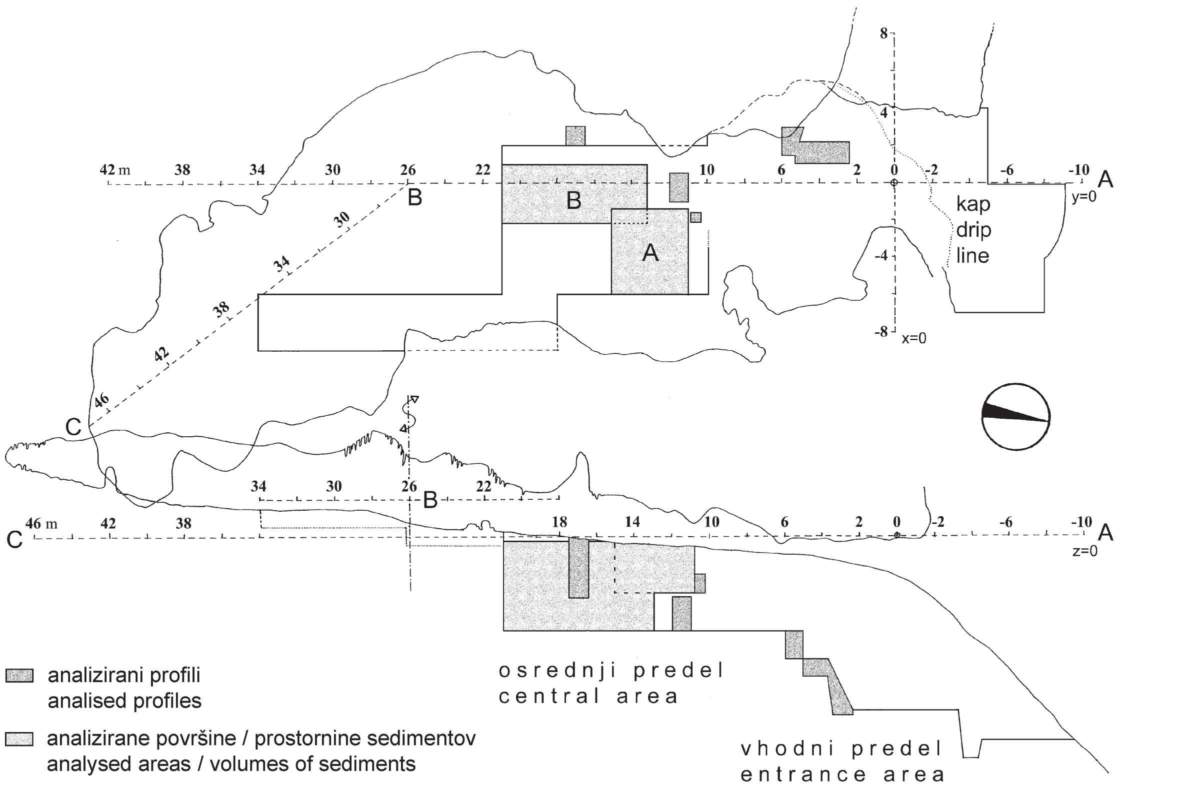
Med izkopavanji se je prvotna površina 83 m^2 zaradi nepredvidljivih objektivnih ovir skrčila, tako da sem na koncu vse podatke analiziral na največji možni strnjeni površini, kjer praktično ne manjka noben podatek za posamezni prostorski del te površine (v danem primeru je to kvadrat in en vodoraven reženj). Uporabno površino sem iz metodoloških razlogov razpolovil. Poleg površine B (= 21 m^2), odkopane od 10-50 cm pod današnjim površjem do relativne globine -465 cm (plast $17a_1$), sem izbral še referenčno površino A (= 25 m^2), odkopano od samega površja do relativne globine -285 cm (cementirana plast 8a). Površina A je zajela 60 m^3, površina B pa 83 m^3 sedimenta (*sl. 1*).

Manjšino podatkov sem zbral pri vzorčevanju petih profilov, združenih v stratigrafski stolpec na koncu izkopavanj (*sl. 1*), in sicer na skupni površini, veliki samo približno 2,4 m^2, tako da se je prostornina vzorčenih sedimentov gibala od 18 dm^3 do 25 dm^3. Kostne fragmente v vzorcih iz stratigrafskega stolpca sem kasneje utežil na enak volumen (18 dm^3).

Plasti, ki sem jih določil in vzorčil v profilih, sem na podlagi globin primerjal z režnji oziroma sedimentacijskimi nivoji. Vse plasti vpadajo proti jamskemu vhodu. Pri tem se na en tekoči meter dvignejo/padejo za 0,04 m. Zato sem pri sestavljanju sedimentacijskih nivojev iz režnjev na vsake 3 m naredil stopnico. Za postavljanje stopnice sem imel na voljo 3 možnosti, ki jih predstavljajo 3 kombinacije prečnih nizov kvadratov. Izbral sem kombinacijo, pri kateri sem ugotovil z navzkrižnim primerjanjem največjo podobnost v profilih med podolžnimi in prečnimi nizi kvadratov. Postopek temelji na dejstvu, da plasti vpadajo samo v podolžnih nizih kvadratov, medtem ko so v prečnih nizih skoraj vodoravne. Popolnoma vodoravne *sensu lato* so plasti samo v vsakem posameznem kvadratu. Poseben problem predstavljajo nagubane (valovite) plasti. Gubanja sedimentacijski nivoji ne upoštevajo.

Med izkopavanji sem lahko določil mejo dveh sosednjih plasti z največjo natančnostjo ± 12 cm. Tudi če je bila valovita. To so pokazale kasnejše analize. Vendar je bila večina plasti določena z manjšo natančnostjo, kar se je pokazalo pri ponovnem določanju istih plasti z odmikom nekaj let. Natančnost določitve je bila odvisna predvsem od tega, kako ostra je bila meja. Plast 4 sem npr. pravilno določil tako med izkopavanjem v vhodnem kot v osrednjem predelu jame zaradi izstopajoče sive barve. Pravilno določitev plasti sta kasneje potrdila prilegajoča se artefakta (odbitka) štev. 292 in 459, ki sta bila najdena 9 m narazen in z odmikom 8 let, oba opredeljena v plast 4. Odbitka, ki ju je nedvomno naredil človek, pripadata torej istemu sedimentacijskemu nivoju, ki ga enačim z delom nagubane plasti 4. Zaradi gubanja je med odbitkoma le 7 cm globinske razlike, namesto pričakovanih 36 cm, ki jih narekuje vpad plasti in razdalja med najdbama.

Kljub gubam v plasteh 2-5a, sem lahko zelo natančno vzorčil vsako plast v profilu, če sem se omejil na njen osrednji del. Vzorce sem lahko kasneje skrbno pregledal in ocenil natančnost pregledovanja



Sl. 1: Tloris in profil jame z lociranimi profili, ki predstavljajo stratigrafski stolpec, in z blokom sedimentov na površini A in B.
Fig. 1: Ground plan and profile of the cave with location of separated profiles which represent the stratigraphic sequence of the site and with location of blocks of sediments in areas A and B.

s ponovnim pregledovanjem že pregledanega.

Za profil ali stratigrafski stolpec je kot rečeno značilno navidezno poenotenje časa in prostora. Povsod tam, kjer je na voljo več profilov, lahko izbiram med tipičnim profilom in njegovim nasprotjem.

Tipični profil je tisti profil, ki najmanj odstopa od vseh razpoložljivih profilov, kar pomeni, da je najbolj podoben vsem ostalim profilom. Izberem ga lahko z zamudnim računskim postopkom ali hitrejšim, vendar manj zanesljivim vizualnim postopkom. Računski postopek temelji na vsoti srednjih vrednosti kvadrata vseh odstopanj po sedimentacijskih nivojih in profilih od vsakega profila posebej. Vizualni postopek temelji na grafičnem prikazu profilov. Sestavljen je iz dveh korakov. V prvem koraku izberem pomožne tipične profile v vseh prečnih nizih profilov, tako da krivuljo srednjih vrednosti vsakega prečnega profila vizualno primerjam s krivuljami dejanskih vrednosti vsakega prečnega profila in ocenim odstopanja. Pri tem mi ni treba upoštevati vpada plasti, ker so plasti v prečni smeri skoraj vodoravne. V drugem koraku razvrstim tako izbrane tipične profile v vzdolžni niz, tako da upoštevam vpad plasti. S primerjanjem krivulje srednjih vrednosti vsakega pomožnega tipičnega profila s krivuljami dejanskih vrednosti končno dobim tipični profil. To je tisti profil, katerega krivulja najmanj odstopa od krivulje srednjih vrednosti vseh profilov.

Profil, ki je bil dolgo močno priljubljen okvir podatkov v slovenski paleolitski arheologiji (glej zelo natančne risbe profilov in opise plasti v objavah najdišč in prizadevanja, da se vse najdbe povežejo s plastmi), načeloma kaže spremembe v času, vendar lahko samo navidezno, če ne poznam sprememb v prostoru, ki jih v profilu ne moremo ugotoviti. Zato sem sklenil, prvič in ne zadnjič, analizirati tudi spremembe v prostoru. Kako?

Kvadrati in sedimentacijski nivoji zaradi svoje združljivosti oziroma deljivosti ponujajo možnost, da ločeno analiziram spremembe, povezane s časom, ki ga predstavljajo režnji ali sedimentacijski nivoji, in prostorom, ki ga predstavljajo posamezni ali združeni kvadrati, kar je vsekakor prednost pred profilom in plastmi. Druga prednost je možnost, da ocenim zanesljivost podatkov in sklepov.

Vendar obstajajo tudi pomanjkljivosti, povezane s kvadrati in sedimentacijskimi nivoji. Zaradi narave dela mej med plastmi nisem mogel več zasledovati s takšno natančnostjo kot v profilu. Vendar to niti ni pomembno, ker imam vsa dogajanja opredeljena z globino. Resnejši problem so gube v plasteh 2-5a. Vodoravni režnji so presekali gube in pomešali lastnosti različnih plasti. Kako in do kakšne mere se da ugotoviti, če uporabim ustrezno metodo. Vendar o tem v nadaljevanju. Med pomanjkljivosti uporabljene terenske metode sodi tudi manjša natančnost, povezana s časovno stisko, ki spremlja vsako terensko delo, če želim biti na terenu učinkovit v ekonomskih mejah.

Tako agregati kot kostni fragmenti so bili določeni v premešanem sedimentu vzorca (bodisi kvadrat-reženj bodisi reženj v profilu). Zato predstavlja vsaka vrednost *eo ipso* povprečje vzorca. Napaka je bila določena s ponavljanjem postopka, tj. z večkratnim merjenjem volumenske mase in pobiranjem spregledanih kostnih fragmentov. Pri agregatih, kjer na terenu in pozneje ni bilo časovne stiske zaradi enostavnosti postopka, je bila napaka pri določanju volumenske mase največ ± 0,05 g/cm^3 ali 3,2 % do 6 % glede na razpon volumenske mase, ki je 1,54 g/cm^3 do 0,82 g/cm^3. Pri kostnih fragmentih, kjer je bilo pregledovanje sedimenta in sprotno pobiranje najdb časovno omejeno, je bila napaka večja in odvisna od velikosti in števila najdb. Izrazil sem jo v odstotkih nepobranih najdb. Napaka se povečuje obratno sorazmerno z velikostjo najdb. Za velikostni razred kostnih fragmentov 3-10 mm, ki smo jih še sistematično pobirali, se giblje med 61 % do 82 %. Manjše fragmente nismo sistematično pobirali. Številčni delež zadnjega velikostnega razreda najdenih kostnih fragmentov je največji, saj znaša kar 99,3 % za celotno najdišče. Masni delež ni znan,vendar ga lahko ocenim na podlagi 35 vzorcev, vzetih iz sestavljenega profila. Njegova srednja vrednost je 45 %, v celoti pa znaša 33 % vse mase kostnih fragmentov. Iz tega sledi, da je skupina kostnih fragmentov, za katere je značilna velika "terenska napaka", pomembna frakcija celotnega analiziranega vzorca. Predpostavljam, da terensko-laboratorijska napaka vpliva na rezultate kasnejših analiz premo sorazmerno z velikostjo napake.

Red velikosti napake je odvisen predvsem od terenske metode in od tega, kako metodo izvajam. Za primer navajam napako za fosilne ostanke enoletnih jamskih medvedov, najdene v Divjih babah I v letih 1980-1986 in v letih 1990-1999. V letih 1980-1986 je bila napaka 98 %, v letih 1990-1999 pa 31 %. Viden napredek v odpravljanju napake je rezultat mokrega sejanja sedimentov po letu 1989. Variabilnost napake nedvomno prispeva k variabilnosti arheoloških in drugih zbirk. Ker je variabilnost gradiva glavni predmet arheološkega proučevanja, je treba terensko-laboratorijsko napako upoštevati pri razlagi gradiva.

Agregate, ki se sicer pojavljajo v vseh frakcijah, sem količinsko opredelil s pomočjo volumenske mase v frakciji 0,5-3 mm. Ta frakcija ima najmanjše masne deleže med vsemi frakcijami. Gibljejo se od najmanj 1,4 % v plasti 10-11 do največ 14,8 % v sosednji plasti 8b-10. Ocena temelji na normalni porazdelitvi masnih deležev sedimentne frakcije 0,5-3 mm v startigrafskem stolpcu in je 99 % zanesljiva.

Kostne fragmente, ki sem jih opredelil s pomočjo mase in ki so prisotni v vseh sedimentacijskih nivojih, sem izbral zaradi velike fragmentarnosti fosilnih kostnih ostankov. Med ostanki, ki so večji od 10 mm, je namreč kar 93 % fragmentov, pri ostankih, ki so manjši od 10 mm, pa je fragmentarnost skoraj 100 %. Masni delež vseh kostnih fragmentov je 79,5 % in se hitro zmanjšuje sorazmerno z velikostjo fragmentov. Povprečna teža fragmenta za celotno najdišče, katere zgornja meja je 1,83 g, dokazuje, da prevladujejo zelo majhni fragmenti (manjši od 5 mm).

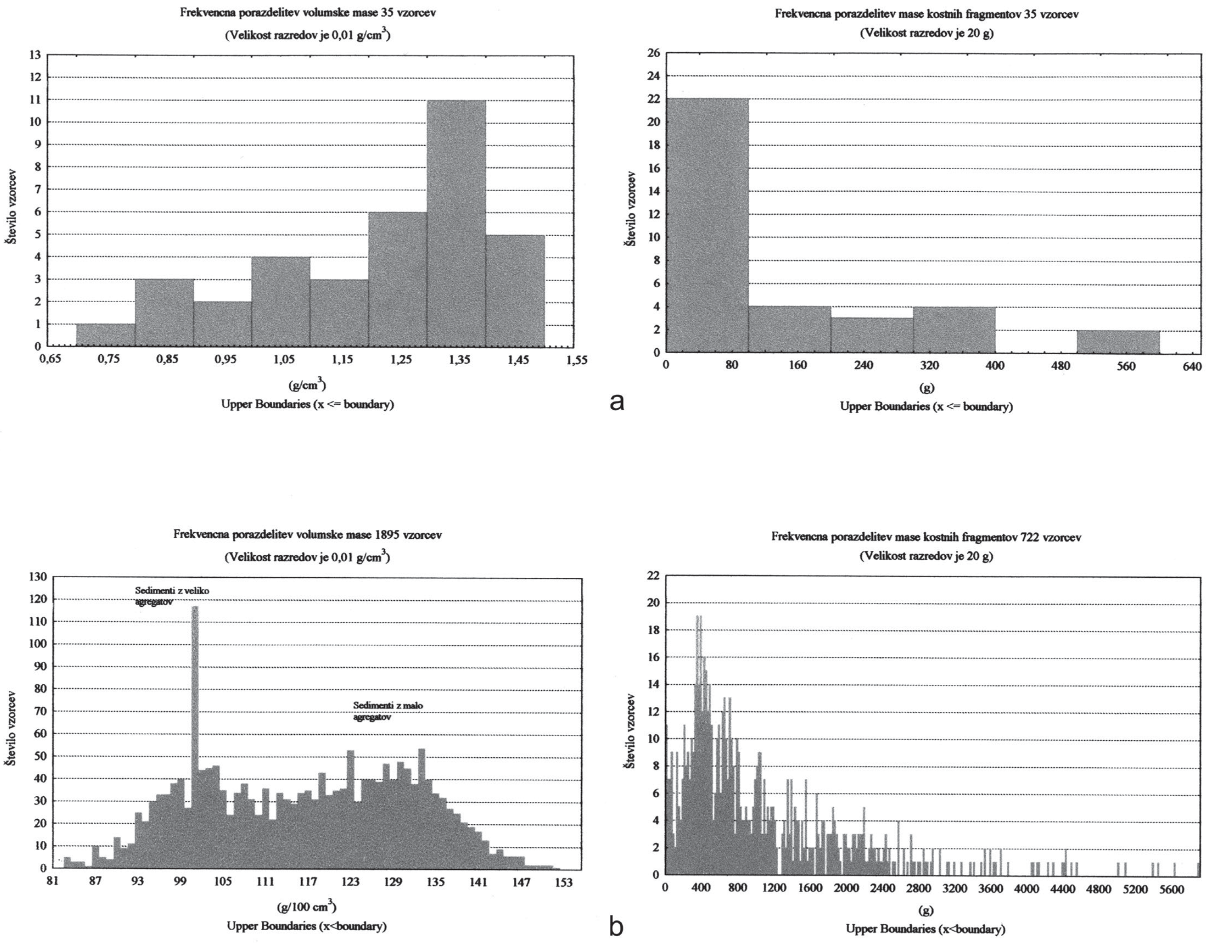
4. BREZČASNA PORAZDELITEV AGREGATOV IN KOSTNIH FRAGMENTOV

Porazdelitev vrednosti agregatov in kostnih fragmentov v stratigrafskem stolpcu je prikazana na *sl. 2:* a. Velikost obeh vzorcev (N = 35) naj bi zagotavljala statistično zanesljivost izsledkov. Vendar temu ni tako.

Če oba vzorca močno povečam s širitvijo v čas in prostor (N = 1895 in 722), ne da bi čas in prostor upošteval pri analizi, dobim drugačno sliko (*sl. 2:* b). Porazdelitev agregatov postane izrazito bimodalna, medtem ko je bila prej asimetrična v levo. Največ vrednosti se gosti okoli vrednosti 1 g/cm^3, ki je značilna vrednost plasti 8, kateri pripada približno 10 % vseh analiziranih sedimentov. Porazdelitev kostnih fragmentov ostaja navidezno nespremenjena, tj. asimetrična v desno. Izhajajoč iz te in prve slike sta agregati in kostni fragmenti, statistično gledano, dve različni množici. Tudi sicer sta to dve različni stvari. Vendar samo navidezno. Dejansko so agregati in kostni fragmenti vzročno (kavzalno) povezani, tako da so agregati posredno ali neposredno posledica kostnih fragmentov, kar bo razvidno v nadaljevanju prispevka. Navidezna različnost je posledica neupoštevanja časovno-prostorske razsežnosti, ki je ključnega pomena pri vsaki arheološki raziskavi.

5. AGREGATI IN KOSTNI FRAGMENTI V ČASU IN PROSTORU

Agregate in kostne fragmente v času in prostoru sem analiziral korakoma:



Sl. 2: Porazdelitev agregatov in kostnih fragmentov iz stratigrafskega stolpca (a) in iz večjega bloka sedimentov (b).
Fig. 2: Distribution of aggregates and bone fragments from the stratigraphic sequence (a) and from a large block of sediments (b).

1.) v profilu oziroma stratigrafskem stolpcu,
2.) v bloku sedimentov na površini B in
3.) v bloku sedimentov na površini A.

Namen tega početja je bil dvojen:

1.) ugotoviti koliko vrhuncev v kopičenju agregatov in kostnih fragmentov se je zvrstilo v času, kateri vrhunec je največji, kateri najmanjši in tako naprej, če stvar močno poenostavim in

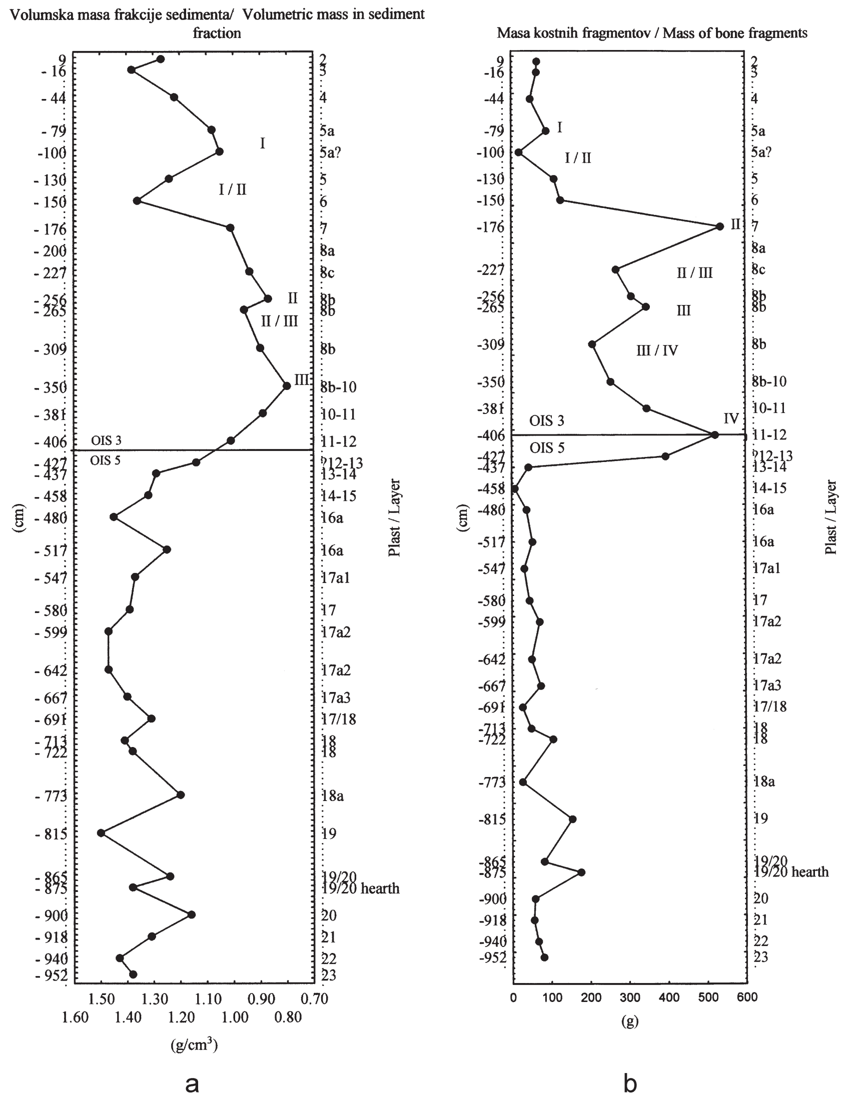
2.) ugotoviti, kako se posamezni vrhunci zvrstijo v času.

Prvi korak je bila analiza profila, natančneje povedano, analiza sestavljenega ali kompozitnega profila, ki sem ga dobil tako, da sem združil profile iz različnih predelov jame v en sam profil (*sl. 3:* a,b). To je rutinska, induktivna raziskovalna metoda. Ker v profilu ni mogoče ločiti časovne (vertikalne) komponente od prostorske (bočne) komponente, je ugotavljanje vrhuncev samo na podlagi podatkov direktno iz profila dvomljivo, kar je pomanjkljivost rutinske metode.

V profilu lahko vsak podatek neposredno povežem s plastjo, kar je prednost rutinske metode. Globine v sestavljenem profilu so srednje vrednosti, usklajene z vpadom plasti. Upoštevani so neenaki odmiki pri jemanju vzorcev. Ti odmiki so označeni s pikami, ki predstavljajo enake stratigrafske presledke, debele 7 cm. Posebej je označena časovna meja med kisikovo izotopno stopnjo (OIS) 5 in 4, ki jo obeležuje sedimentacijska vrzel, ki obsega celotno OIS 4 (Yu et al. 2001). Ta časovna meja trenutno predstavlja edini zanesljivi, visoko ločljivi časovni horizont v najdišču (Turk et al. 2001) (*sl. 3:* a,b).

Ker so bili doslej odkopani in ustrezno analizirani samo sedimenti, ki pripadajo OIS 3, ne bom obravnaval celotnega sestavljenega profila, ampak samo njegov zgornji del do vključno plasti 13.

Pri agregatih so v sestavljenem profilu vidni trije vrhunci, ki naraščajo z globino. Označeni so z rimskimi številkami I-III. Deli profila med vrhunci so označeni kot I / II in II / III (*sl. 3:* a).



Sl. 3: Agregati (a) in kostni fragmenti (b) v stratigrafskem stolpcu sestavljenega profila.
Fig. 3: Distribution of aggregates (a) and bone fragments (b) in the stratigraphic sequence of the composite profile.

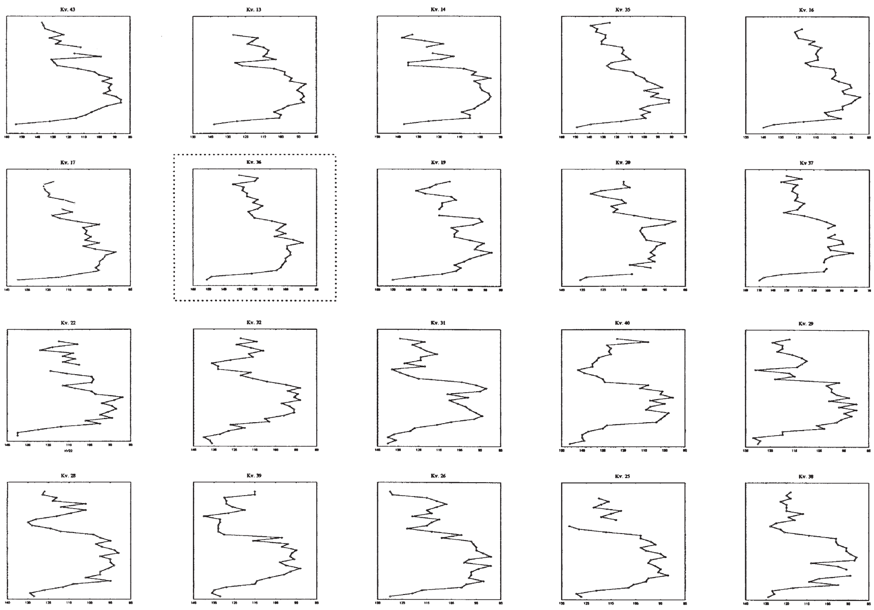
Pri kostnih fragmentih so v profilu vidni štirje vrhunci (I-IV), ki ne naraščajo z globino (*sl. 3:* b).

Pozornost pritegne precejšnja podobnost med krivuljo agregatov in krivuljo kostnih fragmentov v profilu. Podobnost lahko izrazim s korelacijskim koeficientom R (R = -0,653, p < 0,05, N = 36). Korelacija je statistično značilna. K temu se bom še vrnil.

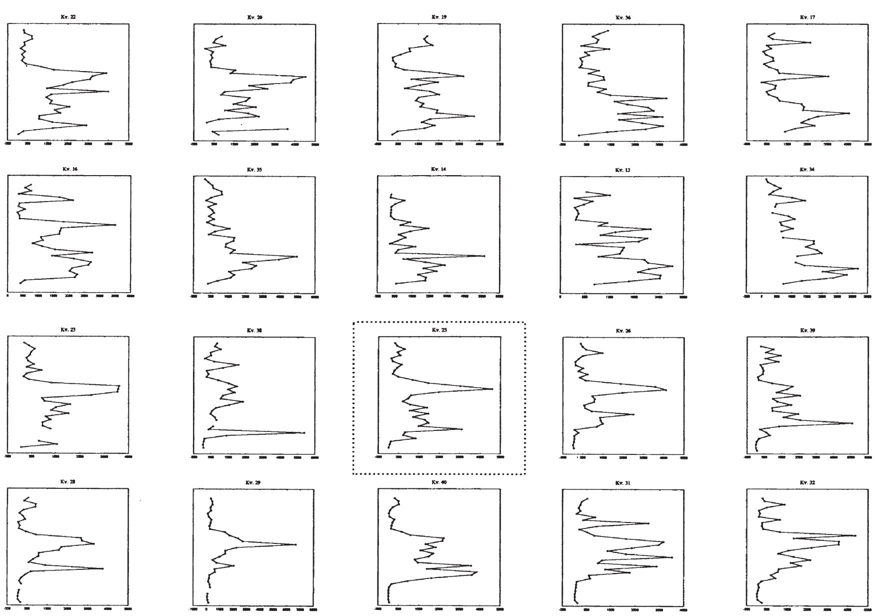
Če zberem profile (= stratigrafske stolpce) na površini B, tako da globine predstavljajo sedimentacijske nivoje, se pokaže variabilnost podatkov, povezana predvsem s časom in prostorom, pa tudi z metodo horizontalnih režnjev (*sl. 4:* a,b). Na variabilnost začetnega in končnega dela profilov vpliva predvsem vpad plasti in uporabljena terenska metoda. Že bežen pogled odkrije, da so podatki za kostne fragmente (*sl. 4:* b) bistveno bolj variabilni kot podatki za agregate (*sl. 4:* a). Iz tega sledi vprašanje, kateri profil je pravi in kakšne so povezave med sedimentacijskimi nivoji in plastmi. Na tej točki se je zapletla že marsikatera arheološka razprava. Ponujene rešitve so bile običajno zelo subjektivne. Rešitev, ki jo predlagam, je tipični profil ter njegovo nasprotje. Vsi drugi profili so nekje vmes med obema skrajnima profiloma. Na rutinske povezave podatkov s plastmi je zaenkrat bolje pozabiti, sicer se lahko zgodi, da vnesem pri razvrščanju podatkov po plasteh med podatke več zmede kot reda.

Tipični profil za agregate ima štiri vrhunce (I-IV), ki še vedno naraščajo z globino (*sl. 5:* a). Podobnost s sestavljenim profilom je precejšnja.

Tipični profil za kostne fragmente ima samo dva vrhunca (I-II), ki sta drugače razporejena kot v



a



b

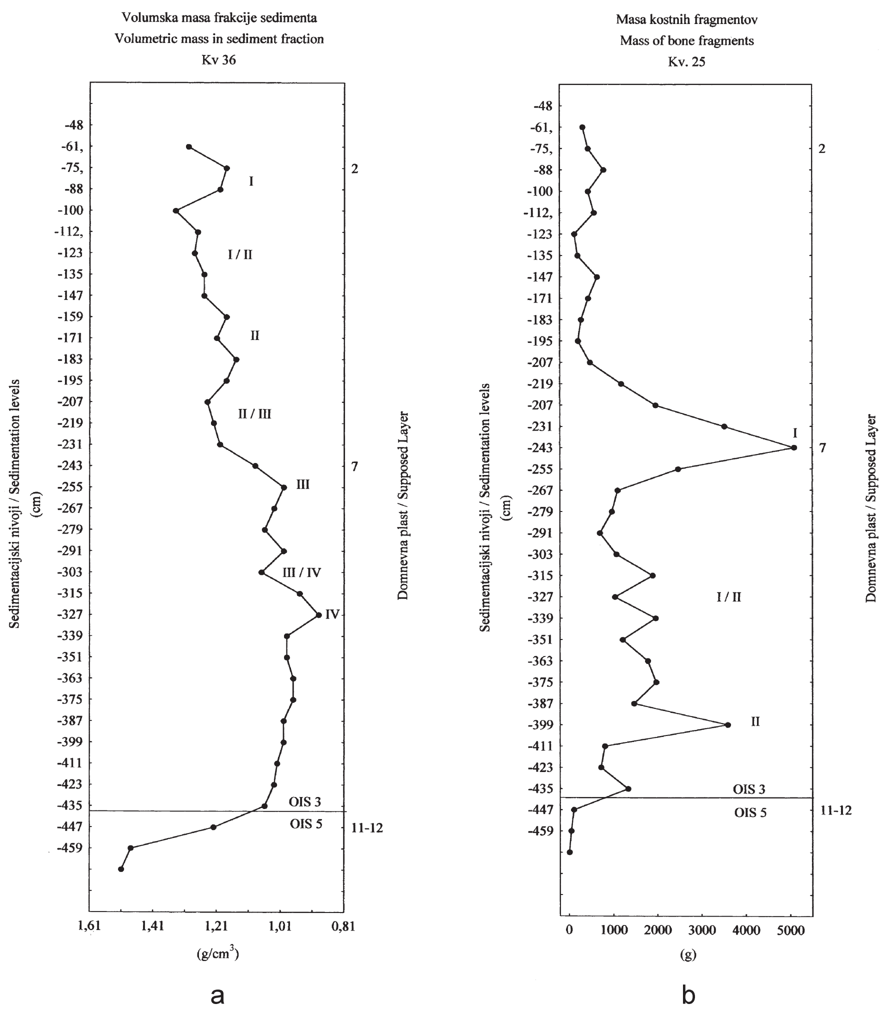
Sl. 4: Agregati (a) in kostni fragmenti (b) v različnih stratigrafskih stolpcih na površini B.
Fig. 4: Distribution of aggregates (a) and bone fragments (b) in various stratigraphic sequences in area B.

sestavljenem profilu (*sl. 5:* b). Podobnost s sestavljenim profilom je precejšnja.

Manj vznemirljiva je podobnost med tipično krivuljo agregatov in tipično krivuljo kostnih fragmentov. Statistično značilna korelacija, pri kateri sem upošteval vpad plasti, ima naslednje parametre: $R = -0{,}532$, $p < 0{,}05$, $N = 34$.

Do tega trenutka me ni zanimalo, kako zanesljivi so posamezni podatki, čeprav sem iz večje variabilnosti kostnih fragmentov lahko sklepal na njihovo manjšo zanesljivost v primerjavi z agregati. Zanesljivost podatkov sem ocenil s pomočjo različnih profilov na površini B, upoštevajoč vpad plasti. Tako sem prišel do najobjektivnejše slike agregatov in kostnih fragmentov (*sl. 6:* a,b).

Podatke, zbrane na površini B, lahko pogojno



Sl. 5: Tipični profil agregatov (a) in kostnih fragmentov (b) na površini B.
Fig. 5: Distribution of aggregates (a) and bone fragments (b) within typical profiles in area B.

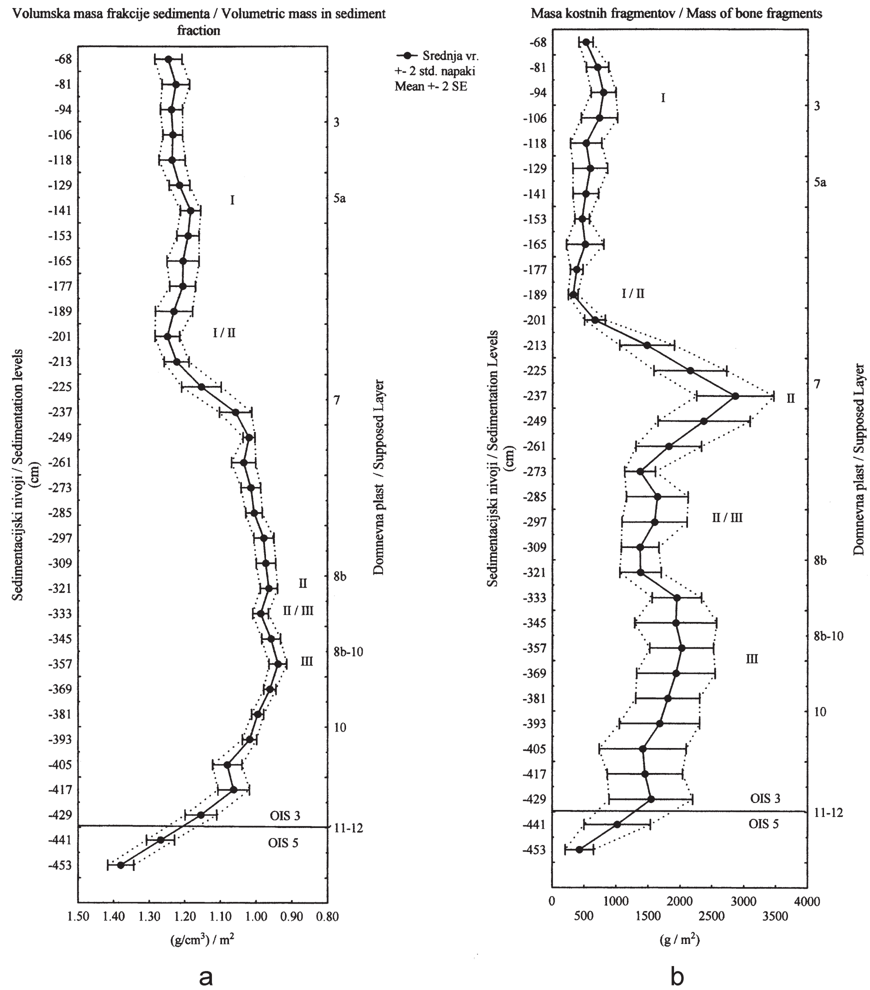
posredno povežem s plastmi na podlagi podobnosti/različnosti porazdelitev podatkov v profilu in v bloku sedimentov na površini B. Pri tem se zavedam, da lahko posamezni podatki kljub vsemu pripadajo različnim časovnim horizontom. Sedimentacijski nivoji na površini B in stratigrafski presledki v sestavljenem profilu predstavljajo namreč časovne horizonte z največjo možno ločljivostjo 1400 let za površino B in 600 let za sestavljeni profil. Časovno ločljivost sem izračunal na podlagi radiometričnih datacij sestavljenega profila (glej Turk et al 2001, tab. 1) in števila sedimentacijskih nivojev (N = 33) in stratigrafskih presledkov (N = 170). Globine na površini B so srednje vrednosti sedimentacijskih nivojev, sestavljenih iz treh prvotnih režnjev. Podatki so prikazani s 95 % intervalom zaupanja (2 standardni napaki, SE). Podana je časovna meja med OIS 5 in OIS 4. Njena umestitev je zaneslivejša kot so povezave z večino plasti, ki temeljijo izključno na subjektivni presoji (*sl. 6:* a,b).

Pri kostnih fragmentih (*sl. 6:* b) je standardna napaka bistveno večja kot pri agregatih (*sl. 6:* a). To pomeni, da so podatki za kostne fragmente statistično manj zanesljivi kot podatki za agregate. Vsi podatki, ki padejo v isti interval zaupanja, so statistično enaki. Velikost intervala je odvisna od velikosti napake. Tako lahko določim vrhunce v krivulji agregatov in kostnih fragmentov (s) 95 % zanesljivo(stjo).

Pri agregatih so zanesljivi samo trije vrhunci (I-III), ki jih lahko domnevno povežem s plastmi 5a, 8b in 8b-10 (*sl. 6:* a).

Pri kosteh so zanesljivi trije vrhunci (I-III), ki jih lahko domnevno povežem s plastmi 3, 7 in 10 (*sl. 6:* b). Največji je II. vrhunec. Vse to ni razvidno niti v sestavljenem profilu niti v tipičnem profilu.

Kostni fragmenti so metodološko dober nadomestek za arheološke najdbe. Pri tem mislim na stratigrafijo



Sl. 6: Agregati (a) in kostni fragmenti (b) na površini B, prikazani kot srednja vrednost sedimentacijskega nivoja na celotni površini B in 2 standardni napaki (95 % interval zaupanja srednje vrednosti).
Fig. 6: Distribution of aggregates (a) and bone fragments (b) in area B, shown as a mean value of the sedimentation level on the whole of area B and ±2 standard errors (95% interval of confidence of the mean).

in tlorisno razprostranjenost ("planigrafijo"). Zato lahko nekatere ugotovitve, ki zadevajo kostne fragmente in sploh fosilne ostanke, posplošim.

Na prvem mestu moram poudariti veliko variabilnost, povezano s časom in prostorom. Ta je bistveno večja kot pri sedimentoloških podatkih, ker gre za živo snov, ki ima to lastnost, da se tudi sama giblje.

Na drugem mestu moram omeniti frakcije oziroma sestavine celotnega gradiva, ki se morajo ravnati po celoti, kateri pripadajo. Na primer, če uporabim kateri koli skeletni del jamskega medveda, dobim podobno porazdelitev v profilu, kot pri kostnih fragmentih. Vendar je pri tem treba upoštevati pojavnost (frekvenco) posameznih elementov v prostoru in njihovo velikost. Manjša je pojavnost, večji prostor potrebujemo za zanesljiv rezultat. Vendar je prostor relativen, ker je odvisen od velikosti elementov, ki prostor zasedajo.

Cele kosti predstavljajo zelo majhno frakcijo celote (manj kot 7 %), vendar dajo na površini B zanesljivo sliko, ki je dobro primerljiva s sliko kostnih fragmentov. Na majhni površini bi bila informacija na podlagi celih kosti, glede na njihovo velikost, skrajno nezanesljiva.

Kostni drobci, manjši od 3 mm, močno prevladujejo med kostnimi fragmenti. Zaradi svoje majhnosti dajo zanesljivo sliko že na majhni površini. Da bi dobil primerljiv rezultat kot za kostne fragmente na površini B (=21 m^2), bi zadostovala analiza kostnih drobcev na površini, veliki 1 m^2. S tem pa sem že posegel v področje ekonomske upravičenosti obsežnih izkopavanj, kakršna so bila izkopavanja v Divjih babah I.

Analiza frakcij (frakcioniranje vzorca) je eden od elementov znanstvene metode. Frakcije morajo namreč po pričakovanju dati podoben rezultat kot vzorec, če se pogoji, v katerih poteka analiza, ne spreminjajo.

Porazdelitvi agregatov in kostnih fragmentov na površini B sta si bolj podobni kot porazdelitvi v sestavljenem in tipičnem profilu. Pomembno je, da se pri obeh porazdelitvah do sedimentacijskega nivoja natančno ujemajo prehodi iz enega v drugo stanje oziroma plast. Zato si upam trditi, da so fosilni ostanki *sensu lato* vzrok, agregati pa njihova posledica. Kavzalno zvezo lahko izrazim tudi matematično s statistično značilnim korelacijskim koeficientom: R = -0,757, p < 0,05, N = 33. V podrobno razlago tega odnosa in z njim povezanega procesa se na tem mestu ne bom spuščal, ker sem ga delno že obdelal drugje (Turk et al. 2002). Pomembnejša od tega se mi zdi analiza tega odnosa na referenčni površini A, ki mi nudi še eno možnost za to, da preverim pravilnost celotnega postopka in se izognem temeljni napaki, zaradi katere bi bil celoten postopek zgrešen.

Če površina B predstavlja koridor, po katerem se je prišlo v jamo, predstavlja površina A bivalni prostor ob koridorju. Na površini A je v 20 sedimentacijskih nivojih zajetih 469 podatkov od 500 možnih, na površini B pa je v 33 sedimentacijskih nivojih zajetih 671 podatkov od 693 možnih. Posamični podatki manjkajo zaradi objektivnih vzrokov: npr. zaradi blokov v sedimentih in drugih motenj. Globine združenih površin so srednje vrednosti globin sedimentacijskih nivojev z obeh površin, ki se jim ena globina podvoji.

V skladu z definicijo plasti mora obstajati podobnost med površino A in B. Manjša odstopanja, zajeta v standardni napaki, so lahko posledica prostorske variabilnosti in metodoloških pomanjkljivosti. Če ni podobnosti, sem naredil temeljno napako.

Primerjava med površinama je 95 % zanesljiva. Posamezne *ad hoc* določene plasti izgubijo pomen, ker po kriteriju agregatov in kostnih fragmentov ne izpolnjujejo pogojev, opredeljenih z definicijo plasti. Zato sem jih zamenjal z novimi temeljnimi stratigrafskimi enotami, ki te pogoje izpolnjujejo. To so nove plasti A-C (*sl. 7:* a,b). Nove plasti, so tako kot stare, sestavljene iz stratigrafskih nivojev. Prehod iz ene plasti v drugo plast je natančno opredeljen, saj se po pričakovanju zgodi v okviru enega sedimentacijskega nivoja na celotni površini A ali B. Na površina A in B je odmik prehoda iz plasti B v plast A pri agregatih reda velikosti enega sedimentacijskega nivoja. Tolikšen je tudi največji možni odmik med porazdelitvama agregatov na obeh površinah. V idealnih pogojih, ki bi jih dosegel z izključitvijo vseh napak, narejenih na terenu, odmika ne bi smelo biti.

Prehod iz plasti C v plast B sovpada z radiometrično določeno časovno mejo med OIS 5 in OIS 4 (ca. 74.000 BP). Če mi uspe klimatološko razložiti plast B (za prvi poskus glej Turk et al. 2001 in 2002), dobim prvovrsten kronostratigrafski označevalec (marker) za vsa najdišča, ki so vsebinsko podobna Divjim babam I. Takšnih najdišč je v Sloveniji in okolici kar nekaj. Vendar je to že druga tematika, ki se je bo lahko nekdo uspešno lotil samo na podlagi temeljite priprave. Rutinsko zbrani podatki za druga najdišča s katerimi danes razpolagam, za kaj takega ne zadostujejo, ker niso dokumentirani in interpretirani na način, kot so dokumentirani in interpretirani podatki v Divjih babah I.

Za ilustracijo navajam podatke za volumenske teže (agregate) na prehodu iz ene plasti v drugo plast za površino A in B. Iz navedbe režnjev (globine od-do) je razvidno tudi, kako sem upošteval vpad plasti.

Površina A:

Sedimentacijski nivo (krovni) -231 cm, plast A

1,01	1,26	1,09	1,03	1,08	
1,26	1,08	1,14	1,25	1,14	gl. -237 cm do -249 cm
1,12	1,20	1,39	1,20	1,23	
1,08	1,13	1,10	1,25	1,15	
0,91	1,09	1,14	1,10	1,00	gl. -249 cm do -261 cm

Sedimentacijski nivo (prehodni) -243 cm, plast A/B

-	-	-	1,01	1,06	
1,06	1,03	1,20	1,12	1,03	gl. -249 cm do -261 cm
1,13	1,05	1,08	1,10	1,15	
1,05	1,02	1,08	1,00	1,00	
1,04	1,04	1,04	1,04	0,97	gl. -261 cm do -273 cm

Površina B:

Sedimentacijski nivo (krovni) -219 cm, plast A

1,30	1,25	1,16	gl. -201 cm do -213 cm
1,33	1,19	1,23	
1,14	1,03	1,01	
1,08	1,04	1,00	gl. -213 cm do -225 cm
1,20	0,94	1,20	
1,24	1,05	1,11	
1,27	1,27	1,35	gl. -225 cm do -237 cm

Sedimentacijski nivo (prehodni) -231 cm, plast A/B

1,29	1,04	1,09	gl. -213 cm do -225 cm
1,30	1,03	0,97	
1,01	1,03	1,09	
1,01	1,03	0,97	gl. -213 cm do -225 cm
1,09	0,92	0,90	
1,08	1,04	1,00	
1,14	1,09	1,08	gl. -237 cm do -249 cm

Površina B

Sedimentacijski nivo (krovni) -429 cm, plast B

1,37	1,28	1,29	gl. -405 cm do -417 cm
1,15	1,13	1,20	
1,22	1,08	1,09	
1,03	1,19	-	gl. -417 cm do -429 cm
1,06	1,09	-	
1,17	1,22	1,10	
1,15	1,06	1,05	gl. -429 cm do -441 cm

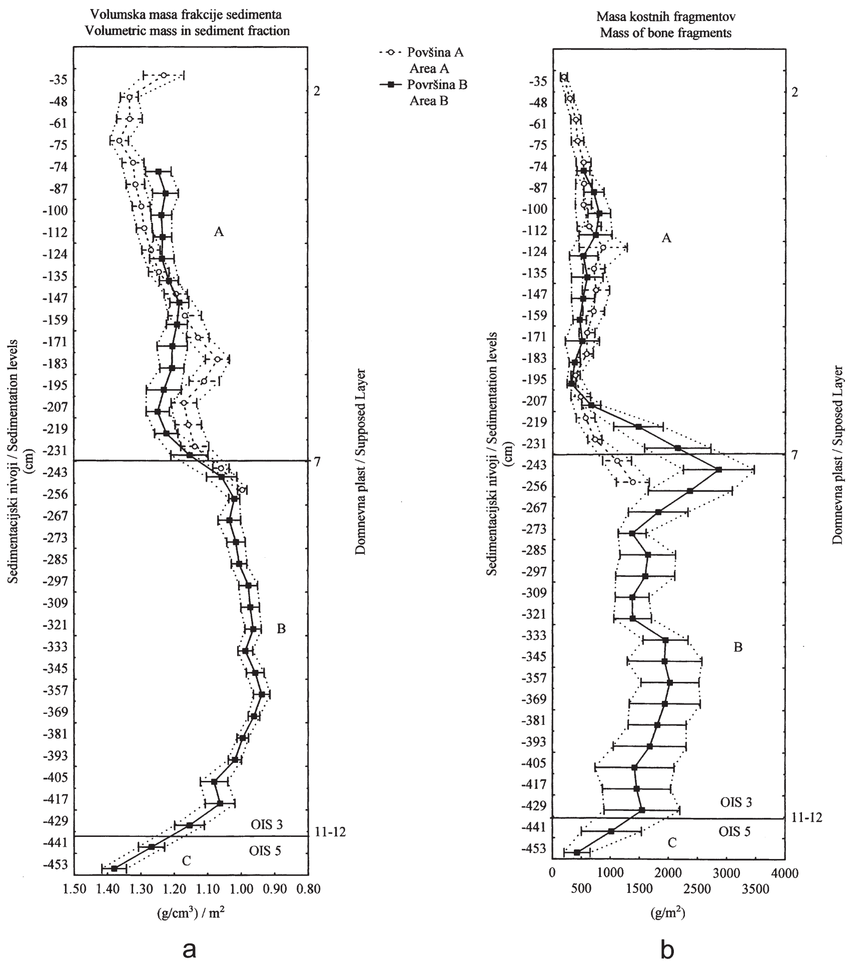
Sedimentacijski nivo (prehodni) -441 cm, plast B/C, časovni horizont 74.000 BP

1,40	1,37	1,32	gl. -417 cm do -429 cm
1,29	1,18	1,20	
1,32	1,21	1,17	
1,34	1,30	1,18	gl. -429 cm do -441 cm
1,22	1,18	1,11	
1,39	1,39	1,19	
1,32	1,30	1,25	gl. -441 cm do -453 cm

Tako agregati kot kostni fragmenti pripadajo istemu litotostratigrafskemu oziroma biostratigrafskemu ciklusu, sestavljenemu iz treh plasti. Plasti A, ki vsebuje malo agregatov in kosti, sledi plast B, ki vsebuje veliko agregatov in kosti, tej pa plast C, ki vsebuje malo agregatov in kosti, in tako naprej na podlagi podobnosti med sedimentološkimi in paleontološkimi podatki v bližini največje dosežene globine 1150 cm in v plasti B (*sl. 7:* a,b).

Agregati na površini A in B se delno ujemajo (R = 0,719 , p <0,05, N = 16). Enake vrednosti v smislu intervala zaupanja 95 % ima šest sedimentacijskih nivojev od šestnajstih. Porazdelitev v vertikali je različna, vendar je porazdelitev na površini A, tako kot porazdelitev na površini B, sestavljena iz vrednosti plasti A in B. Vrednosti plasti A so na površini A najprej manjše, nato pa večje kot na površini B. V plasti B se vrednosti na obeh površinah izenačijo (*sl. 7:* a).

Kostni fragmenti na površini A in B se tudi delno ujemajo (R = 0,724, p < 0,05, N = 16). Porazdelitev v vertikali je bolj podobna kot pri agregatih. Enake vrednosti v smislu intervala zaupanja 95 % ima pet sedimentacijskih nivojev od šestnajstih. Porazdelitev kostnih fragmentov na površini A je tako kot porazdelitev na površini B sestavljena iz vrednosti plasti A in B. Vrednosti plasti A so na površini A na splošno nekoliko večje kot na površini B, vrednosti plasti B pa manjše (*sl. 7:* b).



Sl. 7: Agregati (a) in kostni fragmenti (b) na površini A in B, prikazani kot srednja vrednost sedimentacijskega nivoja na celotni površini A in B in 2 standardni napaki (95 % interval zaupanja srednje vrednosti).

Fig. 7: Distribution of aggregates (a) and bone fragments (b) in areas A and B, shown as a mean value of the sedimentation level on the whole of area A and B and ±2 standard errors (95% interval of confidence of the mean).

Na podlagi korelacijskih koeficientov lahko pojasnim 52-55 % odnosa med površino A in B, ki izhaja iz podobnosti med plastmi na obeh površinah, kar zadeva agregate in kostne fragmente. Preostalih 48-45 % nepojasnjenih variacij lahko pripišem vplivu prostora, ki je domnevno veliko prispeval k variabilnosti agregatov in kostnih fragmentov na površini A in B. V mislih imam različne procese, ki so potekali istočasno (izohrono) na obeh površinah. Del nepojasnjenih variacij je nastal tudi zaradi slabe usklajenosti časovnih horizontov, ki je posledica majhne časovne ločljivosti (1400 let). Vse procese, ki niso potekali istočasno na obeh površinah, namreč ni mogoče časovno ločiti. Del nepojasnjenih variacij lahko ne nazadnje pripišem valovitosti sedimentov in terenski metodi.

Splošno vzeto se podatki z obeh površin skladajo. Vendar obstajajo razlike, ki so lahko povezane s prostorom kot stalnico: na eni strani z vstopnim koridorjem v jamo, ki je bil bolj izpostavljen zunanjim vplivom (površina B), na drugi strani z bivalnim prostorom, ki je bil bolj zaščiten pred zunanjimi vplivi (površina A). Primerjavo med površina A in B lahko zapletejo tudi gube v povezavi s terensko metodo vodoravnih režnjev. Vendar so največja odstopanja med obema površinama v predelu profila, kjer ni več gub. Dokaj neobičajno je tudi to, da je bil v enem od sedimentacijskih nivojev v predelu gub pri agregatih ugotovljen izrazit gradient (Turk et al. 2002). Agregati samo v tem nivoju precej enakomerno naraščajo v smeri v jamo na površini, veliki 32 m^2. Gradient volumenske mase je takšen:

1,20	1,08	0,97	1,23		1,12
1,27	1,19	1,11	1,15		1,18
1,30	1,22	1,12	1,25		1,22
1,33	1,27	1,30	1,25		1,29
1,33	1,36	1,34	1,18		1,30
1,35	1,48	1,32	1,34		1,37
1,33	1,35	1,34	1,36		1,35
1,38	1,44	1,38	1,34		1,39

Zadnji stolpec predstavlja srednje vrednosti posameznega prečnega niza kvadratov.

Ali gube v povezavi s terensko metodo vplivajo na vsebnost agregatov in porazdelitev kostnih fragmentov, sem raziskal z varianto klasterske metode, imenovano *Two-Way Joining*. Ta metoda istočasno razporedi podatke po kvadratih (vrsticah) in sedimentacijskih nivojih (stolpcih) glede na medsebojno podobnost. Pričakoval sem, da bodo kvadrati in sedimentacijski nivoji dvostransko prispevali k odkritju smiselnega vzorca klastrov, če ločeno analiziram dve skupini sedimentacijskih nivojev in kvadratov: tiste z valovitimi sedimenti in tiste z vodoravnimi sedimenti. Predpostavljal sem, da so bili agregati in kostni fragmenti enako premešani zaradi valovitosti sedimentov in odstranjevanja sedimentov po vodoravnih režnjih. Po tej predpostavki si bi morala biti klasterska vzorca vsebnosti agregatov in porazdelitve kostnih fragmentov v nečem podobna.

Vzorca valovitih in vodoravnih sedimentov (plasti) sta različna, kar zadeva klastre kvadratov in sedimentacijskih nivojev, vendar sta vzorca podobna pri agregatih in kostnih fragmentih (*sl. 8:* a,b).

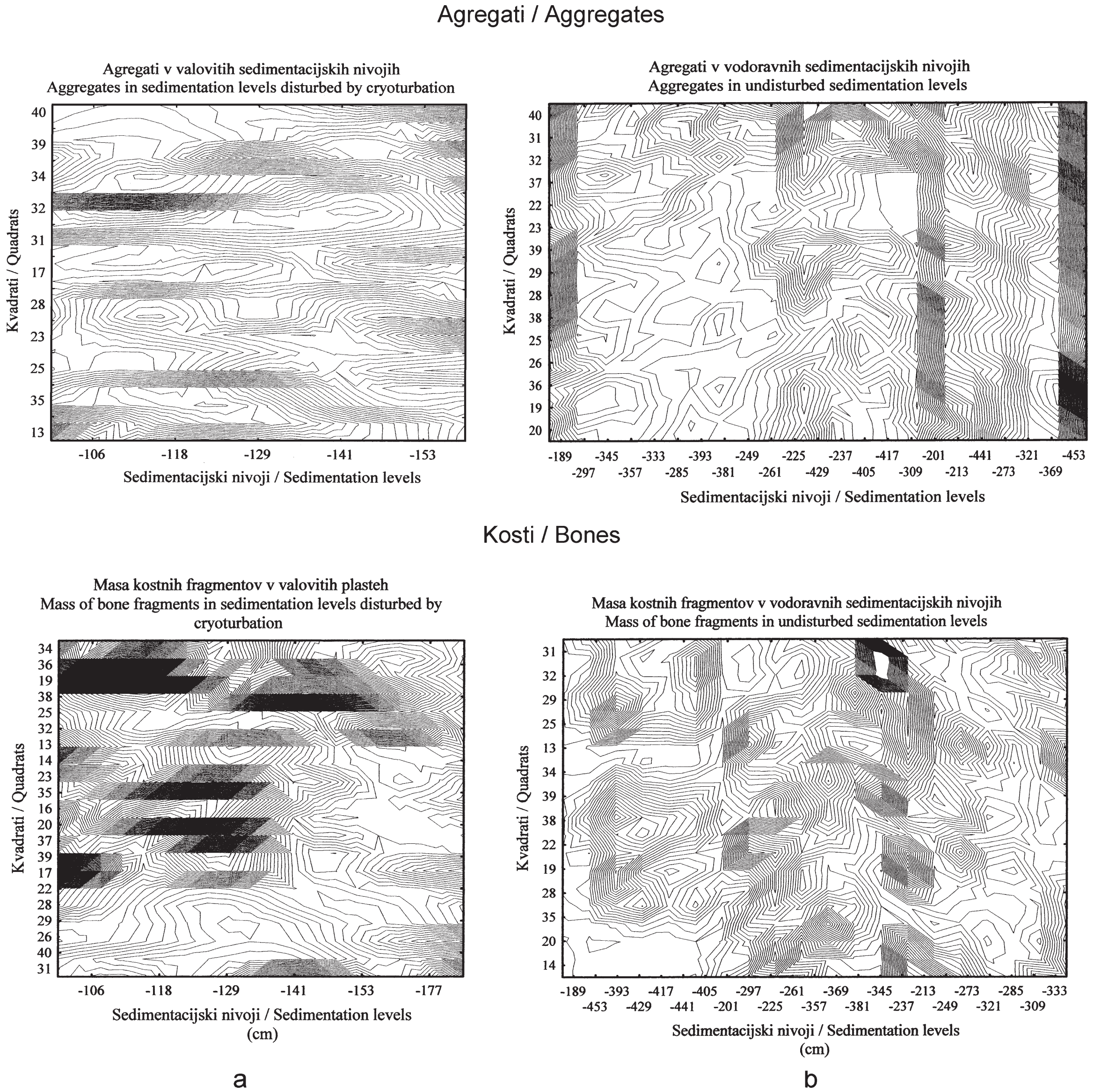
Pri vodoravnih sedimentih se vzorec vrednosti agregatov in kostnih fragmentov ponavlja ali vztraja v istih sedimentacijskih nivojih. Posamezni kvadrati ali skupine kvadratov v okviru istega sedimentacijskega nivoja imajo podobne vrednosti. Težnja po ponavljanju vzorca v horizontalni smeri je bolj izrazita kot težnja po ponavljanju vzorca v vertikalni smeri, gledano v celoti.

Pri valovitih sedimentih se vzorec vrednosti agregatov in kostnih fragmentov ponavlja ali vztraja v različnih sedimentacijskih nivojih. Posamezni sedimentacijski nivoji ali skupine sedimentacijskih nivojev imajo podobne vrednosti v okviru istega kvadrata. Težnja po ponavljanju vzorca v vertikalni smeri je bolj izrazita kot težnja po ponavljanju vzorca v horizontalni smeri, gledano v celoti.

Valovitost dela sedimentov in metoda vodoravnih režnjev sta verjetno prispevali k navideznemu poenotenju analiziranih podatkov v navpični smeri. Rezultat metode *Two-way Joining* je potrdil sum, da sedimenti valovitih plasti dejansko niso več v svoji prvotni legi. Da so nekatere plasti valovite, je videti v vseh dokumentiranih profilih. Vendar bi bila lahko valovitost samo navidezna. Da je valovitost še kako resnična, je potrdila tudi analiza naklonskega kota kosti v navidezno valovitih in navidezno vodoravnih sedimentih (Turk 1997).

6. **SKLEPI**

Do leta 1986 sem v Divjih babah I izkopaval na način, ki bi ga še najbolje označil s čelnim kopanjem blokov sedimenta. To je tako kot običajno potekajo izkopi v gradbeništvu in rudarstvu. Pri tem sem dokumentiral predvsem nize prečnih profilov, ki so predstavljali čelo izkopa. Vse najdbe sem sproti umeščal v *ad hoc* določene plasti, ki sem jim sledil od profila do profila. Razdalje med profili so znašale od enega do več metrov (Osole 1990, 10 s). Pravilno določitev plasti je kasneje potrdil M. Brodar (1999). Zato zapletena stratigrafija navidezno ni bila sporna. Tako določene plasti in najdbe, ki naj bi jim pripadale, je bilo sicer mogoče



Sl. 8: Vzorec agregatov in kostnih fragmentov v valovitih (a) in vodoravnih sedimentih (b) na površini B, kot se izriše z uporabo klasterske metode *Two-way joining*.
Fig. 8: Pattern of aggregates and bone fragments in undulating (a) and horizontal sediments (b) in area B, as outlined by the use of the *Two-way joining* cluster method.

združevati ali deliti na posamezne dele, vendar nobena takšna operacija ni razkrila cikličnega vzorca v sedimentaciji in diagenezi in poenostavljene stratigrafije (Turk et al. 1989; Brodar 1999), kot je prikazana v tem prispevku (*sl. 7:* a,b). To dejstvo je dokaz, da je bila metoda do leta 1986 v bistvu zgrešena v tistem delu, ki se je nanašal na podatke zbrane po plasteh med profili. Plasti so namreč dobro izhodišče za analizo profilov in slabo izhodišče za analizo večjih blokov sedimentov. Za te so primernejše izhodišče sedimentacijski nivoji.

Izkopavanja pred letom 1989 so imela še eno veliko pomanjkljivost. Kontrola napake in zanesljivosti podatkov, zbranih do leta 1989, ni bila mogoča, časovna ločljivost večine dogodkov pa je bila zaradi režnjev, debelih 20-30 cm, majhna.

Po letu 1989 sem se trudil odpraviti nekatere pomanjkljivosti, kar mi je tudi delno uspelo.

Časovno ločljivost sem povečal, tako da sem režnje stanjšal z 20-30 cm na 12 cm. Zmanjšal sem tudi terensko napako, s tem da sem vse sedimente mokro presejal. Kontroliral sem terensko-laboratorijsko napako in zanesljivost podatkov. Slednje sem dosegel tako, da sem analiziral stratigrafske stolpce v prostoru. Izkazalo se je, da so najzaneslivejši izsledki, ki se nanašajo na večji prostor (blok sedimentov) v okviru najdišča, če so ustrezno analizirani. Vprašanje, ki ostaja nerešeno, je, koliko je ta sorazmerno majhen prostor reprezentativen za sorazmerno veliko celotno najdišče.

Subjektivno določevanje plasti na terenu sem dopolnil z določitvijo plasti po končanih izkopavanjih z analitskimi postopki. Tako sem se objektivno bolj približal definiciji plasti.

Plasti v Divjih babah I se med seboj razlikujejo predvsem na podlagi dveh značilnosti:

1.) diagenetskih sprememb in

2.) vsebnosti fosilnih ostankov.

Pri tem je pomembno, da sta obe značilnosti tudi vzročno povezani, zaradi česar lahko litostratigrafske enote neposredno enačim z biostratigrafskimi enotami.

Dosedanja izkopavanja paleolitskih najdišč v Sloveniji niso izkoristila prednosti arheološke terenske metode pred geološko metodo. Po vzoru geologije so bili vsi podatki v bistvu stisnjeni v stratigrafski stolpec. Zato ni bilo mogoče uspešno preveriti izohronosti oziroma diahronosti najdb in procesov drugače kot z neodvisnimi metodami datiranja. S temi metodami pa so tudi težave (glej Turk et al. v tem letniku *Arh. vest*.).

Moj pristop odpira možnosti za reševanje ključnega vprašanja paleolitske arheologije, ki je: ali so podobne najdbe in procesi izohroni ali diahroni. To vprašanje je treba najprej reševati v okviru vsakega posameznega najdišča in šele nato med najdišči na regionalni ravni. Šele ko bo to rešeno, se bomo enkrat za vselej nehali vrteti v začaranem krogu enačb: lito-, bio- in arheostratigrafija je enako kronostratigrafija in kronostratigrafija je enako geokronometrija. Veliko bo treba postoriti tudi na področju vse bolj pomembne geokronometrije (glej članek Turk et al. v tem letniku *Arh. vest.*). Najbolj zanesljive rezultate pa tako ali tako da samo kombinacija vseh možnih oblik stratigrafije.

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How to make better use of archaeological methods of excavation in post-excavation analysis and interpretation of the results
Experiences of excavations at Divje babe I, Slovenia

Translation

1. INTRODUCTION

I do not intend in this contribution to go outside the framework of Slovene Palaeolithic questions. My main purpose is to explain some (non)standard procedures connected with the analysis of material of the second phase of excavations at Divje babe I, from 1989-1999. Since a number of different results have already been published (Turk et al., 2001; 2002) there is some concern that these results will be understood as the product of "hocus pocus" methods, especially since the new results are not entirely in agreement with the old ones. Not least, it is my intention to contribute to the development of Palaeolithic archaeology in Slovenia.

I recognised in my work that although I may know a great deal about things, I do not know how to explain them and the processes connected with them, since I lack the appropriate knowledge. Science is that which knows how to explain how things work in the sense of models of cause and effect. Scientific method must be developed for this, which enables concurrent control of the quality and reliability of the results, and which as far as possible uses experiment in the wider sense of the word, which means that it also tests various methods even if it does not develop them at all. I would like to demonstrate some of this in specific cases.

2. PREMISES, CONCEPTS AND DEFINITIONS

Control of quality (accuracy of collecting and processing data) and the **reliability** of results with the aid of error assessment is an essential element of any scientific method.

Accuracy of collection and processing of data depends primarily on the method, the time invested and the character of those who implement the method.

The interpretation of the results is mainly a function of the research method and the knowledge of the individual.

The reliability of the data and the reliability of the conclusions that are based on the reliability of the data is not always dependent on the accuracy with which the data have been collected and processed. A large amount of less exact data can sometimes be more reliable than a limited amount of very exact data.

Then there is also a matter of **credibility**, which is a matter of scientific ethics. Data can be treated in one way or another, depending on the aim that is being followed. If it is all the same and only the treatment is different, I can achieve various aims. The question of the credibility of the scientific achievement rests on this point of the operation.

The basis of science is mathematics. Mathematics should also be introduced into Slovene archaeology, at least through the statistical method (see Brodar 1962-1963) in order to be able to start thinking about scientific methods in archaeology. Mathematics and physics have already been indirectly present here for a long time, mainly in Palaeolithic archaeology, in the form of radiometric methods of dating (Osole 1974, 1983 and above all Nelson 1997; Lau et al. 1997, in which in an individual case two different methods of dating are explained, which gave different results). Unfortunately, that is more or less all, at least as far as Palaeolithic archaeology is concerned. I would therefore like to show, despite my deficient knowledge of mathematics, what are the actual possibilities for the use of mathematical methods that are offered to "pure" archaeology, without so-called auxiliary professions, in the case of two apparently unconnected matters:

1.) structural aggregates, i.e. fragments of soil mass, of size 0.5-3 mm, composed of aggregated primary particles (Ćirić 1986, 96 ss) and

2.) fossil remains, i.e., bone fragments, larger than 3 mm, belonging almost exclusively to cave bear.

Neither has much in common with archaeology, except for being located at a Palaeolithic site, but the finds of bones in particular very well illustrate a typical archaeological situation and its dilemmas.

Before entering into the matter, I must also explain some questions related to chronology.

Familiarity with the time sequence of events is a basic condition for explaining things and how such things operate in the sense of cause and effect.

Things can change in relation to time and space, either isochronously ("occurring at the same time") or diachronically ("obliquely with time"). If a space is enlarged, the differences connected with things can also increase, independent of time. If, simultaneously, time increases (time resolution reduces), differences also increase between things in space, this time dependent on time and space. In archaeological practice, we only monitor apparent changes between things in time and space, to the point when we increase the time resolution to the maximum, i.e., we reduce the units of time, such as years, decades, centuries, millennia. There is no sense in talking in smaller time units in prehistoric archaeology.

Expressed simply, time in archaeology represents a vertical extension and space a horizontal or lateral extension of things. Not taking space, and spatial variability connected with it, into account can have serious consequences in archaeology and in related professions. Unfortunately, archaeologists are not always aware of this in their work and trust too much to deeply rooted presuppositions about the isochroneity of similar things and processes.

In an archaeological spatial unit which cannot be further divided (e.g., quadrant, sample taken from a profile) time and space are apparently unified, so differences connected with time cannot be distinguished from differences connected with space. Apparently, because everything depends on the divisibility of the spatial unit, while temporal resolution which otherwise affects the non-uniformity of the space, in such a case does not appear to affect the space. In larger spaces, time and space are also distinct with small temporal resolution, so differences connected with time are distinguished from differences connected with space. How this is done will be clear later in the case of aggregates and bone fragments.

The concept of time has a number of meanings in archaeology (Siiriäinen 1992). In the present case, only two meanings are important, which I have characterised as **time horizon** and **sedimentation level**. The time horizon represents events in a precisely defined physical time, which can be determined within a framework by various radiometric methods. All events that occur at the same physical time are contemporaneous. The sedimentation level, which is composed of horizontal dug units (spits) in such a way that it takes into account the angle of incidence (dip) of the layer, represents relative time. Everything that happened within a specified thickness of sediment belongs to a specific sedimentation level. Events captured in a sedimentation level are not necessarily contemporaneous in the sense of absolute physical time. So sedimentation levels and time horizons cannot simply be equated. Sedimentation levels should be as thin as possible since that increases the time resolution in the packet of sediments.

A number of sedimentation levels compose a layer (bed, stratum), which is the basic deposition unit. A layer is a homogenous totality, which was (theoretically) created under constant physical and chemical conditions in uniform processes and their uniform succession. A layer is separate from the underlying stratum and overlaying stratum on the basis of one (or more) basic characteristics of the sedimentary rock. Physical, chemical, biological (including anthropological), geological and diagenetic conditions affect the character of a layer. Bedding generally occurs in sediment when there is a change in the material deposited. Gaps between layers (hiatuses) which affect the completeness of the chronological record are created because of a break in sedimentation, erosion, chemical changes or changes in the conditions of sedimentation (deposition).

So geological layers found in the field are only temporary working aids of a chronological nature and do not have essentially greater weight than arbitrary dug units, stratigraphic units and similar stratigraphic aids until the real nature of each individual layer or group of layers has been established. This is only rarely possible in the field, where layers are *ad hoc* delineated and characterised.

Both layers and sedimentation levels normally belong to time horizons of varying length. This means that the sedimentation rate is not uniform, or that sedimentation is, or is not, dependent on various internal and external conditions at the site. The sedimentation rate is thus a very important variable, depending on sedimentation conditions.

3. MATERIAL AND METHODS

The majority of data for aggregates and bone fragments was collected during excavations by quadrats 1 x 1 m and horizontal spits 12 cm thick in an area that at the start of excavation was 83 m^2. The thickness of the spit was decided optimally in relation to the texture of the sediments in the spits, of which more than half of the spits in the quadrats contained from 51% to almost 100% of dolomite fragments larger than 10 cm, and other spits in quadrats from a few percentage to 50%. Since the size of the quadrats and the thickness of the spits did not change during excavation, the bone fragments are spatially weighted. Because of the different shares of dolomite fragments larger than 10 cm, the space actually available to bone fragments changed spatially from spit to spit in the quadrats. The weight of bone fragments is therefore in inverse proportion to the volume of dolomite fragments larger than 10 cm, which show negative, relatively high, statistically significant correlation coefficients. If bone fragments are weighted with the volume of dolomite fragments larger than 10 cm, the absolute values of bone fragments increase but the relative ratios between them are unchanged. I therefore conclude that the texture of the sediment does not essentially affect the time-spatial pattern of bone fragments in the sediment.

During excavations, the original area of 83 m^2 contracted because of unanticipated objective obstructions, so that at the end I analysed all data on the largest possible consecutive area in which practically no data for an individual spatial part of this area was lacking (in the given case this is a quadrat and a horizontal spit). For methodological reasons, I halved the usable area. In addition to area B (= 21 m^2), excavated from 10-50 cm below today's surface to a relative depth of -465 cm (layer $17a_1$), I chose a further reference area A (= 25 m^2), excavated from the surface itself to a relative depth of 285 cm (cemented layer 8a). Area A included 60 m^3, and area B 83 m^3 of sediment (*Fig. 1*).

I chose a minority of data in sampling five profiles, united into a stratigraphic sequence at the end of excavations (*Fig. 1*), namely on a total area only approximately 2.4 m^2 large, in such a way that the volume of the sampled sediment ranged 18 dm^3 to 25 dm^3. I later weighted the bone fragments in samples from the stratigraphic sequence to the same volume (18 dm^3).

I compared the layers that I had determined and sampled in the profiles on the basis of depth, with the spit or sedimentation level. All layers dip towards the cave entrance. Thus in one running meter they rise/fall by 0.04 m. In composing the sedimentation levels from the horizontal spits, I therefore made a step every 3 m. I had available 3 possibilities for making the step, which represent three combinations of transverse series of quadrats. I chose the combination with which I found by cross comparison the greatest similarity to the profiles between the longitudinal and transverse series of quadrats. The procedure is based on the fact that the layers only dip in the longitudinal series of quadrats while they are almost level in the transverse series. The layers are only completely horizontal *sensu lato* in each individual quadrat. Folded (undulating) layers are a specific problem. Sedimentation levels do not take folding into account.

During excavation, I determined the boundary of two neighbouring layers with a maximum accuracy of ± 12 cm. Even if it was undulating. Later analyses showed this. However, the majority of layers were determined with less accuracy, as was demonstrated by a redetermination of the same layers with a gap of a few years. The accuracy of the determination depended mainly on how sharp the boundary was. Layer 4, e.g., was properly recognised during excavation both in the entrance and in the central part of the cave because of the outstanding grey colour. The correct determination of the layer was later confirmed by conjoining flakes no. 292 and 459, which were found 9 m apart and with a gap of 8 years, both classified to Layer 4. The flakes, which were undoubtedly man made, thus belong to the same sedimentation level, which I equate with a part of the folded Layer 4. Because of the deformation due to folding, there was only 7 cm depth difference between the flakes, instead of the expected 36 cm, which the dip of the layer and the distance between the finds would dictate.

Despite the folds (involutions) in Layers 2-5a, I could sample each layer very accurately in profile if I restricted myself to the central part of the layer. I could later carefully examine the samples and verify the accuracy of the examination by re-examining those that I had already examined.

For a profile, or stratigraphic sequence, as has been said, an apparently uniform time and space is characteristic. Everywhere where a number of profiles are available, I can chose between typical profiles and their opposite.

A typical profile is the profile that least deviates from all the available profiles, which means that it is most similar to all other profiles. I can choose it with a delayed calculation procedure or by a quicker but less reliable visual procedure. The calculation procedure is based on the sum of mean values of the square of all deviations by sedimentation levels and profiles from each profile individually. The visual procedure is based on a graphic display of the profiles. It consists of two steps. In the first step, I choose the subsidiary typical profiles in all transverse series of profiles, so that the curve of the distribution of mean values of each transverse profile is visually compared with the distribution curves of actual values of each transverse profile and I assess the deviation. It is not necessary to take into account in this the dip of the layer since the layers are almost horizontal in the transverse direction. In the second step, I classify the typical profiles so chosen in a longitudinal series, taking into account the dip of the layer. By comparison of the distribution curves of mean values of each subsidiary typical profile with the curves of actual values, I finally obtain a typical profile. This is the profile, the curve of which least deviates from the distribution curve of mean values of all profiles.

The profile, which was for long a very popular framework of data in Slovene Palaeolithic archaeology (see the very precise drawings of profiles and descriptions of layers in publications of sites and efforts to connect all finds with layers), in principle shows changes in time, but it can be only apparent if we do not know changes in space, which we cannot ascertain in profile. I therefore decided also to analyse changes in space, first and not last. How?

Quadrats and sedimentation levels, because of their combinability or divisibility offer the possibility of analysing separately the changes connected with time that spits or sedimentation levels represent and the space represented by individual or joined quadrats, which is certainly an advantage over profiles and layers. Another advantage is the possibility of evaluating the reliability of data and conclusions.

However, deficiencies also exist connected with quadrats and sedimentation levels. Because of the nature of the work, boundaries between layers can no longer be followed with such accuracy as in profiles. However, this is not important, since all events are defined by depth. The folds in Layers 2-5a are a more serious problem. Horizontal spits intersect folds and mix the properties of different layers. How and to what extent can be verified if I use a suitable method. However, more about that below. Among the deficiencies of the field methods used belongs also the lesser accuracy connected with time pressures that accompany any fieldwork if I want to be effective in the field within economic boundaries.

Both aggregates and bone fragments were determined in homogenized sediment samples (either quadrat-spit or spit in profile). So each value *eo ipso* represents an average sample. An error was determined by repeating the procedure, i.e., measuring the volumetric weight and collecting bone fragments. With aggregates, where there was no time pressure in the field and later because of the simplicity of the procedure, the error in determining the volumetric weight was a maximum ± 0.05 g/cm^3 or 3.2% to 6% in relation to the range of volumetric weight, which is 1.54 g/cm^3 to 0.82 g/cm^3. With bone fragments, where examining sediments and concurrent collecting of finds was time limited, the error was greater and dependent on the size and number of finds. I expressed it as a percentage of uncollected finds. The error increased in reverse proportion to the size of finds. For the size class of bone fragments 3-10 mm, which we systematically collected, it ranged between 61% and 82%. We did not systematically collect smaller fragments. The numerical share of the last size class of bone fragments found is the largest, since it amounts to 99.3% for the whole site. The share by weight is not known, but it can be assessed on the basis of 35 samples taken from a composite profile. Its mean value is 45% and in entirety it amounts to 33% of the total weight of bone fragments. It follows from this that the group of bone fragments for which "field error" is characteristic, is a significant fraction of the total analysed sample. I presume that the field-laboratory error affects the results of later analyses proportionately to the size of the error.

The order of size of the error depends mainly on the field method and how the method is carried out. I cite as an example the error for fossil remains of yearling cave bears found in Divje babe I in 1980-1986 and in 1990-1999. In 1980-1986, the error was 98%, and in 1990-1999 31%. The visible progress in removing the error is a result of wet sieving of sediments after 1989. The variability of error undoubtedly contributes to the variability of archaeological and other collections. Since the variability of material is the main subject of archaeological study, field-laboratory error must be taken into account in explaining various assemblages.

I determined aggregates, which appear in all fractions, quantitatively with the aid of volumetric weight in the 0.5-3 mm fraction. This fraction has the smallest mass share of all fractions. They range from at least 1.4% in Layer 10-11 to a maximum of 14.8% in neighbouring Layers 8b-10. The assessment is based on the normal distribution of the mass shares of sediments of fraction 0.5-3 mm in the stratigraphic sequence and is 99% confident.

I chose bone fragments, which I determined by means of weight and which are present in all sedimentation levels, because of the large fragmentation of fossil bone remains. Among remains larger than 10 mm, namely, there are some 93% of fragments and with remains smaller than 10 mm, fragmentation is almost 100%. The share by weight of all bone fragments is 79.5% and rapidly diminishes in proportion to the size of fragments. The average weight of fragments for the whole site, of which the upper limit is 1.83 g, shows that very small fragments (smaller than 5 mm) prevail.

4. TIMELESS DISTRIBUTION OF AGGREGATES AND BONE FRAGMENTS

The distribution of values of aggregates and bone fragments in stratigraphic sequences is shown in *Fig. 2: a*. The size of the two samples (N = 35) should ensure statistically confident results. However, this is not so.

If both samples are greatly increased by extension in time and space (N = 1895 and 722), without taking time and space into account in the analysis, a different picture is obtained (*Fig. 2:* b). The distribution of aggregates becomes explicitly bimodal, while previously it was asymmetrical to the left. The most values are condensed around the value 1 g/cm^3, which is the typical value of layer 8, to which approximately 10% of all analysed sediments belong. The distribution of bone fragments remains apparently unchanged, i.e., asymmetrical to the right. Deriving from this and the first picture, aggregates and bone fragments, viewed statistically, are two different populations. They are also two different things. But only apparently. In fact, aggregates and bone fragments are causally linked in such a way that aggregates are indirectly or directly a consequence of bone fragments, as will be made clear below. The apparent difference is a result of not taking into account the time-space dimension, which is of crucial importance in any archaeological research.

5. AGGREGATES AND BONE FRAGMENTS IN TIME AND SPACE

Aggregates and bone fragments in time and space were analysed in steps:

1.) in profiles or stratigraphic sequences,
2.) in blocks of sediments in area B, and
3.) in blocks of sediments in area A.

There was a dual purpose in doing this:

1.) to establish how many peaks there were in accumulations of aggregates and bone fragments ranked in time, which peak is the largest, which is the smallest and so on, to greatly simply matters, and
2.) to establish how individual peaks rank in time.

The first step was analysis of the profile, or more precisely, analysis of a composite profile that I obtained by uniting profiles from various parts of the cave into a single profile (*Fig. 3:* a,b). This is a routine, inductive research method. Since it is not possible in the profile to separate the time (vertical) component from the spatial (lateral) component, the finding of peaks only on the basis of data directly from the profile is dubious, which is a deficiency of the routine method.

In a profile, each datum can be directly linked to a layer, which is the advantage of the routine method. Depths in the composite profile are average values, adjusted by the dip of the layer. Unequal gaps in the taking of samples are taken into account. These gaps are marked with dots, which represent equal stratigraphic intervals, 7 cm thick. The time boundary between oxygen isotope stages (OIS) 5 and 4 is marked individually, which marks a sedimentation lacuna covering the whole of OIS 4 (Yu et al 2001). This time boundary currently represents the only reliable, highly distinguishable time horizon at the site (Turk et al. 2001) (*Fig. 3:* a,b).

Since to date only sediments belonging to OIS 3 have been excavated and suitably analysed, I will not deal with the whole composite profile but only its upper part, down to and including Layer 13.

With aggregates, three peaks are visible in the composite profile, which increase with depth. They are marked with Roman numerals I-III. Parts of the profile between the peaks are marked as I / II and II / III (*Fig. 3:* a).

Four peaks are visible with bone fragments (I-IV), which do not increase with depth (*Fig. 3:* b).

Attention is drawn to the considerable similarity between the distribution curve of aggregates and the distribution curve of bone fragments in the profile. The similarity can be expressed by the correlation coefficient R ($R = -0.653$, $p < 0.05$, $N = 36$). The correlation is statistically significant. I will return to this.

If I read the profile (= stratigraphic sequence) in area B, in such a way that depths represent sedimentation levels, variability of data appears, connected mainly with time and space but also with the method of horizontal spits (*Fig. 4:* a,b). Above all the dip of the layer and the field method used affect the variability of the beginning and end parts of profiles. Even a fleeting look reveals that data for bone fragments (*Fig. 4:* b) are essentially more variable than data for aggregates (*Fig. 4:* a). From this follows the question of which profile is correct and what are the links between data in the profiles and layers. A great deal of archaeological discussion has revolved on this point. The solutions offered are normally very subjective. The solution I propose is a typical profile and its opposite. All other profiles are somewhere in between the two extreme profiles. It is better for the moment to forget the routine linking of data with layers, since more confusion than order could be introduced among data by classifying data by layers.

The typical profile for aggregates has four peaks (I-IV), which still increase with depth (*Fig. 5:* a). The similarity with the composite profile is considerable.

The typical profile for bone fragments has only two peaks (I-II), which are differently disposed than in the composite profile (*Fig. 5:* b). The similarity with the composite profile is considerable.

The similarity between the typical distribution curve of aggregates and the typical distribution curve of bone fragments is less disturbing. The statistically significant correlation, by which I took into account the dip of the layers, has the following parameters: $R = -0.532$, $p < 0.05$, $N = 34$.

Until now, it has not interested me how reliable individual data are, although I could conclude from the greater variability of bone fragments their lower reliability in comparison with aggregates. I assessed the reliability of data with the aid of various profiles in area B, taking into account the dip of layers. I thus arrived at the most objective picture of aggregates and bone fragments (*Fig. 6:* a,b).

Data collected in area B can conditionally be indirectly linked with layers on the basis of similarity/differences of distribution of data in the profile and in the block of sediments in area B. I am aware in this that individual data can nevertheless belong to different time horizons. Sedimentation levels in area B and stratigraphic intervals in the composite profile namely represent time horizons with a maximum possible resolution of 1400 years for area B and 600 years for the composite profile. I calculated the time resolution on the basis of radiometric dating of the composite profile (see Turk et al 2001, Table 1) and the number of sedimentation levels ($N = 33$) and stratigraphic intervals ($N = 170$). Depths in area B are average depth values of sedimentation levels composed of the three original spits. Data are shown with a 95% confidence interval (2 standard errors, SE). The time boundary between OIS 5 and OIS 4 is given. Its positioning is more reliable than are the links in the majority of layers, which are based exclusively on subjective judgement (*Fig. 6:* a,b).

With bone fragments (*Fig. 6:* b) the standard error is essentially larger than with aggregates (*Fig. 6:* a). This means that data for bone fragments are statistically less reliable than data for aggregates. All data that belong in the same interval of confidence are statistically the same. The size of an interval depends on the size of error. I can thus determine peaks in the curves of aggregates and bone fragments with 95% confidence.

With aggregates, only three peaks are reliable (I-III), which can be assumed to be linked to Layers 5a, 8b in 8b-10 (*Fig. 6:* a).

Three peaks are reliable with bones (I-III), which can be assumed to be linked to Layers 3, 7 in 10 (*Fig. 6:* b). The largest is peak II. None of this is evident in the composite profile, nor in the typical profile.

Bone fragments are a good substitute for archaeological finds in the methodological sense. In this I am thinking of stratigraphy and ground-plan disposition ("planigraphy"). I can thus generalise some of the findings concerning bone fragments and fossil remains in general.

First of all, I must stress the great variability connected with time and space. This is essentially greater than with sedimentation data since it concerns living material, which has the property that it can also itself move.

Secondly, I must mention the fractions or components of the whole material, which must display the same characteristic as the whole to which they belong. For example, if I take any skeletal part of cave bear, I get a similar distribution in the profile as with bone fragments. However, it is necessary to take into account here the frequency of individual elements in the space and their size. The lower the frequency, the greater the space I need for reliable results. However, space is relative, since it depends on the size of the elements occupying the space.

Whole bones represent a very small fraction of the whole (less than 7%), but in area B they give a reliable picture, which compares well with the picture of bone fragments. On a small area, information on the basis of whole bones, in view of their size, would be extremely unreliable.

Bone detritus smaller than 3 mm greatly prevails among bone fragments. Because of the small size, they give a reliable picture even on a small area. In order to get comparable results as for bone fragments in area B (= 21 m^2), it would be enough to analyse bone detritus on an area of 1 m^2 (see Turk et al. in this issue of *Arh. vest*., *Fig. 2*). And I have thus already entered into the sphere of economic justification of extensive excavations, such as the excavations in Divje babe I.

Analysis of the fractions (fractioning of the sample) is one of the elements of the scientific method. One would expect fractions to give similar results as the sample, provided the conditions under which the analysis takes place are unchanged.

The distribution of aggregates and bone fragments in area B are more similar than their distribution in the composite and typical profiles. It is important that in two distributions, to the sedimentation level exactly fit the transition from one to another state or layer. I therefore dare to claim that fossil remains *sensu lato* are the cause and aggregates their result. I can express the causal connection mathematically with the statistically significant correlation coefficient: $R = -0.757$, $p < 0.05$, $N = 33$. I will not enter into a detailed explanation of this relation and the process connected with it here, since I have already partially dealt with it elsewhere (Turk et al. 2002). It seems to me more important to make an analysis of this relation in the reference area A, which provides another opportunity to check the accuracy of the whole procedure and avoid a first order mistake because of which the whole procedure could be misplaced.

If area B represents a corridor by which the cave was entered, area A represents a living space beside the corridor. In area A, 469 data of a possible 500 are embraced in 20 sedimentation levels, and in area B, 671 data of a possible 693 in 33 sedimentation levels. Individual data are missing for objective reasons: e.g., because of blocks in sediments and other disturbances. The depths of the combined areas are the average values of the depths of sedimentation levels from the two areas, the two depths of which are almost equal.

In accordance with the definition of a layer, there must be a similarity between areas A and B. Minor deviations covered in standard error can be the result of spatial variability and methodological deficiencies. If there is no similarity, I have made a basic mistake.

Comparison between the areas is 95% confident. Individual *ad hoc* determined layers lose significance because they do not fulfil conditions according to the criteria of aggregates and bone fragments. I therefore replaced them with new basic stratigraphic units that fulfil these conditions. These are new Layers A-C (*Fig. 7:* a,b). The new layers, like the old ones, are composed of stratigraphic levels. The transition from one layer to another is exactly defined, since according to expectations they are made up within the framework of one sedimentation level in the entire area A or B. In areas A and B there is a shift of the transition from Layer B to Layer A with aggregates of the order of size of one sedimentation level. Such is also the maximum possible shift between distributed aggregates in the two areas. Under ideal conditions, which would be achieved with the exclusion of all errors made in the field, there should be no shift.

The transition from Layer C to Layer B coincides with the radiometrically determined time boundary between OIS 5 and OIS 4 (ca. 74,000 BP). If we succeed in explaining new Layer B climatologically (for a first attempt see Turk et al. 2001 and 2002), we obtain an excellent chronostratigraphic marker for all sites that are similar in content to Divje babe I. There are several such sites in Slovenia and its vicinity. However, this is another theme, which someone will successful enter into only on the basis of thorough preparation. Routinely collected data for other sites available today are not sufficient for any such thing, since they are not documented and interpreted in the way that data in Divje babe I are documented and interpreted.

For illustration, I cite data for volumetric weight (of aggregates) at the transition from one layer to another for areas A and B. From the statement of spits (depths from-to) it is also clear how I have taken into account the dip of the layers.

Both aggregates and bone fragments belong to the same litho-biostratigraphic cycle, composed of three layers: Layer A, which contains few aggregates and bones, followed by Layer B, which contains a great deal of aggregates and bones, and

Area A:

Sedimentation level (overlaying) -231 cm, Layer A

1.01 1.26 1.09 1.03 1.08
1.26 1.08 1.14 1.25 1.14 depth -237 cm do -249 cm
1.12 1.20 1.39 1.20 1.23
1.08 1.13 1.10 1.25 1.15
0.91 1.09 1.14 1.10 1.00 depth -249 cm do -261 cm

Sedimentation level (intermediate) -243 cm, Layer A/B

- - - 1.01 1.06
1.06 1.03 1.20 1.12 1.03 depth -249 cm to -261 cm
1.13 1.05 1.08 1.10 1.15
1.05 1.02 1.08 1.00 1.00
1.04 1.04 1.04 1.04 0.97 depth -261 cm to -273 cm

Area B:

Sedimentation level (overlaying) -219 cm, Layer A

1.30 1.25 1.16 depth -201 cm to -213 cm
1.33 1.19 1.23
1.14 1.03 1.01
1.08 1.04 1.00 depth -213 cm to -225 cm
1.20 0.94 1.20
1.24 1.05 1.11
1.27 1.27 1.35 depth -225 cm to -237 cm

Sedimentation level (intermediate) -231 cm, Layer A/B

1.29 1.04 1.09 depth -213 cm to -225 cm
1.30 1.03 0.97
1.01 1.03 1.09
1.01 1.03 0.97 depth -213 cm to -225 cm
1.09 0.92 0.90
1.08 1.04 1.00
1.14 1.09 1.08 depth -237 cm to -249 cm

Area B

Sedimentation level (overlaying) -429 cm, Layer B

1.37 1.28 1.29 depth -405 cm to -417 cm
1.15 1.13 1.20
1.22 1.08 1.09
1.03 1.19 - depth -417 cm to -429 cm
1.06 1.09 -
1.17 1.22 1.10
1.15 1.06 1.05 depth -429 cm to -441 cm

Sedimentation level (intermediate) -441 cm, Layer B/C, time horizon 74,000 BP

1.40 1.37 1.32 depth -417 cm to -429 cm
1.29 1.18 1.20
1.32 1.21 1.17
1.34 1.30 1.18 depth -429 cm to -441 cm
1.22 1.18 1.11
1.39 1.39 1.19
1.32 1.30 1.25 depth -441 cm to -453 cm

then Layer C which contains few aggregates and bones, and so on, on the basis of similarity between sedimentological and palaeontological data to the vicinity of the maximum achieved depth of 1150 cm and in Layer B (*Fig. 7:* a,b).

Aggregates in areas A and B are in partial agreement ($R = 0.719$, $p < 0.05$, $N = 16$). Six of sixteen sedimentation levels have the same values within a 95% confidence interval. The distribution in the vertical is different, but the distribution in area A, similar to the distribution in area B, is composed of the values of two stratigraphic sets corresponding to Layers A and B. The values of Layer A are initially smaller in area A, but then larger than in area B. In Layer B, the values in both areas are the same (*Fig. 7:* a).

Bone fragments in areas A and B are also partially in agreement ($R = 0.724$, $p < 0.05$, $N = 16$). The distribution in the vertical is more similar than with aggregates. Five of sixteen sedimentation levels have the same values within a 95% confidence interval. The distribution of bone fragments in area A, similar to the distribution in area B, is composed of the values of Layers A and B. The values of Layer A in area A are in general somewhat larger than in area B, and the values of Layer B smaller (*Fig. 7:* b).

On the basis of correlation coefficients, I can explain 52-55% of the relations between areas A and B deriving from similarities between the layers in the two areas, as far as aggregates and bone fragments are concerned. The remaining 48-45% of unexplained variations can be ascribed to the influence of the space, which presumably contributed a great deal to the variability of aggregates and bone fragments in areas A and B. I have in mind various processes that take place simultaneously (isochronously) in the two areas. Part of the unexplained variations also occurred because of the poor correspondence of time horizons, which is a result of their small time resolution (1400 years). All processes that did not take place simultaneously in the two areas, namely, cannot be separated in time. Part of the unexplained variations can be ascribed not least to the deformation (undulation) of sediments and field methods.

Taken generally, the data from the two areas are in accordance. However, differences exist, which can be connected with the spaces as constants: on the one hand, from the entrance corridor to the cave, which was more exposed to external influences (area B), and on the other the living space, which was more protected from outside influences (area A). A comparison between areas A and B can also be complicated by the folds (involutions) in connection with the field method of horizontal spits. However, the greatest deviations between the two areas are in the part of the profile where there is no longer folding. It is also fairly unusual that an explicit gradient was established in one of the sedimentation levels in the part with folding (Turk et al. 2002). Aggregates in this level also rise fairly uniformly in the direction into the cave, in an area of 32 m^2. The gradient of the volumetric weight is:

1,20	1,08	0,97	1,23		1,12
1,27	1,19	1,11	1,15		1,18
1,30	1,22	1,12	1,25		1,22
1,33	1,27	1,30	1,25		1,29
1,33	1,36	1,34	1,18		1,30
1,35	1,48	1,32	1,34		1,37
1,33	1,35	1,34	1,36		1,35
1,38	1,44	1,38	1,34		1,39

The last column represents the mean value of individual transverse series of quadrats.

I investigated whether the folds in connection with the field method affect the content of aggregates and distribution of bone fragments, using a variant of the cluster method known as *Two-Way Joining*. This method simultaneously distributes data by quadrats (rows) and sedimentation levels (columns) in relation to their mutual similarity. I expected that quadrats and sedimentation levels would bilaterally contribute to revealing a meaningful pattern of clusters if I separately analyse two groups of sedimentation levels and quadrats; those with deformed (undulating) sediments and those with horizontal sediments. I presumed that the aggregates and bone fragments were equally mixed because of the deformation of sediments and removal of sediments by horizontal spits.

The pattern of undulating and horizontal sediments (layers) is different as concerns clusters of quadrats and sedimentation levels, although the two patterns are similar as concerns aggregates and bone fragments (*Fig. 8:* a,b).

With the horizontal sediments, the pattern of values of aggregates and bone fragments repeats or perseveres in the same sedimentation levels. Individual quadrats or groups of quadrats in the framework of the same sedimentation level have similar values. The tendency to repeat the pattern in the horizontal direction is more expressed than the tendency to repeat the pattern in the vertical direction, seen in entirety.

With the undulating sediments the pattern of values of aggregates and bone fragments repeats or perseveres in various sedimentation levels. Individual sedimentation levels or groups of sedimentation levels have similar values within the framework of the same quadrat. The tendency to repeat the pattern in the vertical direction is more expressed than the tendency to repeat the pattern in the horizontal direction, seen in entirety.

The undulation of part of the sediments and the method of horizontal spits probably contributed to the apparently uniform analysed data in the vertical direction. The result of the method of *Two-way Joining* confirmed the suspicion that the sediments of the layers with undulating boundaries are no longer actually in their original position. That some layers are strongly deformed can be seen in all documented profiles. However, the deformation may only be apparent. That the deformation is in fact real was also confirmed by the analysis of angle of inclination of bones in apparently undulating and apparently horizontal sediments (Turk 1997).

6. CONCLUSIONS

Until 1986, I excavated in Divje babe I in a way that could be best characterised as frontal excavation of blocks of sediments. This is how excavation in building or mining normally takes place. I documented in this way mainly a series of transverse profiles, which represented the front of the excavation. I placed all finds concurrently in *ad hoc* determined layers, which I followed from profile to profile. The distance between profiles amounted to from one to several metres (Osole 1990, pp. 10). M. Brodar (1999), who was in fact responsible for this excavation, later confirmed the proper determination of layers. So the stratigraphy, though complex, was apparently not in doubt. The layers and finds that were supposed to have belonged to them, could be joined or divided into individual parts, but no such operation revealed either a cyclical pattern of sedimentation and diagenesis or simplified stratigraphy (Turk et al. 1989; Brodar 1999), as is shown in this contribution (*Fig. 7:* a,b). This is evidence that the method up to 1986 was essentially mistaken in the part that referred to data collected by layers between profiles. Layers, in other words, are a good starting point for analysis of profiles and a bad starting point for the analysis of larger blocks of sediments. Sedimentation levels are a more suitable starting point for these.

Excavations before 1989 had another major deficiency. Control of error and reliability of data collected until 1989 was not possible, and the time resolution of the majority of events was small because of dug units (spits) of a thickness of 20-30 cm.

After 1989, I tried to rectify some of the deficiencies, and was also to some extent successful.

I increased the time resolution by reducing the dug units from 20-30 cm to 12 cm. I also reduced field error by wet sieving all sediments. I controlled field-laboratory error and the reliability of data. I achieved the latter by analysing the stratigraphic sequences in space. It appeared that the most reliable results were those that related to a larger space (block of sediments) in the framework of the site, if they are properly analysed. A question that remains unresolved is how far this relatively small space is representative of the relatively large whole site.

I supplemented the subjective determination of layers in the field with determining layers after completed excavations with the aid of analytical procedures. I thus came closer to a definition of layers by objective means.

Layers in Divje babe I are distinguished from each other mainly on the basis of two characteristics:

1.) diagenetic changes and
2.) content of fossil remains.

It is important in this that the two characteristics are causally connected, because of which lithostratigraphic units can be directly equated with biostratigraphic units.

Excavations of Palaeolithic sites in Slovenia have not to date made use of the advantages of archaeological field methods over geological methods. On the example of geology, all data have in essence been condensed into a stratigraphic sequence. So it was not possible to verify the isochroneity in relation to diachroneity of finds and processes other than by independent dating methods. There are also major difficulties with these methods (see Turk et al. in this issue of *Arh. vest.*).

My approach opens possibilities of resolving the key question of Palaeolithic archaeology, which is: whether similar finds and processes are isochronous or diachronous. This question must first be resolved in the context of each site individually and only then between sites on a regional level. Only when it has been solved will we once and for all stop revolving in the charmed circle of equations: litho-, bio-, and archaeostratigraphy is the same as chronostratigraphy, and chronostratigraphy is the same as geochronometry. It will be necessary also to do a great deal in the area of the ever more important geochronometry (see article Turk et al. in this issue of *Arh. vest.*). Only a combination of all possible forms of stratigraphy one way or another gives the most reliable results.

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