**SUPPLEMENTARY MATERIAL, S**

**S-A**

Integrating equation

= - = = λ

with initial condition at the time to, we obtain:

ln = - λ (t – to)

and

= (1A)

where ln indicates the natural logarithm, t is the time of interest, tois the initial time when the number of atoms is , and is the Neper’s number (e = 2.71828 …).

**S-B**

For the mineral phases 1, 2, …, ϕ, we have:

=

Dividing and multiplying and the generic value by and respectively, and considering the isotopic abundances X, we obtain:

= = (1B)

The ratios for each mineral 1, 2, …, ϕ is a mathematical weight which evaluates the role of the different phases in defining the isotopic features of the total rock, tot, formed by the minerals 1, 2, …, ϕ.

The ratio is frequently substitutes by the ratio, where and are the number of strontium atoms in the mineral i and in the total rock, tot, respectively. Thus:

≅ (2B)

Multiplying and dividing (2B) by the atomic weight, of strontium, we obtain

≅ = (3B)

where Q represents the different masses. Multiplying and dividing for the mass of the minerals 1, 2, …, ϕand of the total rock, tot, is

= + +… + =

= + + … + =

= (4B)

where and are the weight concentrations of strontium in the minerals 1, 2, …, ϕ and in the total rock, tot,and =, =,…, = , the relative weight abundance of the different minerals in the total rock. It is noteworthy that (2B) -and thus (3B)- are rigorously correct only in case the ratio is the same for all the minerals, as demonstrated below.

Consider the number of atoms and the number of atoms of total strontium in the generic mineral i and and in the total rock, tot. In any mineral i as well as in the total rock, tot, the number of moles will be related to total strontium, , present in the single phase i or in the total rock, tot. Thus, for any phases and for the total rock we may write the isotope abundance:

= (5B)

= (6B)

Combining (5B) and (6B), we write:

= (7B)

From equation (7B), it is evident that equation (2B) and (3B) may be used in place of (1B) only in case for all the different minerals 1, 2, …, ϕand, thus, for the total rock, tot, the values are the same, i.e., = 1

**S-C**

Consider equation (3B) referred to the aqueous solution, aq:

≅ = (1C)

where aq refers to the total number of the strontium nuclides transferred in solution from the minerals and aq(i) to the number of nuclides transferred to the aqueous solution by the dissolution of the mineral i, and indicates the relative contribution of the miuneral i to the total strontium transferred into solution.

In conditions far from the solution saturation in calcite and muscovite, in agreement with the kinetic values reported in the text, for calcite and muscovite dissolution in water, aq, we write:

≅ 1 (2D)

Given the formula weight equal to = 100.09 g/mole for calcite and = 316.32 g/mole for muscovite and considering the relation (2D), for the mass of calcite and the mass of muscovite transferred into solution, the following relation holds:

= = 1 → = 0.32 1

Consider now a rock with muscovite and calcite. In the example of Table S-C; we have:

= 0.32 1

+ =

Combining the two equations, we obtain:

= = 3.124902

= (1- 3.124902) = 0.9999688

where small digits have not physical significance but are reported only to make calculation more evident. Thus, the mass of strontium transferred from the minerals to the solution is calculated as follows:

= = 0.080 0.9999688 = 0.07999750

= = 0.0073.124902 = 0.02187431

Strontium transferred from calcite is very high in comparison to that from muscovite. We omit other calculations, which are evident in Table S-C.

**Table S-C. Example of strontium isotope calculation for a water which dissolves calcite (Cc) and muscovite (Mu)**

|  |  |  |  |
| --- | --- | --- | --- |
| = | 0.30 | = | 0.70 |
|  | 0.080 |  | 0.007 |
|  | 0.91954023 |  | 0.08045973 |
|  | 0.9999688 |  | 3.124902 10-5 |
| = | 0.07999750 | = | 0.02187431 10-5 |
| = = | 0.9999972 | = = | 0.273729910-5 |
|  | 0.70700 |  | 0.8105 |
| ≈ = 0.99999720.7070 + 0.2737299  10-5 0.8105 = 0.707000239 | | | |

and , relative weigh amount of Cc and Mu in the total rock. = /, strontium concentration in the mineral i and = /, strontium concentration in the total rock. mass of Cc and Mu transferred from the mineral into solution. and , mass of strontium transferred from Cc and Mu into solution. and , mass of strontium transferred from Cc and Mu into solution and , relative weight amount of strontium transferred from Cc and Mu into solution. Digits are reported in excess (small character) for a better comprehension of the calculations.

**S-D**

Assume that, for each investigated archaeological Area 1 and Area 2 we dispose of twenty data of / obtained on twenty remains collected randomly. We want to verify if the remains *may* bereferred to the same group or not. This, of course, depends on the way we use to define the group. In case the distribution of data is statistically “normal” (normality verified, for instance, using the Shapiro-Wilk and Anderson-Darling normality tests), in order of stating that a sample *may* belong to the group of interest, we may use the “contrast” value (“contrast” ≤ 1). On the contrary, if the data distribution is not “normal”, we can use “kernel density”. The “kernel density” estimation is a [non-parametric](https://en.wikipedia.org/wiki/Non-parametric_statistics) method to [estimate](https://en.wikipedia.org/wiki/Estimation) the [probability density function](https://en.wikipedia.org/wiki/Probability_density_function) of a [random variable](https://en.wikipedia.org/wiki/Random_variable), a method based on [*kernel*](https://en.wikipedia.org/wiki/Kernel_(statistics)), which is a [smoothing](https://en.wikipedia.org/wiki/Smoothing) parameter. In the example reported in Table S-D-Area 1, the data have “normal” distribution and thus the value of the “contrast” is useful for the attribution of the single sample to the group. In our case, all samples exhibit “contrast” ≤ 1: thus, we *cannot exclude* that all the samples come from the same group. The data from tArea 2, have not “normal” distribution; thus, the parameter “contrast” in not significant. In this case, in our opinion, is better to use the “kernel density” as reported in Fig. S-D-Area 2. In this diagram, the distribution simulates bimodal distribution: three samples (0.7086, 0.7089, and 0.7091) are far from the main group. Thus, we state that they may be regarded as not belonging to the group. Note that in case one group merges into the other, for some samples the attribution to one group or to the other could result difficult.

**Table S-D. Data for two different archaeological areas under investigation**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Area 1* | *Contrast* |  | *Area 2* |  |
| 0.7069 | 0.998 |  | 0.7069 |  |
| 0.7076 | 0.999 |  | 0.7076 |  |
| 0.7075 | 0.999 |  | 0.7086 |  |
| 0.7074 | 0.999 |  | 0.7089 |  |
| 0.7071 | 0.999 |  | 0.7091 |  |
| 0.7075 | 0.999 |  | 0.7075 |  |
| 0.7073 | 0.999 |  | 0.7073 |  |
| 0.7074 | 0.999 |  | 0.7074 |  |
| 0.7071 | 0.999 |  | 0.7071 |  |
| 0.7070 | 0.998 |  | 0.7070 |  |
| 0.7072 | 0.999 |  | 0.7072 |  |
| 0.7077 | 0.999 |  | 0.7078 |  |
| 0.7076 | 0.999 |  | 0.7079 |  |
| 0.7073 | 0.999 |  | 0.7073 |  |
| 0.7074 | 0.999 |  | 0.7074 |  |
| 0.7071 | 0.999 |  | 0.7071 |  |
| 0.7072 | 0.999 |  | 0.7072 |  |
| 0.7074 | 0.999 |  | 0.7074 |  |
| 0.7077 | 0.999 |  | 0.7077 |  |
| 0.7078 | 1.000 |  | 0.7079 |  |
|  |  |  |  |  |
| *Normality test, p(normal)* |  |  | *Normality test, p(normal)* |  |
| Shapiro-Wilk | 0.81 |  | Shapiro-Wilk | 0.0057 |
| Anderson-Darling | 0.78 |  | Anderson-Darling | 0.0050 |
| *Number of data* | 20 |  | *Number of data* | 20 |
| *Average,* | 0.70736 |  | *Average,* | 0.70762 |
| *Standard deviation, s* | 0.00025 |  | *Standard deviation, s* | *0.00061* |
| *Treshold, + 3s* | 0.70811 |  | *Treshold, + 3s* | *0.70945* |



**Fig. S-D-Area 1.** “Kernel density” for data of Area 1. Apparently, we could assume that all samples belong to the same group.



**Fig. S-D-Area 2.** “Kernel density” for data of Area 2; the distribution is “bimodal”. Three samples are far from the main group and, thus, we could assume that they belong to a different group.