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THE ALBANO MAAR (ALBAN HILLS VOLCANIC DISTRICT, ITALY): ACTIVE OR DORMANT VOLCANO?

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ABSTRACT: F. Marra, D. B. Karner, *The Albano Maar (Alban Hills Volcanic District, Italy): active or dormant volcano?* (IT ISSN 0394-3356, 2005).
We discuss the geochronological interpretation of several stratigraphic sections where either primary or reworked volcanic products of the most recent eruptive activity of the Albano maar are exposed. A recently performed set of 112 single- and multiple-crystal $^{40}Ar/^{39}Ar$ age determinations, totalling 244 dated crystals from samples of the Albano products, suggests that no magmatic activity occurred after 36 ka. Therefore, based on the lack of evidence for eruptive activity in historical time, Albano should be defined an *inactive* volcano. The time elapsed since the last eruption, however, does not overrun the average recurrence time (45 kyr) for the overall volcanic activity of the Alban Hills Volcanic District through the last 600 kyr, indicating that Albano should be regarded as a *dormant* volcano rather than *extinct*.
Differently from direct $^{40}Ar/^{39}Ar$ dating of the volcanic products, recent C14 age determination on two paleosoils have suggested that eruptive activity younger than 5,000 years occurred at the Albano maar. This interpretation contrasts with the absence of any volcanic deposit in the sedimentary fill of the Albano crater spanning the time interval 25 ka - Present, therefore we believe that the possibility that the dated organic material may have been affected by problems of contamination should be carefully considered. Indeed, stratigraphic, paleomorphologic and paleoclimatic data that we present in this paper are as well compatible with an early emplacement around 39-36 ka for all of these volcaniclastic products, either primary or reworked.

RIASSUNTO: F. Marra, D. B. Karner, Il maar di Albano (Distretto Vulcanico dei Colli Albani, Italia): vulcano attivo o quiescente? *(IT ISSN 0394-3356, 2005).*

In questo articolo discutiamo l'interpretazione geocronologica di alcune sezioni stratigrafiche in cui affiorano i prodotti, sia primari che rimaneggiati, della fase più recente di attività del maar di Albano. Una serie di 81 datazioni effettuate recentemente col metodo $^{40}Ar/^{39}Ar$ su singoli e multipli cristalli, per un totale di 244 cristalli datati, suggerisce l'assenza di attività magmatica posteriore a 36 ka. Ne segue che, in base all'assenza di evidenza certa di attività eruttiva in tempi storici, Albano dovrebbe definirsi un vulcano inattivo. D'altra parte, il tempo trascorso dall'ultima eruzione datata (36 ka) è inferiore al tempo medio di ricorrenza (45 kyr) determinato per l'intera storia eruttiva dei Colli Albani negli ultimi 600 kyr, indicando che Albano deve considerarsi un vulcano quiescente, ma non estinto.
Diversamente dalle indicazioni radiometriche sui prodotti vulcanici, alcune datazioni effettuate con il metodo C14 su paleosuoli hanno fatto ipotizzare l'esistenza di attività eruttiva del maar di Albano posteriore a 5000 anni fa. Questa interpretazione appare in contrasto con l'assenza di prodotti vulcanici all'interno dei depositi sedimentari che colmano il fondo del Lago di Albano e che coprono un intervallo temporale compreso tra circa 25.000 anni fa e il Presente, facendoci sospettare che l'attendibilità delle datazioni effettuate col metodo C14 debba essere più attentamente riconsiderata. Effettivamente, una serie di dati stratigrafici, paleomorfologici e paleoclimatici che vengono discussi in questo articolo sembrano compatibili con una messa in posto attorno a 39-36 ka per tutti questi prodotti volcanoclastici, sia primari che rimaneggiati, affioranti nelle sezioni descritte.

Keywords: Alban Hills, Albano maar, geochronology, volcanism, hydromagmatic activity, peperino.

Parole chiave: Colli Albani, maar di Albano , geocronologia, vulcanismo, attività idromagmatica, peperino.

INTRODUCTION

Recent studies (Villa et *al*., 1999; Karner *al*., 2001a; Funiciello *al*., 2002; 2003; Marra *al*., 2003; Soligo *al*., 2003; Freda *al*., 2005) have focused on evaluating the stratigraphy and the geochronology of the most recent phase of activity of the Alban Hills Volcanic District and re-evaluating its significance in terms of possible volcanic hazards for Rome. However, these works sometimes proposed different stratigraphic interpretations, as well as different time intervals, for this recent volcanic activity. In particular, there is no agreement on the age of the last eruption that occurred in the Albano maar, where the youngest volcanic activity occurred. This is a fundamental issue in order to establish if we have to consider the Albano maar to be an *active* or a *dormant* volcano. Indeed, based on the strict definition proposed in the Smithsonian Institution's catalogue of active volcanoes, only volcanoes that have erupted in the last 10,000 years should be considered active. Alternatively, it is considered that a volcano is dormant when the time elapsed since its last eruption does not exceed the average recurrence period of its past activity.

Establishing which was the actual last eruption that occurred at the Albano maar is fundamental to evaluate the recurrence times and the time elapsed since the last eruptive event, therefore it has a relevant implication on the assessment of the potential hazard for the city of Rome. Recent work (Marra *al*., 2003;

MARRA *al*., 2004) has pointed out that, based on the average recurrence time of the major volcanic cycles that occurred in the last 600 kyr, the Alban Hills should be considered a dormant volcano. This is based on the observation that the last eruptive cycle documented by $^{40}Ar/^{39}Ar$ dating in the Alban Hills spanned the interval 39±1 ka to 36±1 ka in the Albano maar, whereas the average recurrence time through the history of this volcanic district has been estimated to being approximately 45 kyr.

Here we propose a re-interpretation, based on $^{40}Ar/^{39}Ar$ ages of volcaniclastic deposits (FREDA *al*., 2005), of the geochronology for some of the most significant sections where the youngest products of the Albano activity crop out. In particular we discuss the chronostratigraphy of two sections described in previous works (GRA-Appia Antica and Lucrezia Romana sections, SOLIGO *al*., 2003: FUNICIELLO *al*., 2002; 2003), where primary volcanic deposits and post-eruptive lahars and debris-flows were interpreted to be younger than 23±6.7 ka and, in part, younger than 5±0.1 ka. We suggest that the emplacement of the most portions (if not all) of these products more likely occurred in the time span 70 - 36 ka. We base our interpretation on the $^{40}Ar/^{39}Ar$ ages achieved for the primary products cropping out at these sections, while we rely on stratigraphic correlations and paleoclimatic inferences to estimate the ages of the reworked layers.

THE ALBANO MAAR

The Albano multiple-maar center (Fig. 1) hosted the most recent activity of the Alban Hills Volcanic District (VILLA *al*., 1999; KARNER *al*., 2001a; MARRA *al*., 2003; SOLIGO *al*., 2003; FUNICIELLO *al*., 2002; 2003, FREDA *al*., 2005). It was described (DE RITA *al*., 1995a; 1995b) as a multiple tuff ring, the activity of which consisted of five main explosive cycles. The fifth eruption cycle of Albano Maar was driven by phreatomagmatic fragmentation and emplaced a phreatomagmatic basic ignimbrite (GIORDANO *al*., 2002a). This ignimbrite is the most famous deposit of Albano, as it was quarried since the IV Century B.C. by the ancient Roman builders and extensively used under the name of *Lapis Albanus*. The dark-grey colour and the granular texture of this rock led to the local name of “Peperino” (black pepper-like), and so this unit is known in the literature also as “Peperino di Marino” or “Peperino Albano”.

The eruptive activity of Albano Maar was dominated by surge flows which deposits typically show sharp lateral facies variations over relatively short distances. Subordinate fall beds are present throughout the succession. The surge deposits commonly show planar- to cross- laminations in the proximal area, whereby they have massive, lithified facies in the distal sections, where they fill paleovalleys. The scarcity of outcrops due to the vegetation cover and the large development of agricultural soils prevent the straightforward correlation through different localities, therefore making difficult the stratigraphic correlation among the different units. The petrography and chemistry of the Albano products is very homogeneous (TRIGILA *al*., 1995; MARRA *al*., 2003; FREDA *al*., 2005), preventing the identification of any characteristic feature that may be distinctive of the different volcanic units. These facts limit the possibility to establish stratigraphic relationships for the different volcanic units, when they do not occur in the same outcrop. A powerful tool to overcome these difficulties is the $^{40}Ar/^{39}Ar$ dating of the volcanic products that, based on the high precision and reliability of the method, allows for a certain correlation of primary volcanic products containing juvenile phenocrysts (KARNER and RENNE, 1998; KARNER *al*., 2001a; MARRA *al*., 2003, FREDA *al*., 2005).

Here we discuss the implications on the geochronology of the most recent phase of activity of recently obtained $^{40}Ar/^{39}Ar$ data on 12 volcanic deposits of the Albano Maar (FREDA *al*., 2005). These data allow us to correlate two distal sections (GRA-Appia Antica and Casale Ferranti), where the supposedly youngest products are found, to the best exposed and most complete (found so far) proximal stratigraphic section, located within the crater rim of the Albano maar. The correlation of these outcrops is shown in Fig. 2.

ALBANO LAKE PROXIMAL SECTIONS

The best exposed section crops out within the northern crater rim (site 1 of Fig. 1, Reference Section of Fig. 2) and shows a succession of pyroclastic deposits about 80 m thick. This succession overlies a ~1.5 m-thick mature paleosol, developed on pre-Albano hydromagmatic products dated 203±1 ka and attributed to the activity of the nearby Ariccia maar (Marra et al., 2003). Four incipiently pedogenized ash levels indicate the occurrence of four main hiatuses in the Albano maar activity, while small-scale unconformities (either erosional surfaces and thin pedogenized ash layers) record less significant hiatuses. The uppermost part of the Albano succession does not crop out at the Reference section, whereas it is exposed in several outcrops on the eastern and southern outer rims of the Albano maar. The most complete of these outcrops is shown in Fig. 2 (site 1' in Fig. 1). A detailed description of the stratigraphy and of the petrologic features of the products that crop out at these sections is provided in FREDA *et al*. (2005).

Based on $^{40}Ar/^{39}Ar$ ages, two major eruptive cycles, separated by approximately 30 kyr of dormancy, are recognized at the Albano Lake sections (Fig. 2). The first cycle occurred at 69±1 ka, while the second one was characterized by two distinct eruptive sub-cycles at 39±1 and 36±1 ka (see Fig. 2 and Fig. 3). The first cycle produced the lower, more than 60 m thick, suite of deposits at the Reference section. One faintly pedogenized ash layer occurs in the middle of the lower portion of the succession, suggesting the presence of two separate eruptions with statistically indistinguishable ages of 69.4±0.6 ka and 68.6±1.1 ka, respectively. A thick deposit of ash partially altered into clay and capped by a pedogenized layer closes the stratigraphic succession of the first eruptive cycle. Two other incipiently pedogenized ash layers divide the products of the second cycle of activity into at least three different eruptions. These three eruptions occurred at radioisotopically indistinguishable times: the products at the base of the second cycle yielded an age of 41.2±1.1 ka, whereas those at the top yielded an age of

40.9±0.8 ka. The uppermost deposit that crops out along the eastern and southern crater rim (site 1'), and that is missing on top of the Reference section, yielded an age of 35.9±0.6 ka. This is a radiometrically distinct age with respect to the previous ones, and enables us to consider it to be the youngest (dated so far) product of the Albano activity and to correlate it to the Peperino Albano that crops out in Valle delle Petrare.

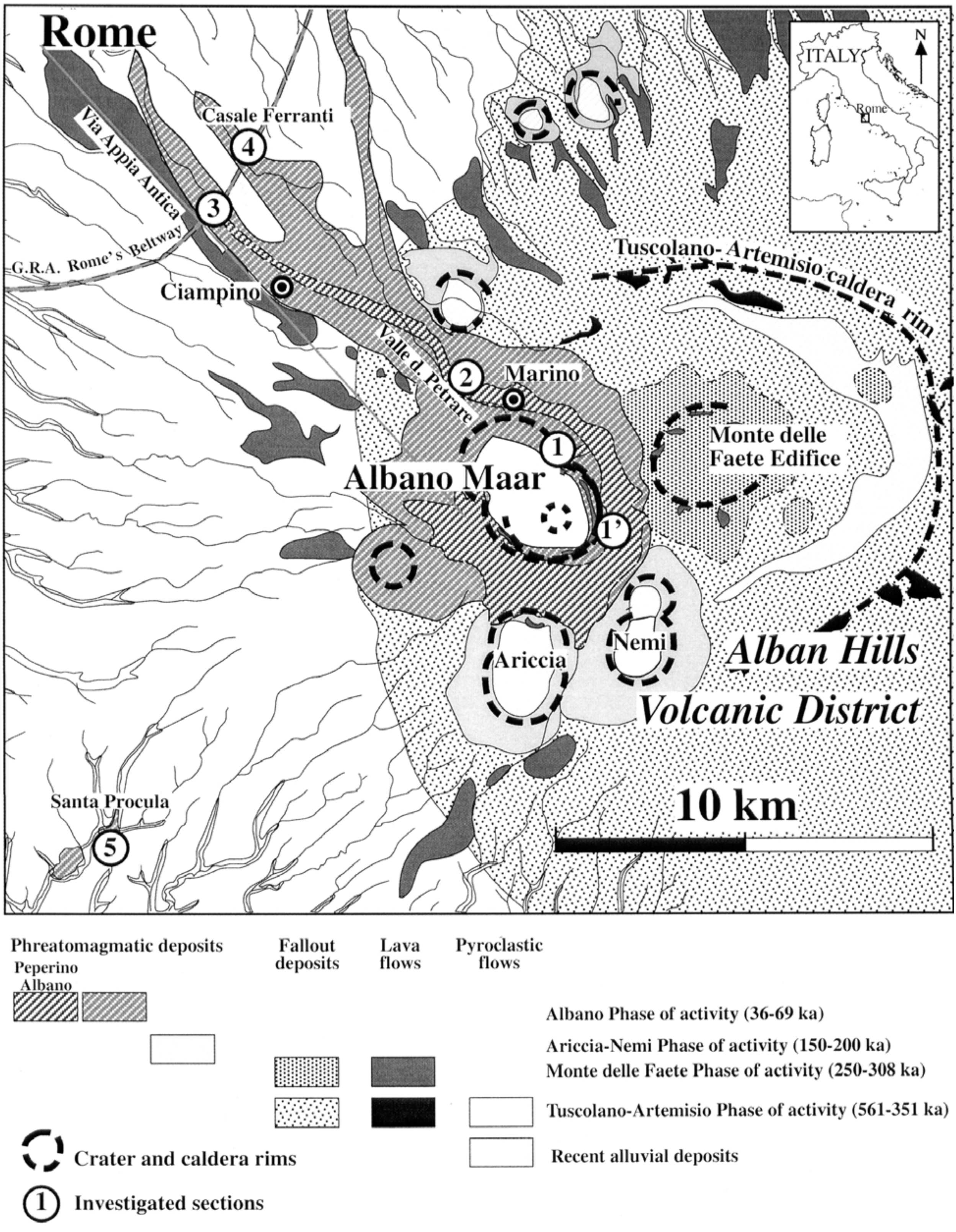

Fig. 1 - Geologic map of the Alban Hills, redrawn from Freda *et al*., 2005.

Schema geologico dell'artea dei Colli Albani, ridisegnato da Freda et al.*, 2005.*

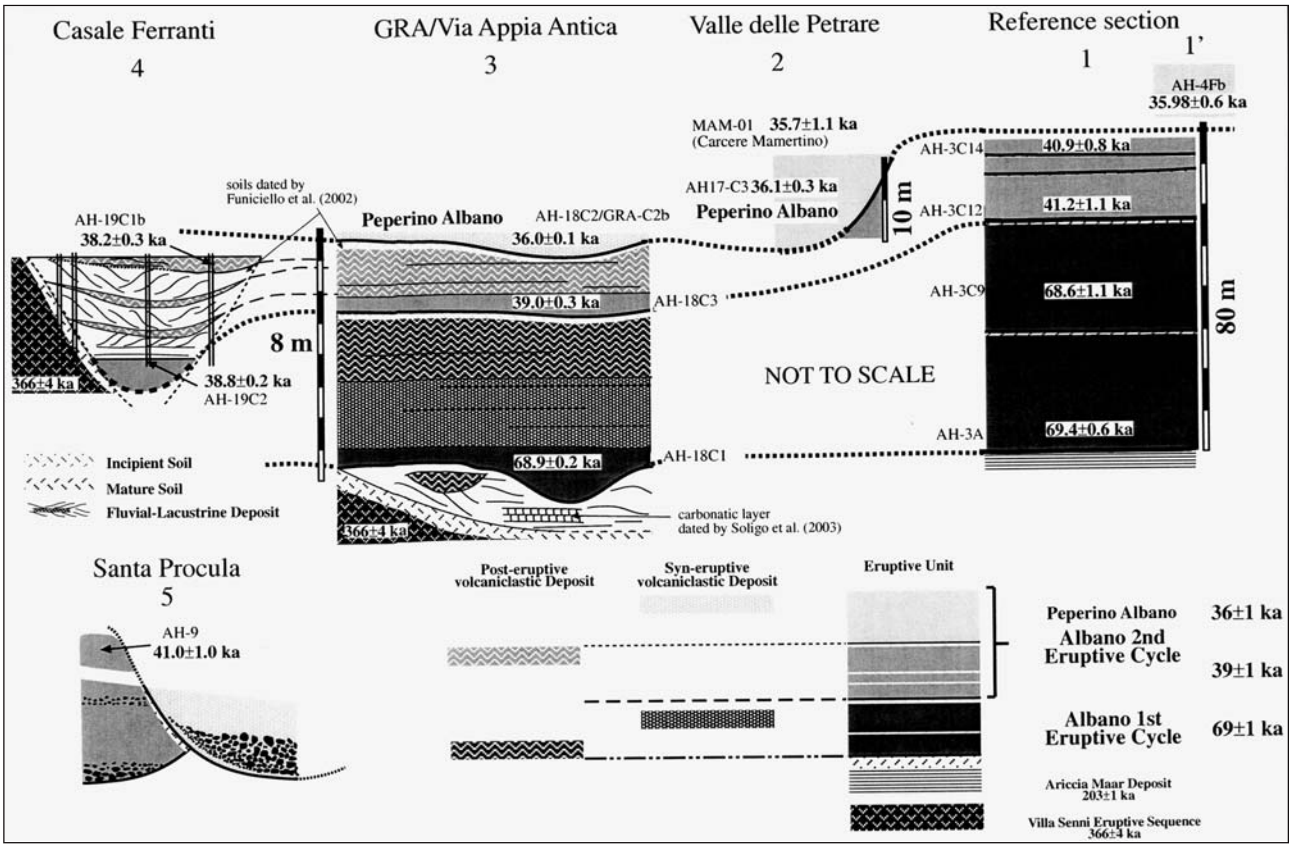

Fig. 2 - Stratigraphic scheme showing the relationship among the investigated sections, as inferred from petrographic correlation and $^{40}Ar/^{39}Ar$ ages of the collected samples (modified from FREDA *et al*., 2005).Two major eruptive cycles occurred at Albano maar: the first one at 69±1 ka, and the youngest one including two statistically distinct, sub-cycles at 39±1 ka and 36±1 ka. During the youngest eruptive cycle the Peperino Albano pyroclastic flow was emplaced.

Schema stratigrafico mostrante le relazioni stratigrafiche esistenti tra le diverse sezioni studiate, basato su correlazioni pertrografiche e sulle età $^{40}Ar/^{39}Ar$ dei campioni analizzati (modificato da FREDA et al.*, 2005). Due principali cicli eruttivi sono riconosciuti per il maar di Albano: uno più antico a 69±1 ka, ed uno più giovane, che comprende due sub-cicli con età statisticamente distinte di 39±1 ka e 36±1 ka. Durante l'ultimo di questi sub-cicli avviene l'eruzione del Peperino Albano.*

VALLE DELLE PETRARE SECTIONS

The Peperino Albano deposit is more commonly known by its historical name, Lapis Albanus. One sample of this stone, collected from the walls of an ancient Roman monument (the Tullianum in the Carcere Mamertino) was dated by $^{40}Ar/^{39}Ar$ methods at 35.7±1.1 ka (KARNER *et al*., 2001b). FREDA *et al*. (2005) carried out a new dating on a sample of Peperino Albano deposit collected in the ancient Roman quarries located in Valle delle Petrare. This sample yielded the age 36.1±0.3 ka, in perfect agreement with that previously determined.

GRA-APPIA ANTICA DISTAL SECTION

$^{40}Ar/^{39}Ar$ datings were carried out on three samples (AH18-C1, AH18-C3, AH18-C2, see Fig. 2) collected in three different volcaniclastic deposits cropping out at the GRA/Appia Antica section (FREDA *et al*., 2005). From the bottom to the top they yielded ages of:

1) Sample AH18-C1, 68.9±0.2 ka. This is the age of the first (oldest) eruptive cycle of the Albano maar, as previously determined (MARRA *et al*., 2003) on the equivalent unit cropping out within the Albano Crater, and confirmed by the age of another sample (AH3-C9) from the upper portion of the lower succession at the Albano Lake Reference section (see Fig. 2). According to FUNICIELLO *et al*. (2003) the product we dated shows the feature of a primary phreatomagmatic pyroclastic-flow deposit, therefore the age of the crystals that we separated from the juvenile portion of the deposit should be considered indicative of the emplacement time.

2) Sample AH18-C3, 39.0±0.2 ka. This age falls into the time span encompassed by the second eruptive cycle of the Albano maar (FREDA *et al*., 2005). According to FUNICIELLO *et al*. (2003) we also interpret this unit to be a primary phreatomagmatic deposit, therefore also in this case the age of the dated crystals is indicative of the emplacement time.

3) Age of sample AH18-C2 was obtained by combining 8 age determinations from two samples (AH18-C2 and GRA-C2bis, see Fig. 3) collected in the same, uppermost volcaniclastic deposit that crops out at the GRA/Appia Antica site. These crystals yielded a combined age of 36.0±0.1 ka. This age is indistinguishable from those obtained on several samples of

Peperino Albano dated so far. This uppermost volcaniclastic horizon appears to be reworked, with sorting, massive facies, stratified base and subrounding of the components, indicating a mechanism of emplacement from a hyperconcentrated flood flow (FUNICIELLO *et al*., 2003).

The three deposits described above correspond, from lowest to highest, to the volcanic layers to which FUNICIELLO *et al*. (2003) have attributed the following stratigraphic and geochronologic interprertations:

1) Peperino Albano phreatomagmatic ignimbrite (D layer in their Figure 3);
2) Phreatomagmatic surge deposit (F layer in their Figure 3), "...to be considered the youngest and previously never described phreatomagmatic eruption from the Albano maar...";
3) Hyperconcentrated flow sandy deposit (H layer in their Figure 3).

Based on an U/Th series age (Soligo et al., 2003) on a carbonate layer underlying the volcaniclastic succession at the GRA/Appia Antica site, Funiciello et al. (2003) interpreted the entire section to be younger than 23±6.7 ka. Moreover, based on a ^{14}C age of 5100±100 years B.P. on an incipiently pedogenized ash layer underlying the youngest volcaniclastic deposit (layer H in their Figure 3), they interpreted the uppermost deposit as a lahar deposit originated by the overspill of the Albano maar lake in historical time.

The geochronologic data and the stratigraphic interpretation by Funiciello et al. (2002) and SOLIGO *et al*. (2003) are in strong conflict with the direct 40Ar/39Ar datings of these deposits, as we discuss below.

CASALE FERRANTI DISTAL SECTION

This is another location where distal products of the Albano maar activity crop out. The deposits fill an ancient paleovalley and they were previously recognized and investigated through a trench excavation (Lucrezia Romana site, FUNICIELLO *et al*., 2002). We have studied this paleovalley and its volcaniclastic filling in the Casale Ferranti site, by means of four borecores located in a construction yard adjacent to the Lucrezia Romana site. We dated and analyzed two samples from these borecores, corresponding to the uppermost and to the lowermost volcanic deposits that fill the paleovalley (Fig. 2). The lowest sample (AH19-C2) is a well-indurated, massive deposit that yielded a $^{40}Ar/^{39}Ar$ age of 38.8±0.2 ka. The age and petrographic features (Freda et al., 2005) of this sample match well those of sample AH18-C3 in the GRA/Appia Antica section, and sample AH3-C14 at the Albano Lake section (site 1 in Fig. 1). Thus, this is very likely a primary product erupted during the early phase of the second eruptive cycle.

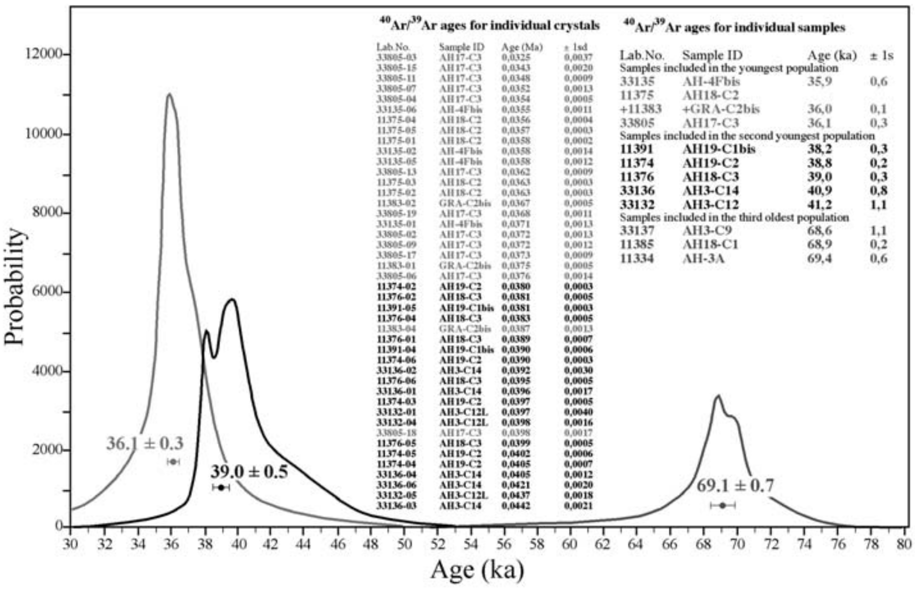

Fig. 3 - Ideogram (age probability diagram) of the crystal ages from all the dated samples from the Albano Center, using 2σ analytical error distributions. Three prominent peaks are noted: ages from each sample tend to concentrate into one peak of the ideogram, supporting the interpretation of three geochronologically distinct eruptive events. Single crystal ages for the samples of the youngest two eruptive events are reported, showing that the crystals which group into the two modes at 36 ka and 39 ka belong to two distinct groups of samples that have always stratigraphic position that is consistent with their radiometric age.

Ideogramma (diagramma probabilistico delle età) relativo alle età dei cristalli di tutti i campioni di prodotti dell'attività di Albano datati, con distribuzione analitica dell'errore a 2σ. Si notano tre picchi principali: l'età di ognuno dei campioni si concentra all'interno di un singolo picco dell'ideogramma, indicando l'esistenza di tre eventi geocronologicamente distinti. Sono inoltre riportate le età dei singoli cristalli dei campioni che originano i due picchi più recenti, evidenziando che i cristalli che originano le due mode che definiscono due eventi eruttivi a 36 e 39 ka appartengono a due gruppi di campioni che hanno sempre una posizione stratigrafica consistente con l'età radiometrica.

The uppermost sample (AH19-C1bis) is an aggregate of rounded scoria, leucite and femic crystals, and heterogeneous lithic fragments. Two younger crystals from this sample yielded a combined age of 38.2±0.3 ka. However, the abundance of contaminant crystals (four crystals out of six, see Appendix) from the scoria cones activity that ended the Villa Senni Eruptive Sequence (351±3 – 356±4 ka, KARNER *et al*., 2001a), and from the Monte delle Faete phase of activity (308±4 – 250±1 ka, MARRA *et al*., 2003), suggest that this may be a thoroughly reworked product.
Funiciello et al. (2002) have correlated the stratigraphic section at Lucrezia Romana to the similar volcaniclastic succession that fills the paleovalley in the GRA/Appia Antica location. The correlation of the two sections is based on a ^{14}Cage of 5150±70 yrs BP obtained on a soil underlying a 20 to 50 cm thick "*hyperconcentrated flow deposit*" that is at the top of a volcaniclastic succession that fills the paleovalley at Lucrezia Romana (see Fig. 5 in FUNICIELLO *et al*., 2002).

DISCUSSION

1. Geochronologic and stratigraphic remarks

The correlation of the primary deposits units cropping out at the GRA/Appia Antica section with those previously studied at the Albano Crater by De Rita *et al*. (1988; 1995a; 1995b) and dated by Marra *et al*. (2003) and Freda *et al*. (2005) is straightforward. This correlation is based on the principle of stratigraphic succession (Fig. 2), and based on the high quality of the dates performed (see Fig. 3 and Appendix). From this large set of dated volcanic deposits we obtained ages that have always been stratigraphically consistent and that define statistically distinct eruption ages at 69±1, 39±1, and 36±1 ka. Figure 3 shows an ideogram of all the crystals (112 single- and multiple-crystal age determinations involving a total of 244 crystals, see Appendix) that we have dated out of 12 different samples of products of the Albano activity. The inset in Figure 3 shows that the crystals that group into the two modes at 36 and 39 ka belong to two distinct groups of samples that have stratigraphic positions that are consistent with their radiometric ages.

Therefore, the interpretation of the basal horizon of the GRA/Appia Antica section that led Funiciello *et al*. (2003) to identify it as a deposit of the Peperino Albano is not supported. Indeed, except for radiometric ages of the crystals of the juvenile fraction of the deposit, there is no other macroscopic feature (either in mineralogic composition or in the sedimentologic characteristics) that can distinguish it from other distal products of the several pyroclastic-flow deposits erupted by the Albano maar.

Moreover, the interpretation by Funiciello *et al*. (2003), that the entire succession cropping out at the GRA/Appia Antica section is younger than 23±6.7 ka, is in conflict with the ages obtained on crystals from the juvenile fraction of the exposed deposits. Therefore, excluding that the whole volcaniclastic succession is completely reworked, the U/Th series age on the carbonate layer at the base of the GRA/Appia antica volcaniclastic succession (Soligo *et al*., 2003; C layer in their Figure 3) should be considered the result of post-depositional process (e.g., recrystallization, significantly later precipitation of carbonate). However, there are no evidences that the succession is entirely reworked. We conclude that the two primary pyroclastic deposits, that with their supply of syn- and post-eruptive debris-flow deposits represent more than 90% of the entire volcaniclastic succession cropping out at the GRA/Appia Antica site, are distal products of the two main eruptive cycles that occurred at the Albano maar 69±1 ka and 39±1 ka.

Regarding the uppermost deposit above the soil dated 5 ka, we believe that a more thorough geochronologic investigation should be conducted in order to evidence the reliability of this young age. The ^{14}C age of 5100 years was performed on an immature soil that occurs at less than 1 meter below the ground surface (see Figure 5 in Funiciello *et al*., 2002): in these conditions the possibility of contamination of the dated material is always possible since the shallow burial does not guarantee sealing and preservation from younger contaminant material. Unfortunately, no description of the sampling and dating procedure of the paleosoil is given in Funiciello *et al*. (2003) and in Funiciello *et al*. (2002).

Funiciello *et al*. (2002; 2003) have not clarified if they interpret the deposit above this paleosoil to be a primary volcanic layer or a reworked product. Based on the homogeneous population of crystals yielding age of 36±1 ka (evidencing lack of xenocrystic contamination) and based on the chronostratigraphic consistent position and on the petrographic characteristics of this deposit, we believe that also the third, uppermost horizon may be regarded as a syn-eruptive deposit (i.e.a syn-eruptive lahar of the Peperino Albano ignimbrite). Therefore, we believe that the possibility that the entire volcaniclastic succession at the GRA-Appia Antica section was deposited in the time span 70-36 ka cannot be excluded. Indeed, a later deposition for the uppermost horizon that we dated to 36.0±0.1 ka is questionable based on several lines of evidence. First, the strictly homogeneous population of crystals (see Appendix) indicates reworking from a single deposit (i.e. the Peperino Albano); this may be suitable for pyroclastic flows as well as syn-eruptive lahars, which originate at the expense of a homogeneous source material (i.e. the material from a single eruption), whereby post-eruptive lahars should more commonly embed a large amount of xenocrysts, since they usually originate from slope failures or flood events that involve deposits from different eruptions. Moreover, it seems unlikely that the thin (~10 cm) incipiently pedogenized ash layer that separates this upper volcaniclastic horizon from the underlying phreatomagmatic products that yielded the age of 39.0±0.3 ka may be representative of a ~34 kyr-long hiatus in the deposition of the sequence, as it would be if the former is younger than 5 ka. This is more unlikely when one realizes that interpretations by Funiciello et al. (2003) require transportation and redeposition of this material without the incorporation of xenocrysts.

Based on the above mentioned possible unreliability of the ^{14}C age determination and on the absence of crystals of the youngest Albano eruptive event in the uppermost unit, we suggest that further geochronological constraints should be provided in order to prove also that any portion of the volcaniclastic succession that fills the paleovalley at Lucrezia Romana site may be of Holocene age. Standing on present data, we cannot exclude that the volcaniclastic succession of the Lucrezia Romana site correlates to the middle stratigraphic unit at the GRA/Appia Antica section, where a primary unit of the ~39 ka eruptive cycle is followed by debris-flow and fluvial deposit that reworked this same unit along with older volcanic units (Fig. 2).

2. Paleomorphological and paleoclimatic implications

We point out here that the assumption of the Ciampino plain being the site of catastrophic inundations in recent times due to the repeated overspill of the Albano maar lake, as suggested by Funiciello *et al*. (2002; 2003), is not the only possible interpretation of the geomorphologic feature of this area. Based on ^{40}Ar/^{39}Ar data, another explanation could be that he paleo-valleys of the Ciampino area were the location of the emplacement of pyroclastic flows since 70 ka, and it is not possible to exclude that they were already completely filled by 36 ka. The less pronounced erosion that occurs throughout the Ciampino plain, that

FUNICIELLO *et al*. (2002: 2003) have cited as the evidence of very recent overfilling of the hydrographic network, can be explained as well as the result of the earlier emplacement of the syn- and post-eruptive products of Albano in the time span 39-36 ka.

The eruption of the Peperino Albano occurred at a time (36 ka) when about 80% of the erosive phase that began since ~120 ka and culminated into the Würmian low-stand (~18 ka) had already occurred (BARD *et al*., 1990; BASSINOT *et al*., 1994). The Ciampino Plain is located on the pyroclastic plateau at the foot of the relief of the Alban Hills, in a position that is significantly influenced by the processes of erosion and aggradation that occur within the main tributary valleys of the Tiber River. These tributary valleys synchronously responded to the erosional-depositional processes that occurred in the Tiber River Valley (AMMERMAN, 2000; KARNER & MARRA, 1998). It is clear that the emplacement of a large amount of volcaniclastic material close to the time of maximum lowering of the sea level may interfere with regular sedimentary and erosive processes and, ultimately, this may be the cause of the Ciampino plain being unaffected by erosion successively to the emplacement of the Peperino Albano phreatomagmatic deposits.

A reconstruction of the evolution of the paleovalleys in the greater area of Rome is shown in Figure 4. A regional uplift of ~40 m that occurred in the last 200 ka (KARNER *et al*., 2001 c) was the concomitant cause of rejuvenation of the morphological features of the hydrographic network which, at each glacial maximum in the last two marine isotopic stages 7 and 5, was excavated deeper than during the previous ones. In particular, the river incisions were substantially filled as a consequence of the sea-level rise at the peak of stage 7 (a); then, during the regressive phase culminating in the glacial maximum of stage 6, the paleovalleys were re-incised as a consequence of sea-level fall (b); however, the concomitant regional uplift of approximately 20 m in this time span caused the new excavated valleys to be deeper than those originated during previous low-stand. The subsequent sea-level rise associated to high-stand of stage 5 accounted only for partial filling of these sharp paleomorphologies (c). This phenomenon occurred also during the following, last glacial cycle (d'-e'), when other ~20 m of uplift occurred in this area, resulting in the particular feature of the hydrographic network that is characterized by "canyoning" of the Holocene alluvial valley, with prominent, steep banks that border the floodplain, as it is visible in the DEM image of Figure 5. This feature is absent in the Ciampino plain, as observed by FUNICIELLO *et al* (2002), as well as in other, limited sectors of the Rome area. Figure 4 d" shows the situation of the paleovalleys in area of Rome 40 kyr ago, just before the second cycle of activity of Albano started. Differently than in all the other valleys in the area of Rome, the incisions in the Ciampino area have been filled by the deposits of the Albano activity in the time span 39-36 ka (Fig. 4 c'''), thus after 80% of the regression associated to the last glacial maximum had occurred (Fig. 4 d"). Actually, regression started after 125 ka and culminated 19 ka, whereby the Peperino Albano was erupted 36 ka: thus only (36-19) 17 kyr of new erosion occurred, after that the marked erosive pattern excavated in (125-36) 89 ka was obliterated by emplacement of the pyroclastic flows. Retrograde erosion during the remaining 20% of the last glacial maximum was probably not enough to re-establish the morphologic features of the hydrographic network, that were excavated during the previous several erosive phases (Fig. 4 c''''). The Holocene sea-level rise then caused this faint morphology to be almost completely obliterated, conferring to the Ciampino plain its present character (Fig. 4 e').

This becomes more apparent when one realizes that a very similar phenomenon occurred toward the southeast of the Albano Lake, where another flat sector, similar to that near Ciampino is present (Figure 5). Here, the Holocene hydrographic network of the Rio Torto stream near the locality of Santa Procula is partially filled and obliterated by the pyroclastic flows and lahars of the 39-36 ka activity (GIORDANO *et al.*, 2002b; MARRA *et al*., 2003; Fig. 2). This similar feature near Santa Procula calls for a nearly syn-eruptive infilling of the hydrographic network due to directional emission of pyroclastic flows and the related emplacement of lahars, as illustrated in Figure 6, rather than being interpreted as due to the overspill of the Albano Lake, suggesting that the very same thing may have occurred also in the Ciampino Plain.

3. Evidence from the sediments of the Albano lake

The absence of any Holocene eruptive activity at the Albano crater can also be inferred after a careful analyses and discussion of the borecore data of the sediments filling Albano Lake and the nearby Nemi lake, provided by the PALICLAS scientific project (Guilizoni and Oldfield Eds. 1996). The analyses of these four borecores indicate the lack of any volcanic deposit of the Albano maar in the time interval 25 ka - present day. The Albano Lake has a maximum depth of 175 m and the morphology of its bottom suggests the existence of three main craters (see Fig. 7b): two craters approximately 2 km in diameter which overlap each other along a NW-SE direction, and a third crater with a diameter of 0.5 km at the center of the southeastern one. The smallest crater is evidently also the youngest crater, while the northwestern crater is the oldest. We suggest that these three craters correlate to the three main eruptive cycles at 36 ka, 39 ka and 69 ka, respectively.

Three borecores (re-labeled here 1, 2 and 3, Fig. 7) drilled at different water depths on the bottom of the Albano Lake were analyzed in CHONDROGIANNI *et al*. (1996). In borecore 1, located at higher elevation (30 m water depth), continuous sedimentary deposits of age between 25.11 and 15.78 ka (age calculated based on two calibrated ages of 21.26 ka and 18.39 ka obtained on pollen grains (errors associated with this ages are not reported), CHONDROGIANNI *et al*., 1996) are present above a volcaniclastic substrate, a sample of which was dated by $^{40}Ar/^{39}Ar$ methods at 45±3 ka (VILLA *et al*., 1999). Age of this sample is consistent with that of the products cropping out at the top of the Albano reference section (Fig. 2) and, more in general, it is consistent at two sigma with the group of ages that constitutes the youngest sub-cycle (39±1 ka) of the second eruptive cycle of the Albano maar (FREDA *et al*., 2005). In borecore 2, a longer sedimentary record, spanning the interval ~30 ka - Present was found above the volcaniclastic substrate dated at 26±1 ka (VILLA *et al*., 1999).

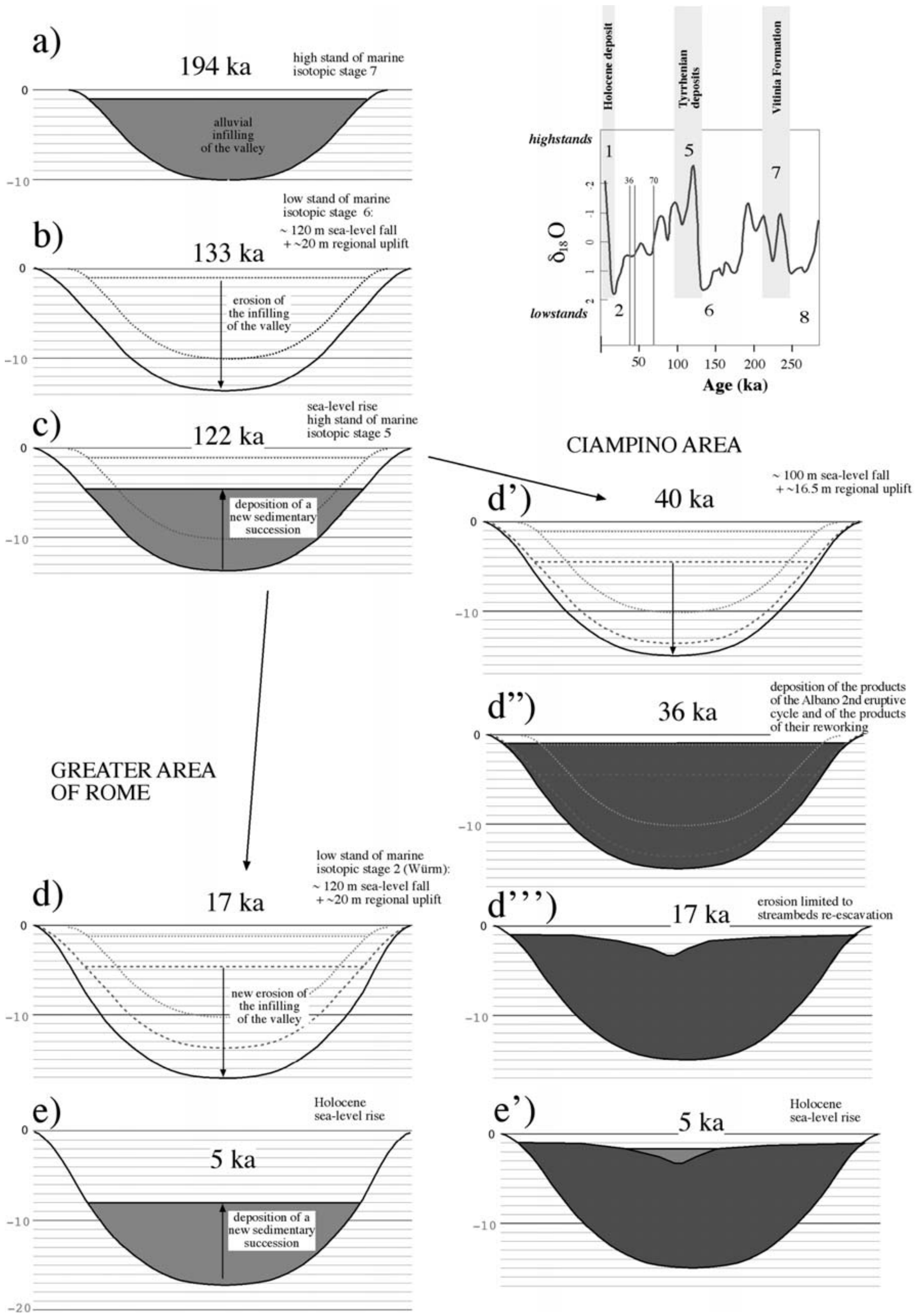

Fig. 4 - Reconstruction of the alternate phases of erosion and deposition, and the effect of regional uplift that influenced the evolution of the Hydrographic network in the area of Rome in the last 200 kyr. Inset on the right upper corner shows the isotopic curve (redrawn from Bassinot et al., 1994) for the last three glacial cycles, and the position of the ages of the eruptive cycles of the Albano Maar with respect the timing of the glacio-eustatic oscillations.

Ricostruzione degli effetti combinati dell'alterenarsi delle fasi erosive e deposizionali e del sollevamento regionale che hanno influenzato l'evoluzione del retricolo idrografico nell'area romana negli ultimi 200.000 anni. Nell'angolo in alto a destra è mostrata la posizione delle età dei cicli eruttivi del maar di Albano sulla porzione della curva degli isotopi dell'ossigeno relativa agli ultimi tre cicli glaciali.

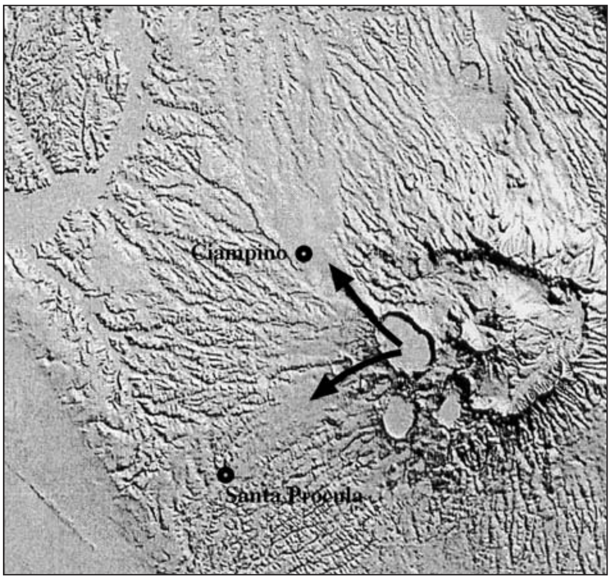

Fig. 5 - DEM (digital elevation map) of the Alban Hills and eastern Rome. A prominent hydrographic network in this region is the result of approximately 40 m of uplift during the last 250 kyr (KARNER *et al*., 2001c), which produced canyon-like valleys with prominent banks over the floodplains. In this framework, several small sectors appear as isolated plateaus: the most prominent of them is the Ciampino plain that FUNICIELLO *et al*. (2003) suggested to be the result of catastrophic inundation in historical times, due to the repeated overspill of the Albano Lake. However, other similar sectors, like that near the Santa Procula locality, are probably the result of obliteration of the paleovalleys due to emplacement of pyroclastic flows from the Albano maar around 39 ka and 36 ka, after most of the erosion linked with the last glacial maximum had already occurred.

*Immagine DEM (digital elevation map) dell'area albana e dell'area orientale di Roma. I caratteri molto marcati del reticolo idrografico in questa regione sono il risultato del sollevamento di circa 40 metri avvenuto negli ultimi 250,000 anni (*KARNER et al.*, 2001c), che ha originato delle valli molto incise, con sponde acclivi che bordano le attuali piane fluviali, in un panorama dal rilievo molto poco marcato. In questo contesto, vi sono alcuni piccoli settori che appaiono come dei plateau isolati: il più evidente di questi è la cosiddetta piana di Ciampino che* FUNICIELLO et al. *(2003) hanno suggerito essere il risultato di un colmamento dovuto a catastrofiche inondazioni in tempi storici, originate dalla tracimazione del Lago di Albano. Si nota tuttavia che altri settori del tutto simili, come quello qui evidenziato in prossimità della località di Santa Procula, sono più verosimilmente il risultato dell'obliterazione delle paleovalli ad opera della messa in posto dei flussi piroclastici originati dall'attività del maar di Albano intorno a 39 ka e 36 ka, quando gran parte dell'attività erosiva legata all'incipiente massimo glaciale würmiano era già avvenuta.*

This latter age would be the youngest eruptive product ever dated by $^{40}Ar/^{39}Ar$ methods at the Alban Hills. However, the step-heating experiments as shown in VILLA *et al*. (1999) yielded release patterns that are unusual for Alban Hills leucites, as stated by the same Authors, and ultimately did not produce plateaus that meet standard criteria of 50% concordant ^{39}Ar release in three contiguous steps (MCDOUGALL and HARRISON, 1999). Additionally, those experiments used small sampling of these pyroclastic layers (1-3 crystals). Given the differences in experimental techniques and methodolo-

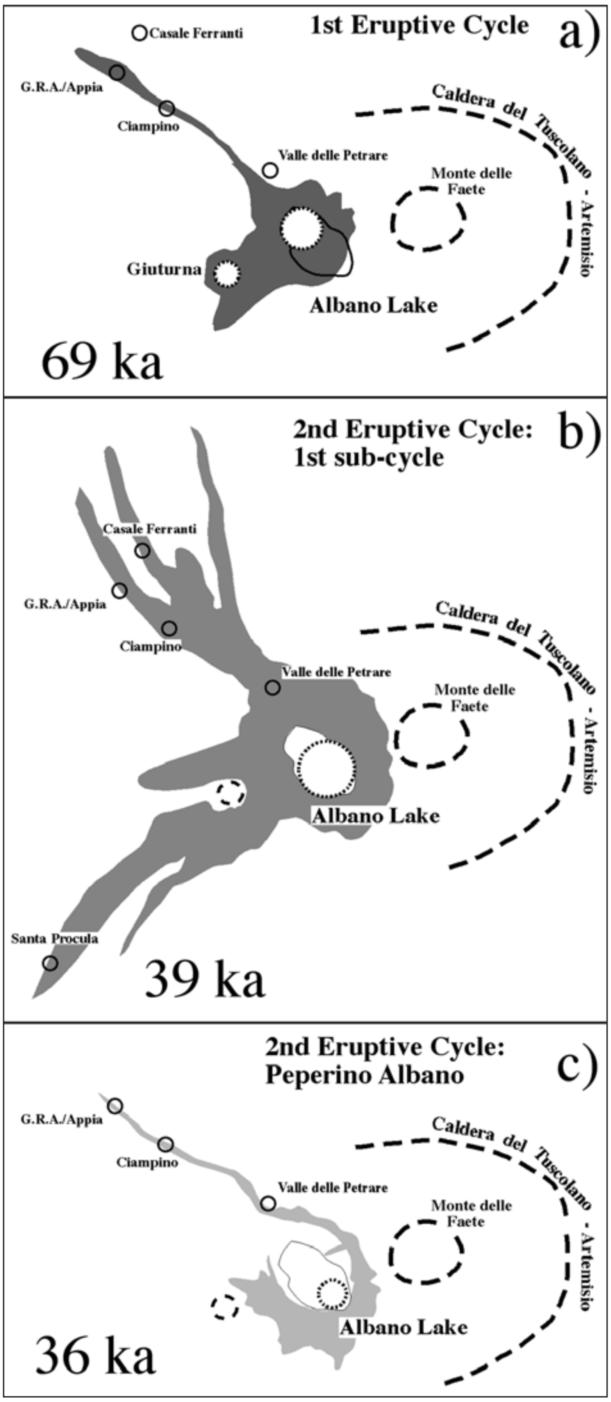

Fig. 6 - Tentative reconstruction of the spatial distribution of the products of the three geochronologically distinct eruptive cycles of Albano, based on field survey data and chronostratigraphic investigation. All the eruptions seem to show NW directionality, with the exception of the first subcycle at 39 ka, which according to FREDA *et al.* (2005) is the most energetic and emplaced the largest volume of products to the NW as well as to the SW of the Albano center.

Ricostruzione ipotetica della distribuzione spaziale dei prodotti dei tre cicli eruttivi principali del maar di Albano, basata su dati di terreno e indagini cronostratigrafiche. Tutte le eruzioni sembrano avere direzionalità verso NW, ad eccezione del primo sub-ciclo eruttivo di 39 ka, il quale, in accordo con FREDA et al. *(2005), appare essere il più energetico e ha determinato la messa in posto del maggiore volume di prodotti sia verso NW che in direzione SW rispetto al centro eruttivo di Albano.*

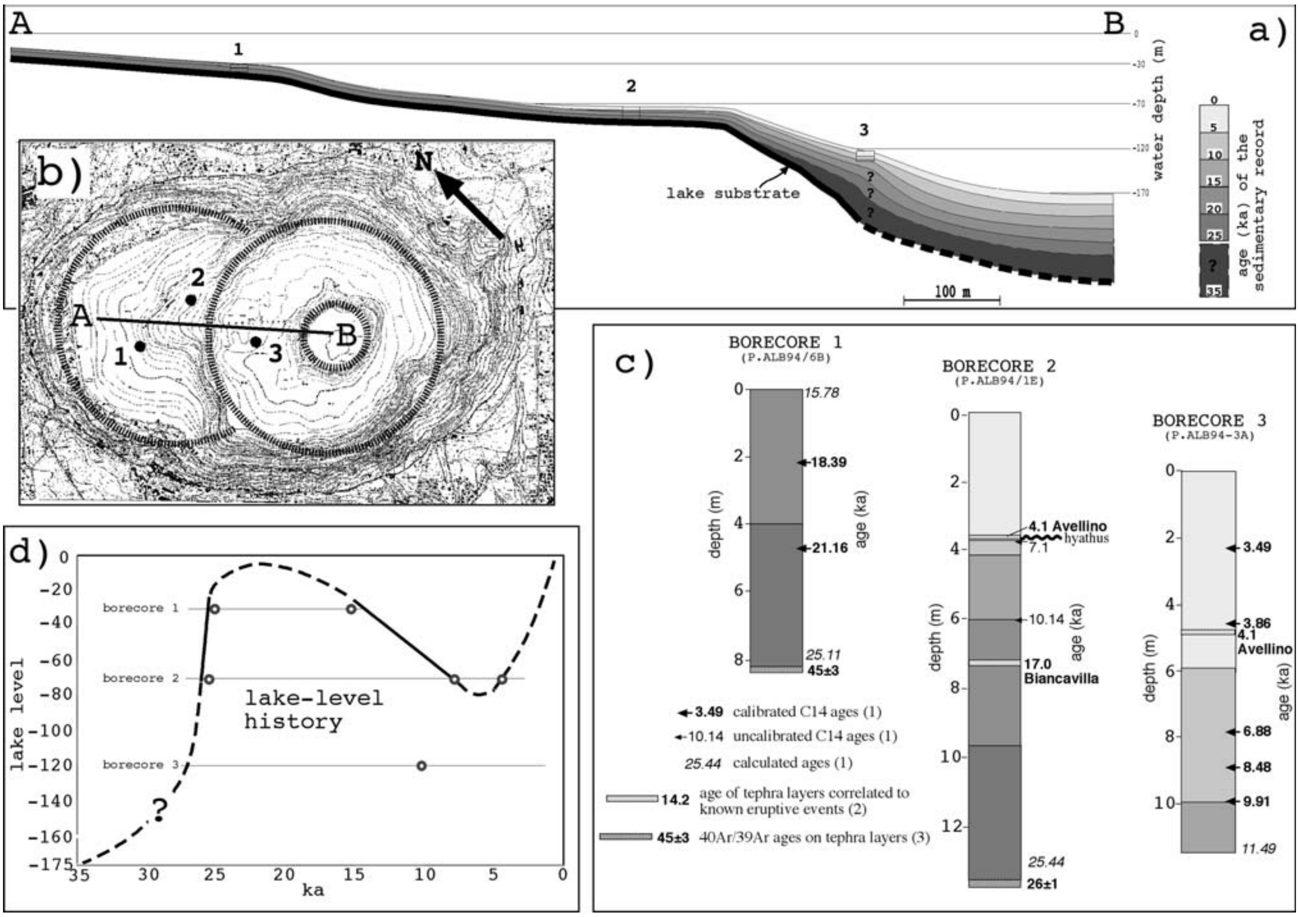

Fig. 7 - a) Cross-section of the sediments of the Albano Lake, reconstructed using seismic reflection and borecore data (c) in CHONDROGIANNI *et al*. (1996). Inset b shows the location of the borecores and of the cross-section. A tentative explanation of the lack of sediments younger than 15.8 ka in core 1 and of the ~3 kyr-long hyatus in core 2 is the lake-level fluctuation as reconstructed in the diagram (d) of this figure, using constrains on the minimum water depth given by the sedimentary record of the three borecores. The absence of any volcanic material within the sedimentary record in the three cores spanning the last 25 kyr that can be attributed to activity of the Albano maar clearly suggests that no such volcanic activity occurred.

a) Sezione stratigrafica dei depositi sedimentari del Lago di Albano, ricostruita in base a dati di sismica a riflessione e carote di sondaggio (c) da CHONDROGIANNI et al. *(1996). La pozizione dei sondaggi e della sezione è mostrata nel riquadro b. Una possibile spiegazione della mancanza di sedimentazione più recente di 15.8 ka nel sondaggio 1, e della presenza di uno hyatus di circa 3 ky nel sondaggio 2 è verosimilmente costituita dalle oscillazioni del livello del lago, così come sono state ricostruite nel diagramma (d) mostrato in figura per mezzo dei vincoli sulla minima profondità dell'acqua forniti dal record sedimentario. L'assenza di qualsiasi prodotto vulcanico attribuibile all'attività albana all'interno dei sedimenti recuperati dai tre sondaggi, che coprono l'intervallo ~25 ka - Presente, è una chiara indicazione dell'assenza di tale attività.*

gies, the error associated to the age of 26 ka obtained by VILLA *et al*. (1999) should be considerably expanded when this age is compared to those obtained by FREDA *et al*. (2005). Therefore, we consider the age of 26±1 ka on the pyroclastic material dated by VILLA *et al*. (1999) to be undistinguishable either from the 39±1 ka or 36±1 ka groups of ages obtained for the most recent activity of the Albano maar by FREDA *et al*. (2005).

An age of about 25.44 ka was tentatively calculated (CHONDROGIANNI *et al*., 1996) for the base of the sedimentary deposit recovered in borecore 2, based on the age of 17 ka for one tephra layer recovered in this borecore and correlated to the Biancavilla eruption, and assuming a constant sedimentation rate. However, sedimentation rates within a lake can be variable; CHONDROGIANNI *et al*. (1996) estimate the start of the sedimentation of the Albano sequences recovered in the analysed borecores to be ~30 ka. If we consider that the deeper portion of the sedimentary fill of the Albano Lake (at least 50 m, as evidenced by the inferred depth of the lake substrate from seismic reflection data in CHONDROGIANNI *et al*., 1996) was not recovered in the analysed borecores (see Fig. 7), it is reasonable to assume that the start of sedimentation may be consistent with a crater formation age of about 36 ka. However, the sedimentary deposit in borecore 2 is not continuous. A hiatus of about 3,000 years is present in between a ^{14}C dated sample at 7.11 ka and an overlying tephra horizon correlated by means of chemical analyses (CALANCHI *et al*., 1996) to the Avellino eruption which occurred at the Somma-Vesuvius (SANTACROCE, 1987) and has a calibrated ^{14}C age (STUIVER and REIMER, 1993) of 4.1 ka. Another tephra layer occurs at the middle of borecore 2 and it is correlated (CALANCHI e*et al*., 1996) to the Y-1 tephra layer (KELLER *et al*., 1978) which corresponds to the Biancavilla-Montalto eruprion, whose calibrated ^{14}C age (STUIVER and REIMER, 1993) is 17 ka. A continuous sedimentary succession is recovered in borecore 3 which spans the time interval 11.5 ka - Present and includes the tephra layer correlated to the Avellino plinian eruption of 4.1 ka. A similar continuous sedimentary record spanning the time interval 10.78 ka - Present (CHONDROGIANNI *et al*., 1996) is found at the nearby (~3 km to the SW) Nemi Lake. In this borecore a tephra layer correlated to the Avellino plinian eruption of 4.1 ka (CALANCHI *et al*., 1996) is also found interbedded within the sedimentary succession.

The sedimentary hiatuses (~15 ka - Present, ~7 ka- ~4ka) observed within two of the four described borecores can readily be explained by oscillations of the water level within the Albano Lake (see figure 7). Alternative explanations, as those provided in VILLA *et al*. (1999) that the hiatuses may be due to draining of the lake by the opening of new craters, seems implausible since no evidence of these hypothesized eruptive events are found in the borecores drilled at Albano Lake or Nemi Lake. The only tephra layers recovered from the sedimentary cores from these lakes during the interval 25 ka - Present, have chemical composition characterized by high SiO2 content (>55% in one case, and >59% in the other three cases) and by low CaO content (CALANCHI *et al*., 1996), which rules out an Alban Hills origin. All the volcanic products erupted by this volcanic district since 600 ka have SiO2 content below 50% and very high CaO content (TRIGILA *et al*., 1995, MARRA *et al*., 2003, FREDA *et al*., 2005). It seems quite unlikely that any eruptive activity occurred at the Albano maar in the time span 25 ka - Present, without leaving any trace of volcanic deposits within the sediments of the very same crater lake.

CONCLUSIONS

Detailed stratigraphic and geochronologic studies conducted recently have chronicled the eruptive history for the Albano maar. Reworked products of the volcanic activity may have been redeposited as lahars in the last 10,000 years, but it remains to be shown that any magmatic activity has occurred in this time span, based on the lack of any crystal younger than 31±3.6 ka in the entire suite of age analyses that we have determined to be primary volcanic material (244 crystals analyzed in 51 single-crystal and 61 multiple-crystal $^{40}Ar/^{39}Ar$ age analyses in FREDA *et al*., 2005).

Based on the geochronologic and stratigraphic data, comprising the lack of any volcanic deposit younger than at least 26 ka correlated to the activity of the Albano maar in the sedimentary filling of the crater lake, and based on the analysis of the geomorphological and paleoclimatic context that we have discussed, it seems also reasonable to interpret all the sections that have been suggested to host primary and reworked products deposited in the last 23,000 years (FUNICIELLO *et al*., 2002; 2003), to be instead outcrops of distal, syn-eruptive or short-termed post-eruptive products of the activity that took place at the Albano maar in the time span 70-36 ka. The only existing geochronologic constraint that allows to ipothesize an emplacement younger than 36 ka for any product (either primary or reworked) of the Albano maar relies on two ^{14}C age age determinations of ~5100 kyr on as many paleosoils. However, we point out that ^{14}C dating of poorly developed, shallow seated soils is always susceptible to be affected by problems of contamination. Ages of the crystals within the reworked products that rest above the dated soils, when considered within the larger chronostratigraphic framework that we have outlined, suggest that they may be as well, in one case (GRA/Appia Antica) subcoeval with the Peperino Albano, and in another case (Lucrezia Romana-Casale Ferranti) older than the Peperino Albano. We conclude that more solid evidences should be provided, comprising both direct and indirect dating, in order to demonstrate that any reworked product among those studied at the GRA-Appia Antica and Lucrezia Romana sites has an emplacement age younger than 36 ka. On the other hand, assuming that the ^{14}C age on the two soils provided in FUNICIELLO *et al*. (2002) be reliable, it has to be ascertain if the overlying deposits are primary or reworked products. In the latter case, it would testify to the existence of thin (50 to 100 cm) layers of reworked volcaniclastic material locally accumulated within small fluvial incisions at the foot of the Alban Hills after the Holocene climatic optimum, which would imply a simple sedimentary process, rather than catastrophic inundations. Completely different would be the case of the identification of primary volcanic products resting above the soils dated by ^{14}C method at 5 ka. In this case the assessment of the reliability of the ^{14}C age becomes a crucial task to establish when (and where) their eruption occurred. However, we point out that, based on the average recurrence time of 45 kyr for the overall activity at the Alban Hills, an eruption at 5 ka following one at 36 ka would diminish the potential hazard rather than increase it.

For the moment, if we rely on the strict definition that is adopted in the Smithsonian Institution's catalogue of active volcanoes, we believe that further, more detailed studies have to be conducted in order to demonstrate that the Albano maar is an active volcano. For this reason we are presently involved in a dedicated research unit within the 2005-2007 GNV-DpC V3_1-Colli Albani Sub-Project, aimed to clarify the issues discussed above.

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Appendix - $^{40}Ar/^{39}Ar$ data. The third column indicates the number of crystals dated in each laser-fusion age determination. Samples in italics were interpreted to contain xenocrysts and were eliminated to reduce the MSWD (mean square weighted deviation) to below 1.5- a reasonable statistic for a group of ages from an eruptive event (see FREDA *et al*., 2005 for details on the procedure). These italicized data were eliminated from the error-weighted mean calculations for each sample above, and were eliminated from the ideogram in Fig. 3.

*Dati radioisotopici $^{40}Ar/^{39}Ar$. La terza colonna indica il numero di cristalli impiegati per ottenere le singole età dalla loro fusione laser. I dati in italico si riferiscono a cristalli o gruppi di cristalli interpretati come contaminanti ed eliminati dal calcolo dell'età al fine di ridurre la deviazione quadratica sotto il valore di 1.5, che si considera un valore statistico adeguato ad identificare un singolo evento eruttivo (si veda F*REDA et al.*, 2005, per i dettagli di questa procedura). I dati in italico sono stati eliminati dal calcolo della media pesata per ogni età dei campioni e dall'ideogramma in Figura 3.*

Lab.No.	Sample ID	# of Crystals	Age (Ma)	± 1σ[d]
Samples included in the youngest population				
33135-01	AH-4Fbis	1	0,0371	0,0013
33135-02	AH-4Fbis	1	0,0358	0,0014
33135-03	AH-4Fbis	1	0,0329	0,0011
33135-04	AH-4Fbis	1	0,0333	0,0011
33135-05	AH-4Fbis	1	0,0358	0,0012
33135-06	AH-4Fbis	1	0,0355	0,0011
	Weighted Mean (4)		**0,0359**	**0,0006**
11375-01	AH18-C2	2	0,0358	0,0002
11375-02	AH18-C2	2	0,0363	0,0003
11375-03	AH18-C2	2	0,0363	0,0003
11375-04	AH18-C2	2	0,0356	0,0004
11375-05	AH18-C2	2	0,0357	0,0003
11383-01	GRA-C2bis	2	0,0375	0,0005
11383-02	GRA-C2bis	2	0,0367	0,0005
11383-03	GRA-C2bis	2	0,2226	0,0009
11383-04	GRA-C2bis	2	0,0387	0,0013
11383-05	GRA-C2bis	2	0,0398	0,0008
11383-06	GRA-C2bis	2	0,0374	0,0004
11383-07	GRA-C2bis	2	0,0448	0,0011
	Weighted Mean (8)		**0,0360**	**0,0001**
11075-01	MAM-01	8	0,0406	0,0040
11075-02	MAM-01	8	0,0445	0,0037
11075-03	MAM-01	8	0,0334	0,0024
11075-04	MAM-01	8	0,0324	0,0025
11075-05	MAM-01	8	0,0370	0,0044
11075-06	MAM-01	8	0,0345	0,0037
11075-07	MAM-01	8	0,0392	0,0031
11075-08	MAM-01	8	0,0315	0,0039
	Weighted Mean (8)		**0,0357**	**0,0011**
33805-01	AH17-C3	1	0,0463	0,0009
33805-02	AH17-C3	1	0,0372	0,0013
33805-03	AH17-C3	1	0,0325	0,0037
33805-04	AH17-C3	1	0,0354	0,0005
33805-05	AH17-C3	1	0,0390	0,0008
33805-06	AH17-C3	1	0,0376	0,0014
33805-07	AH17-C3	1	0,0352	0,0013
33805-08	AH17-C3	1	0,0380	0,0006
33805-09	AH17-C3	1	0,0372	0,0012
33805-10	AH17-C3	1	0,0384	0,0006
33805-11	AH17-C3	1	0,0348	0,0009
33805-12	AH17-C3	1	0,0483	0,0016
33805-13	AH17-C3	1	0,0362	0,0009
33805-14	AH17-C3	1	0,0410	0,0007
33805-15	AH17-C3	1	0,0343	0,0020
33805-16	AH17-C3	1	0,0512	0,0015
33805-17	AH17-C3	1	0,0373	0,0009
33805-18	AH17-C3	1	0,0398	0,0017
33805-19	AH17-C3	1	0,0368	0,0011
33805-20	AH17-C3	1	0,0420	0,0005
	Weighted Mean (12)		**0,0361**	**0,0003**
11391-01	AH19-C1bis	1	0,2986	0,0009
11391-02	AH19-C1bis	1	0,3170	0,0008
11391-03	AH19-C1bis	1	0,3533	0,0011
11391-04	AH19-C1bis	1	0,0390	0,0006
11391-05	AH19-C1bis	1	0,0381	0,0003
11391-07	AH19-C1bis	1	0,3594	0,0013
	Weighted Mean (2)		**0,0382**	**0,0003**
11374-01	AH19-C2	2	0,0402	0,0004
11374-02	AH19-C2	2	0,0380	0,0003
11374-03	AH19-C2	2	0,0397	0,0005
11374-04	AH19-C2	2	0,0405	0,0007
11374-05	AH19-C2	2	0,0402	0,0006
11374-06	AH19-C2	3	0,0390	0,0003
	Weighted Mean (5)		**0,0388**	**0,0002**
11376-01	AH18-C3	3	0,0389	0,0007
11376-02	AH18-C3	3	0,0381	0,0005
11376-03	AH18-C3	3	0,0441	0,0003
11376-04	AH18-C3	3	0,0383	0,0005
11376-05	AH18-C3	3	0,0399	0,0005
11376-06	AH18-C3	3	0,0395	0,0005
	Weighted Mean (4)		**0,0390**	**0,0003**
33136-01	AH3-C14	1	0,0396	0,0017
33136-02	AH3-C14	2	0,0392	0,0030
33136-03	AH3-C14	5	0,0442	0,0021
33136-04	AH3-C14	3	0,0405	0,0012
33136-05	AH3-C14	4	0,0473	0,0023
33136-06	AH3-C14	3	0,0421	0,0020
	Weighted Mean (5)		**0,0409**	**0,0008**
33132-01	AH3-C12L	1	0,0397	0,0040
33132-02	AH3-C12L	1	0,0431	0,0013
33132-03	AH3-C12L	1	0,3571	0,0023
33132-04	AH3-C12L	1	0,0398	0,0016
33132-05	AH3-C12L	1	0,0437	0,0018
33132-06	AH3-C12L	1	0,0498	0,0024
33132-07	AH3-C12L	1	0,0435	0,0010
33132-08	AH3-C12L	1	0,0568	0,0015
	Weighted Mean (3)		**0,0412**	**0,0011**
33137-01	AH3-C9	2	0,0679	0,0021
33137-02	AH3-C9	3	0,0686	0,0020
33137-03	AH3-C9	4	0,0719	0,0020
33137-04	AH3-C9	3	0,0534	0,0124
33137-05	AH3-C9	5	0,0689	0,0072
33137-06	AH3-C9	4	0,0629	0,0035
	Weighted Mean (6)		**0,0686**	**0,0011**
11385-01	AH18-C1	2	0,0697	0,0009
11385-02	AH18-C1	2	0,0707	0,0006
11385-03	AH18-C1	2	0,0698	0,0004
11385-04	AH18-C1	2	0,0682	0,0005
11385-05	AH18-C1	1	0,0688	0,0004
	Weighted Mean (4)		**0,0689**	**0,0002**
11334-01	AH-3A	1	0,0702	0,0012
11334-02	AH-3A	1	0,0690	0,0012
11334-03	AH-3A	1	0,0676	0,0020
11334-04	AH-3A	1	0,0678	0,0017
11334-05	AH-3A	1	0,0721	0,0015
	Weighted Mean (5)		**0,0694**	**0,0006**