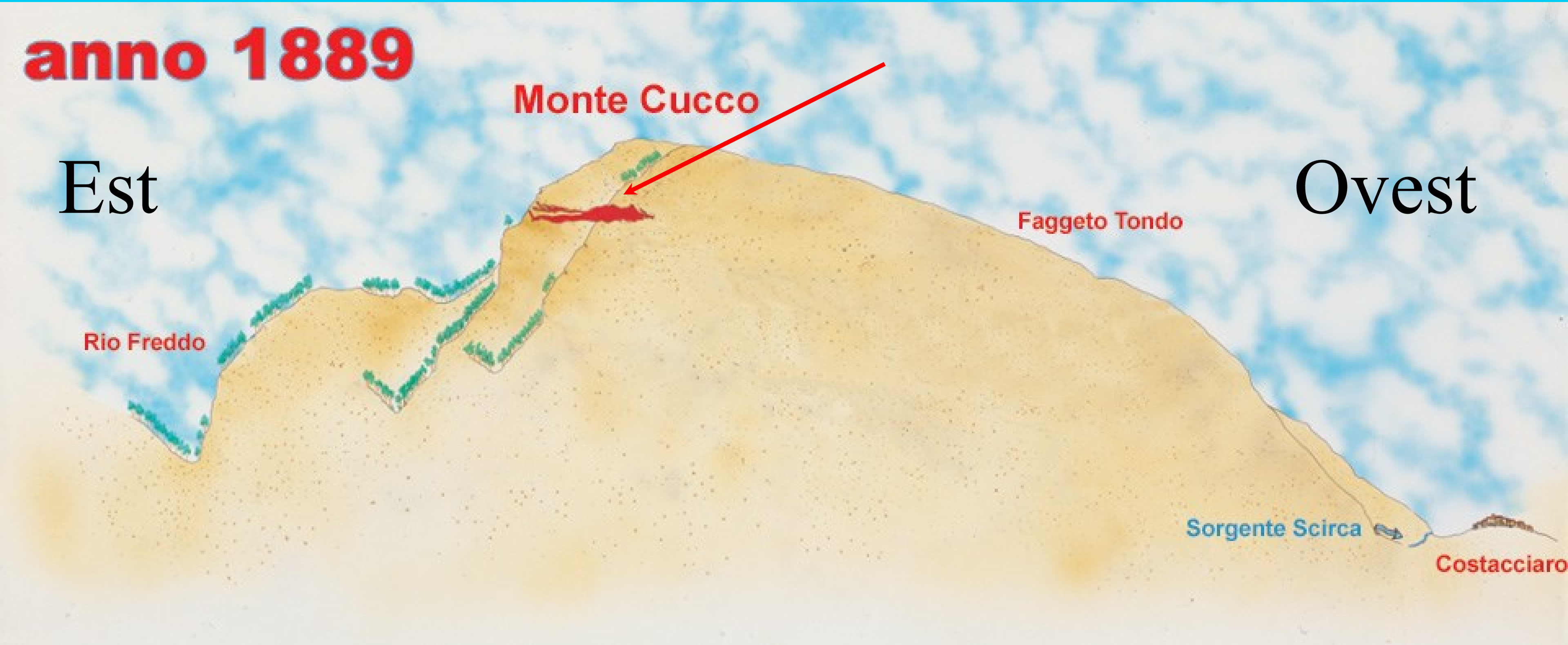
MONTE CUCCO

1957 - 2009

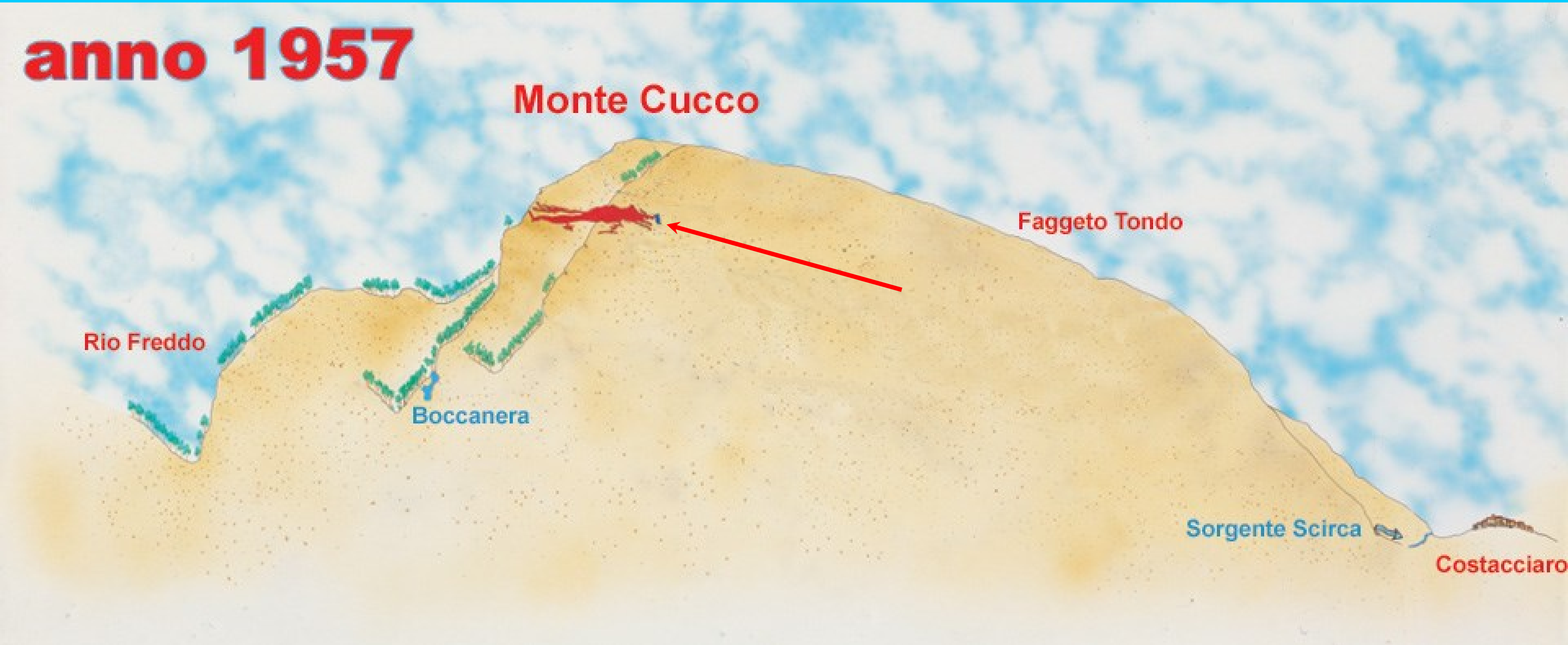
Storia delle esplorazioni e dello studio dell'idrografia sotterranea della Grotta di Monte Cucco

Gian Battista Miliani



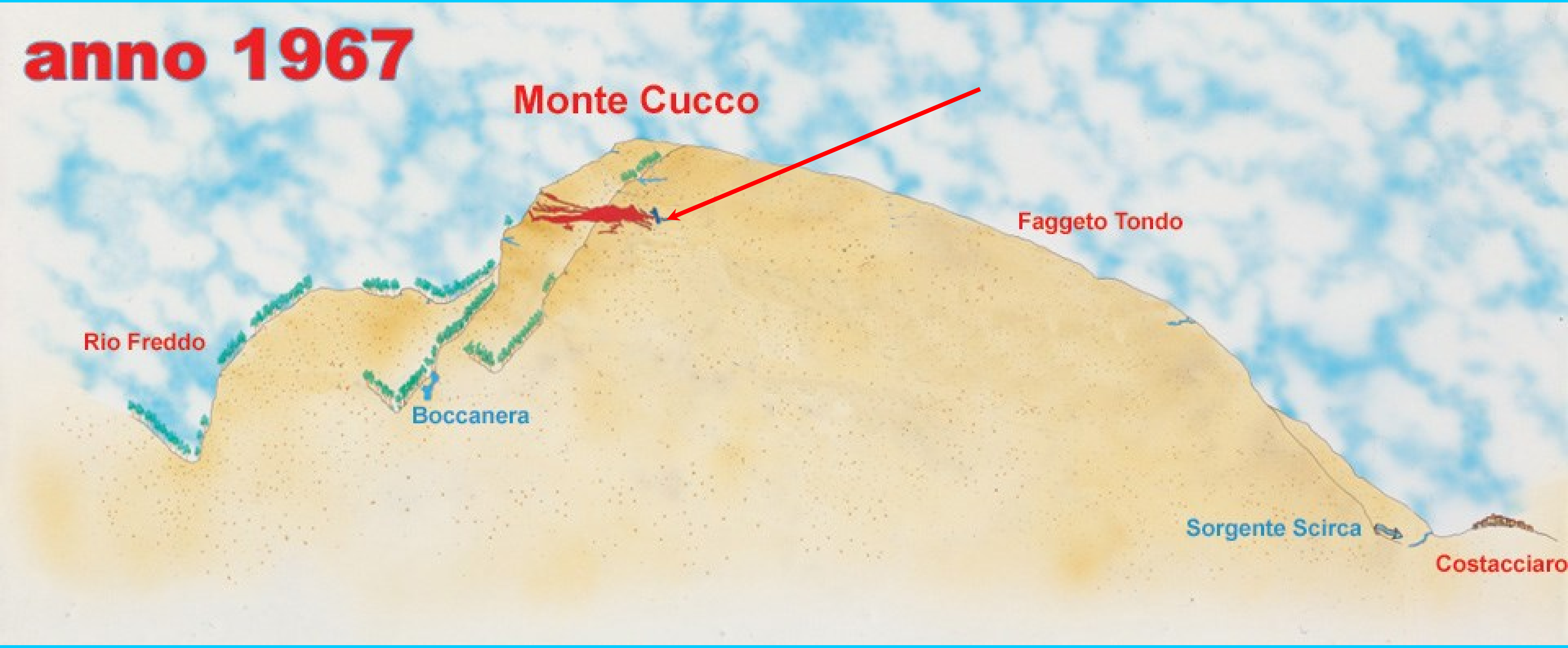
Le prime esplorazioni sistematiche

F. Salvatori - L. Passeri



Nella parete occidentale della Sala Margherita, su indicazione di Miliani, viene scoperto un passaggio in gran parte allagato, oltre il quale si apre una profonda voragine

F. Salvatori C. Leoni A. Orsini



Si scopre la condotta che dal Pozzo Terni porta verso regioni sconosciute

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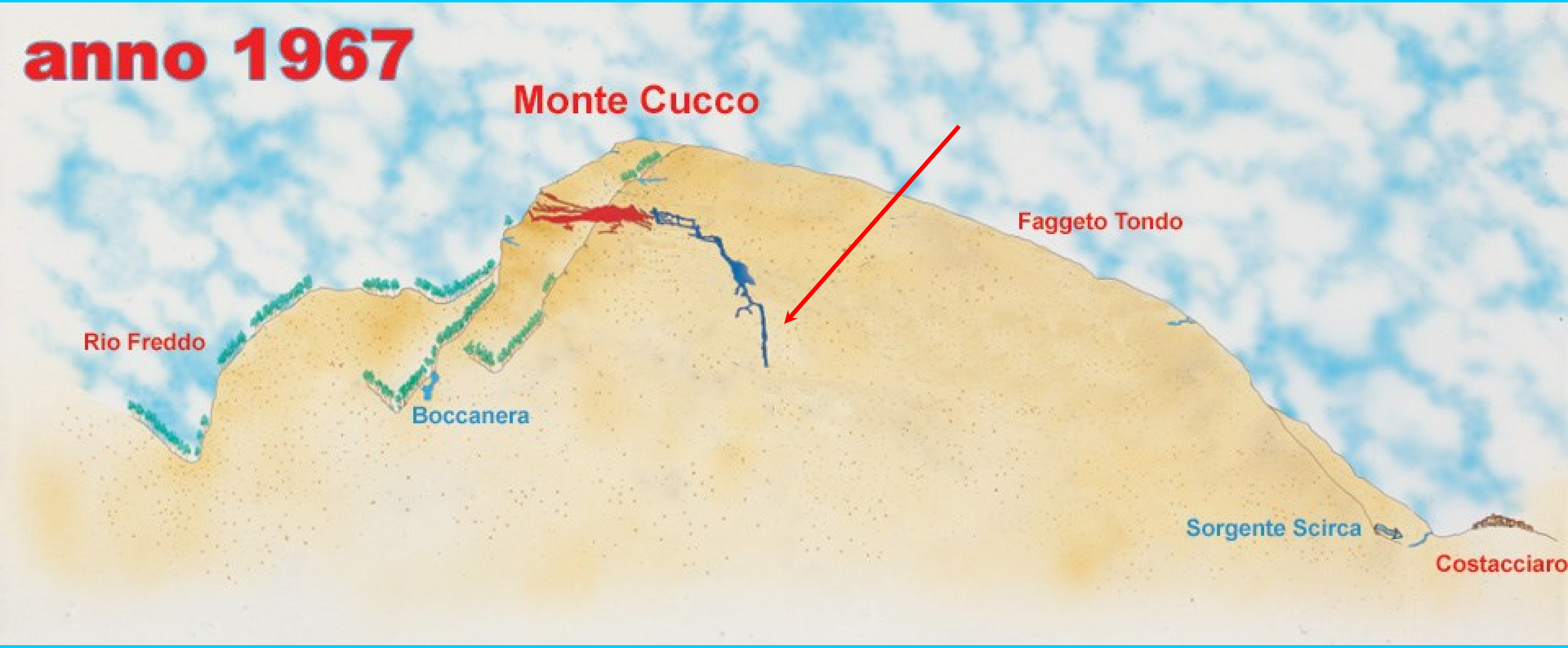

Con una serie di esplorazioni prima dell'inverno si raggiunge il fondo del Pozzo del Gitzmo, una della più grandi verticali mai discese

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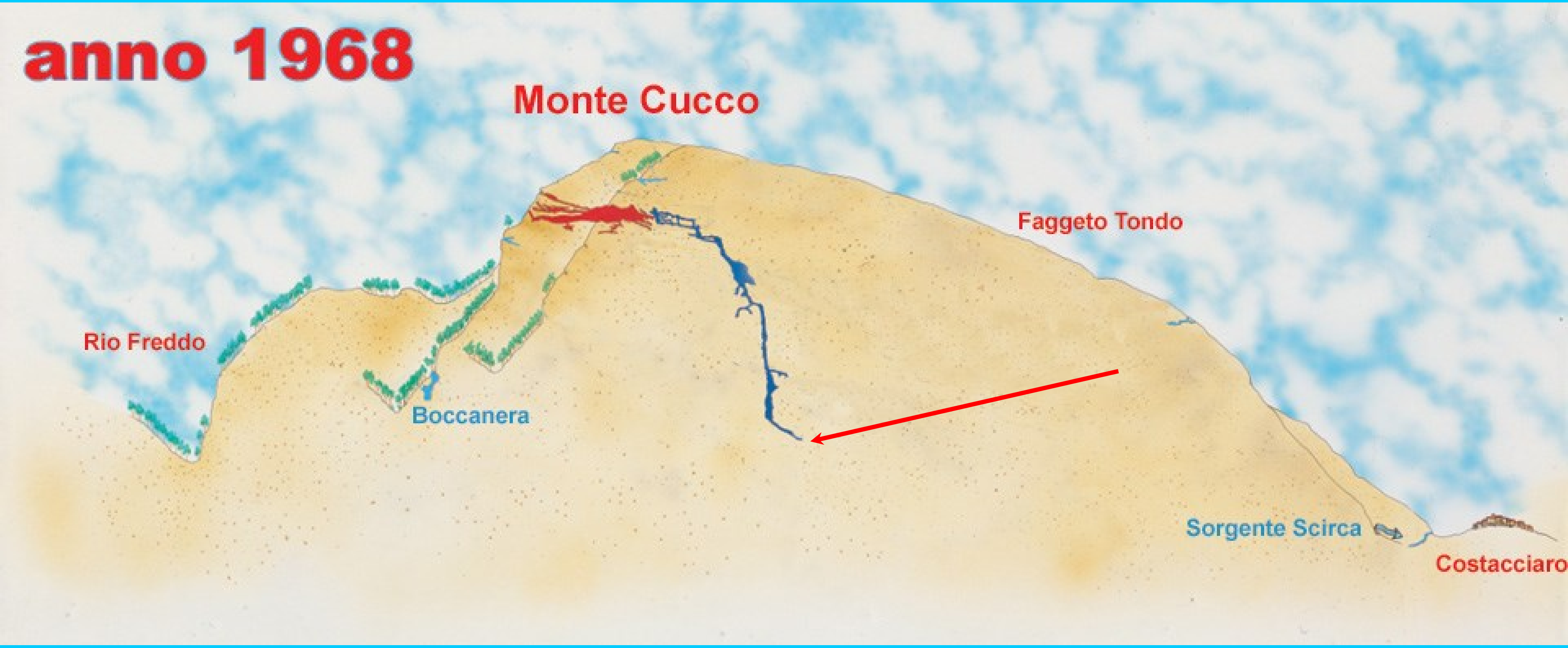

Incominciano i campi interni e nella spedizione di ottobre viene raggiunta la sommità del Pozzo Franco

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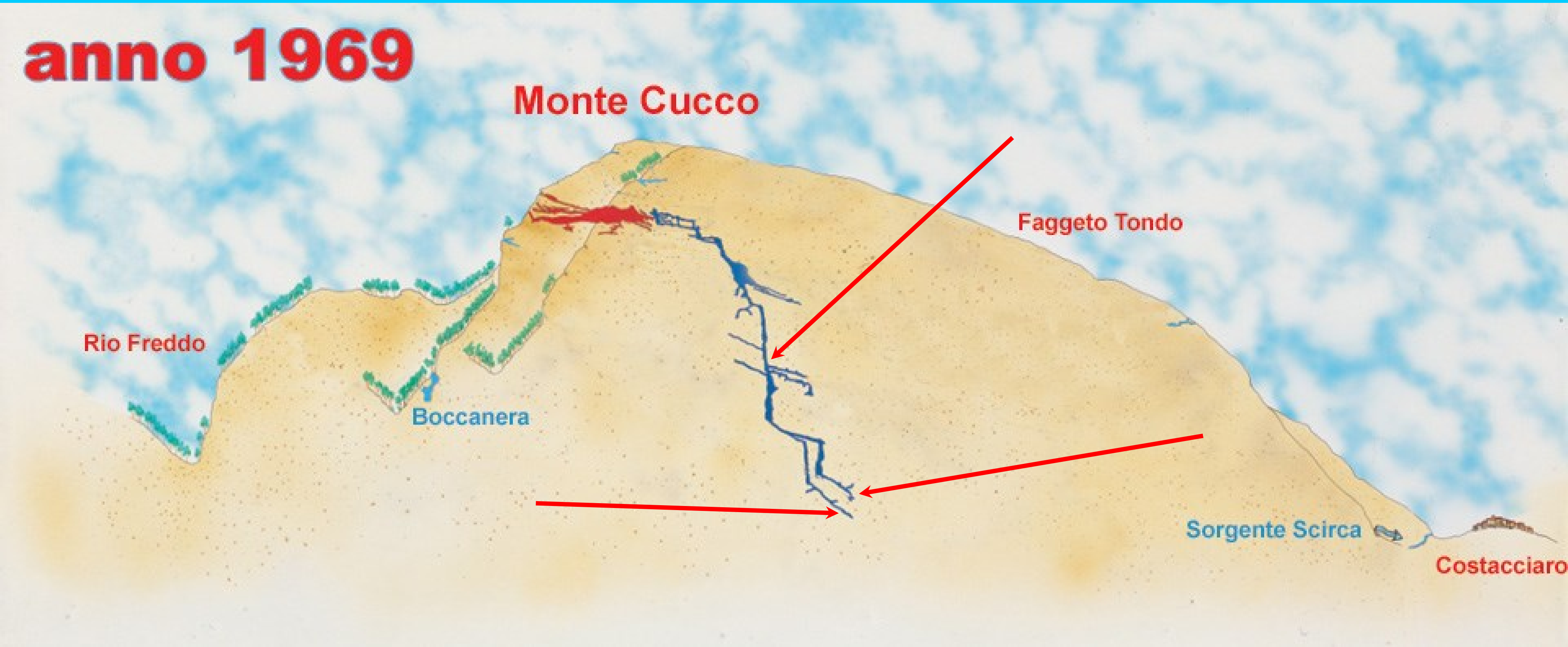
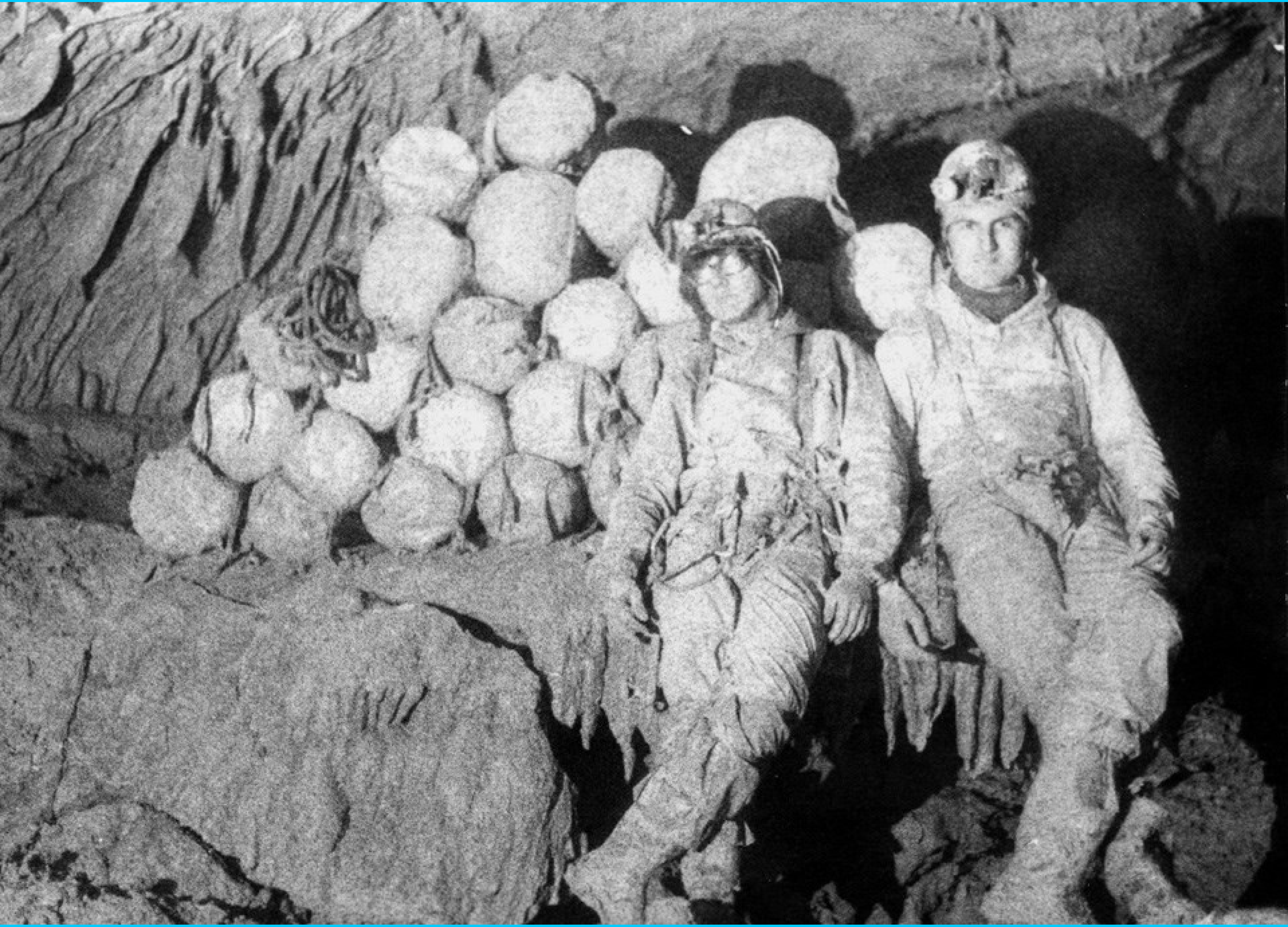
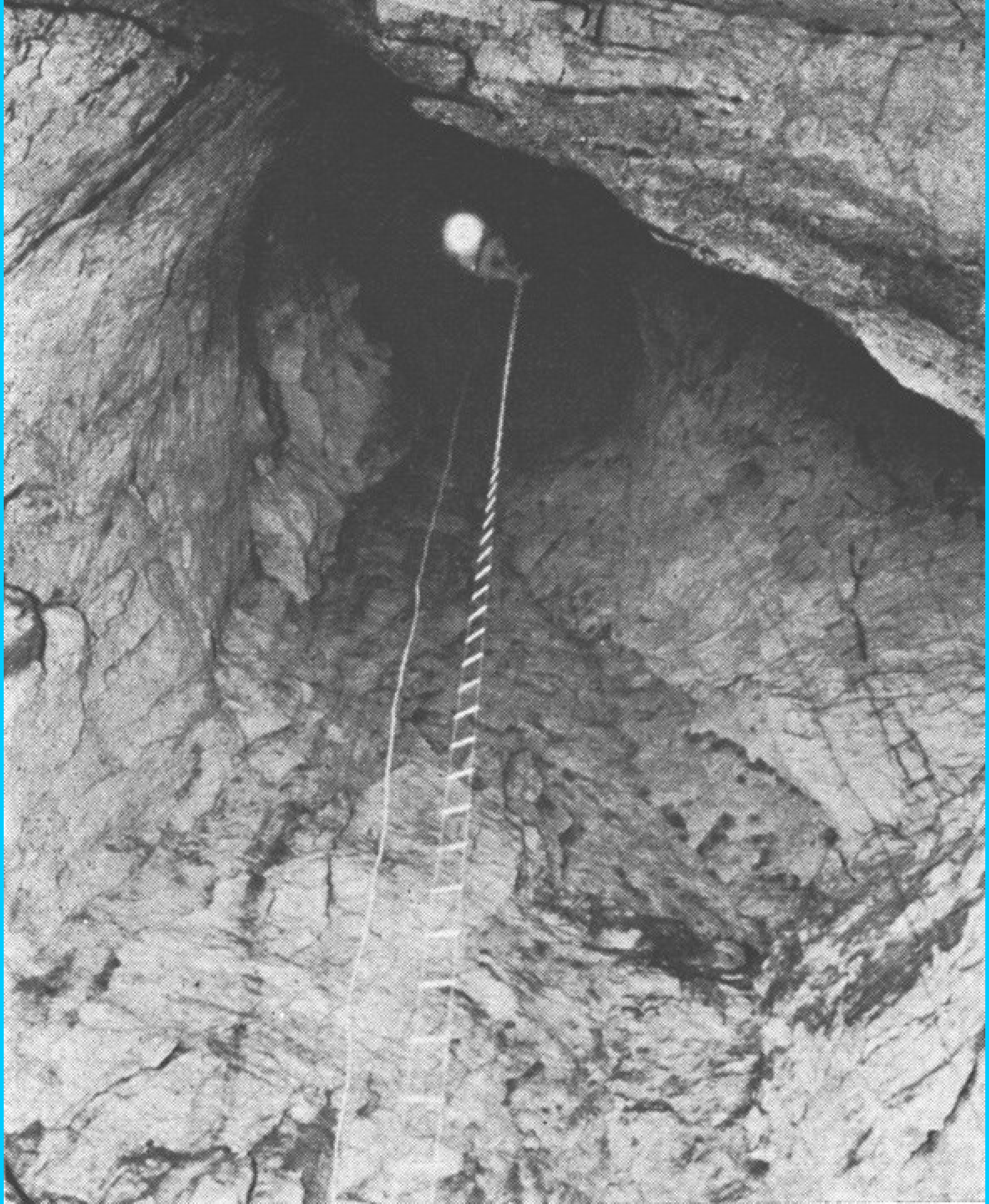


In primavera viene sistemato un campo interno alla base del Pozzo Gitzmo.

Da qui partiranno le tre esplorazioni che permetteranno di raggiungere il fondo della grotta

e il Fiume Miliani





Il torrente sotterraneo che alla massima profondità raccoglie tutte le acque della grotta. E’ stato chiamato Fiume Miliani in onore del grande speleologo fabrianese.

Gruppo Speleologico di Perugia

Dall'inverno del 1969-1970 inizia una sistematica esplorazione e rilevazione della parte più estesa della Grotta di Monte Cucco, individuata nell'estate del 1969 durante la spedizione inglese (Galleria dei Barbari, Meandrino, Burella, Galleria dell'Orco, Infernaccio, Salone Canin, il labirinto della Regione Italiana)

Nel periodo 1970 - 1972 il GS di PG effettua una serie di colorazioni delle acque della Grotta di Monte Cucco per metterle in relazione con la Sorgente Scirca. Viene stabilito un collegamento sicuro fra la Grotta e la Sorgente

Nella primavera - estate del 1987 il CNS e lo Speleo Club Gubbio realizzano la più complessa colorazione di acque sotterranee mai tentata: vengono immessi diversi chili di differenti coloranti i vari punti della Grotta, nella Buca della Valcella e nella Voragine Boccanera. Le analisi sono portate avanti fino all’inverno in tutte le sorgenti circostanti M.Cucco.

I risultati sono straordinari e definiscono l’intera idrografia sotterranea del Massiccio.

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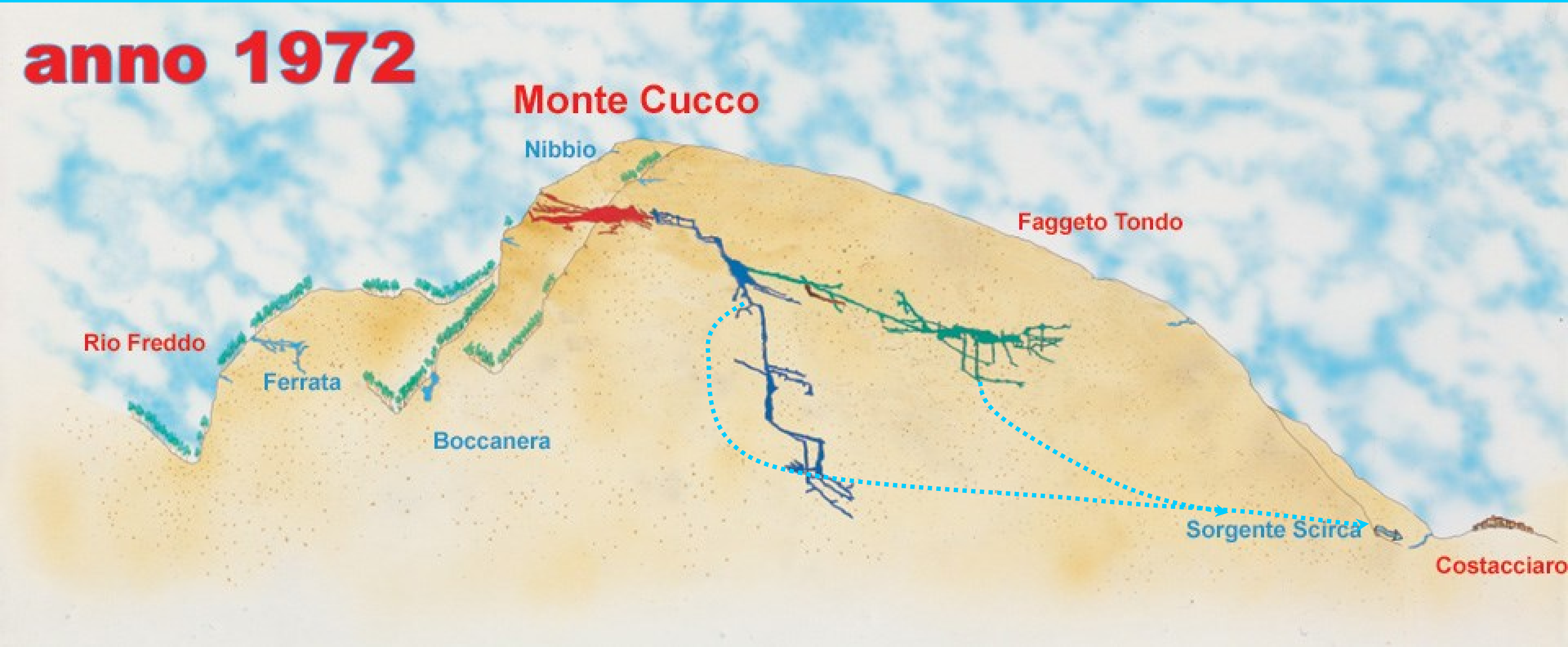


Nell'aprile del 1972 si punta ad individuare il collegamento idrologico fra i torrenti sotterranei e la Sorgente Scirca. Le due colorazioni danno risultati positivi e risulta certo che la grande sorgente appenninica è alimentata dalle acque della Grotta

Gruppo Speleologico di Perugia

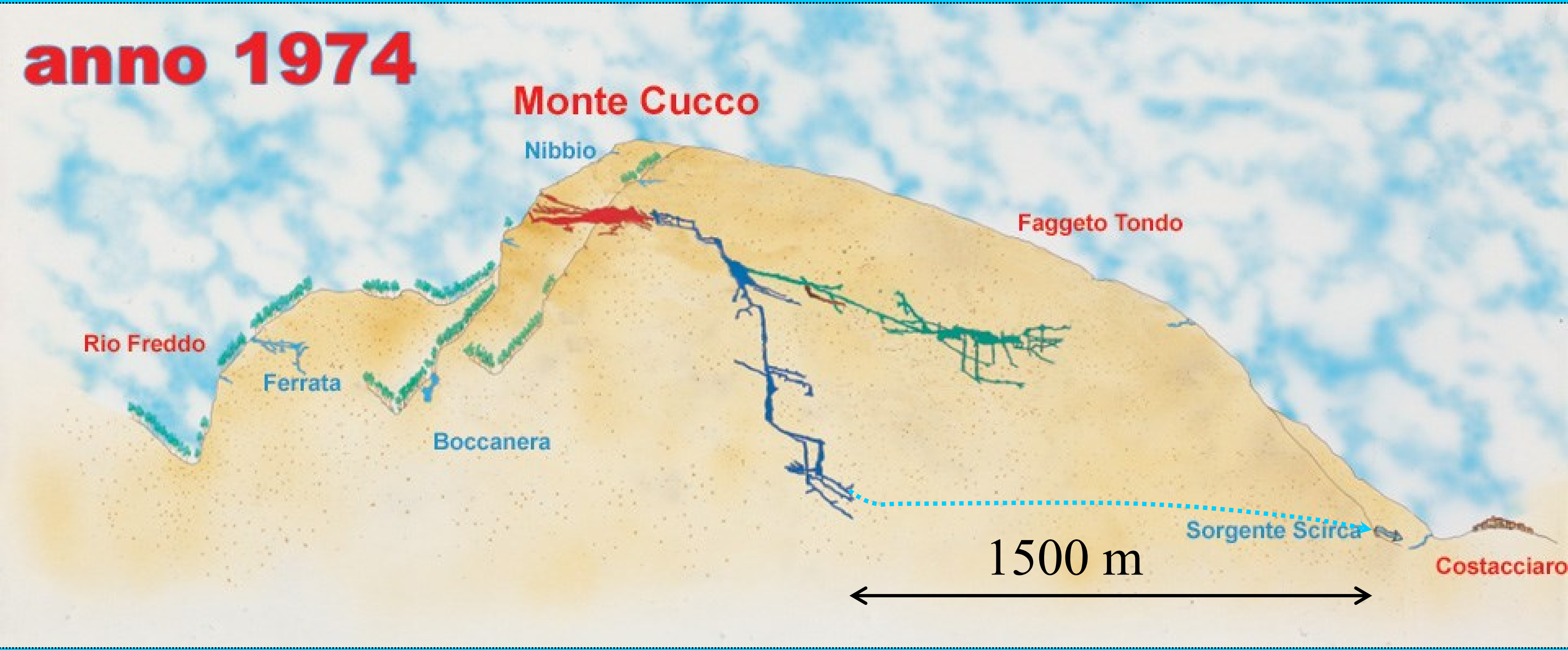
Primavera 1974

Grotta di Monte Cucco

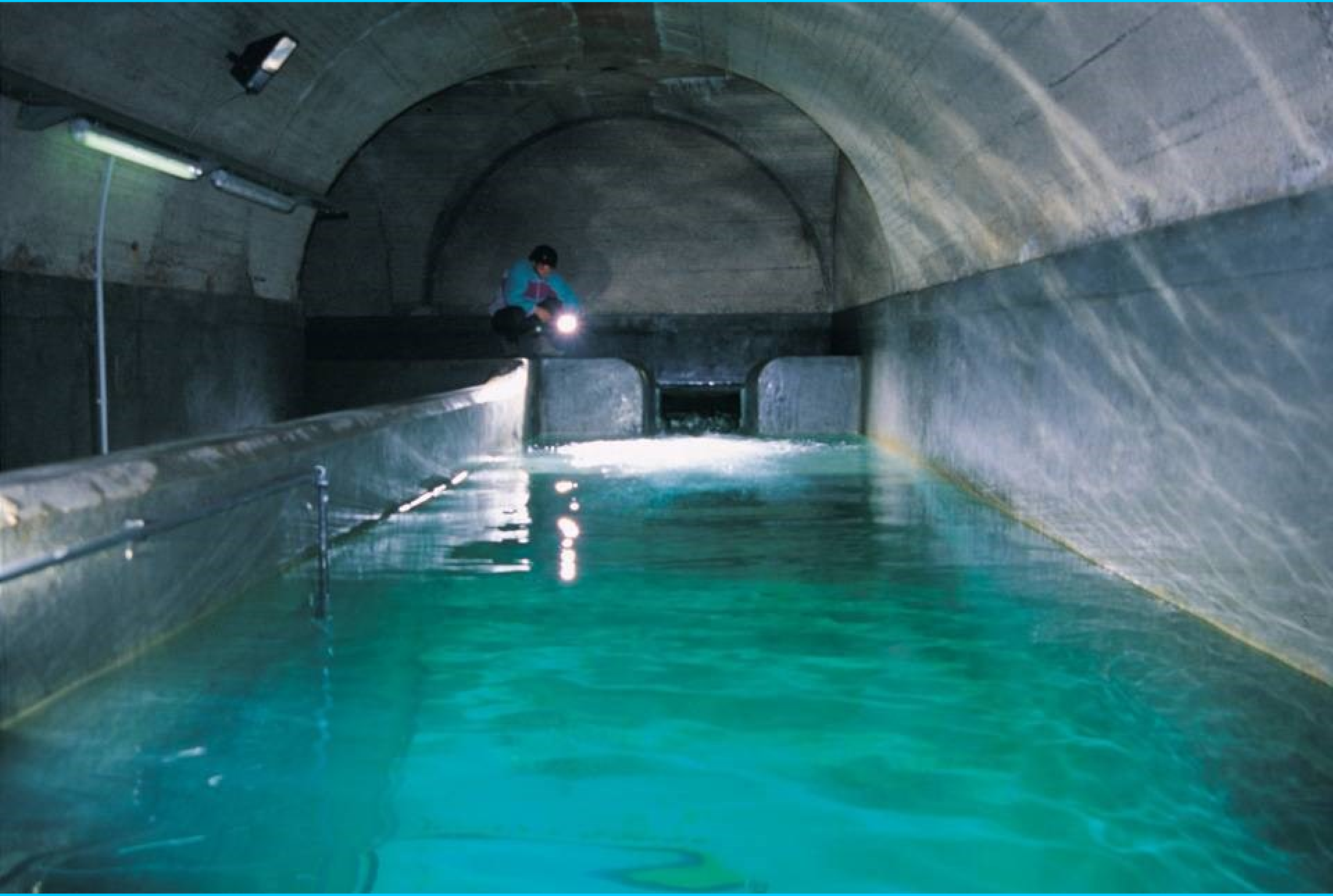
L'ultima discesa su scale fino al fondo per fare un rilievo topografico più attendibile e colorare le acque del Fiume Miliani

Con l’immissione di 5 kg di fluoresceina nel Fiume Miliani si dà inizio ad una prova di colorazione con prelievi giornalieri di campioni di acqua a Scirca. L’esperienza durerà fino al tardo autunno, con risultati straordinari.

Gruppo Speleologico di Perugia



Dopo sei giorni dall’immissione del colorante nel Fiume Miliani il tracciante compare alla Sorgente Scirca. La concentrazione andrà aumentando e solo verso la fine dell’autunno non resteranno che traccie. Il risultato denota la presenza di un vasto bacino sotterraneo.



Ann. Spéléol., 1975, 30, 4, p. 733-741.

RELATIONS BETWEEN MONTE CUCCO UNDERGROUND HYDROGRAPHY AND SCIRCA SPRING,

by M. BERTUCCIOLI (1), G. REICHENBACH (2) and F. SALVATORI (3)

Résumé.

A partir de certaines informations, provenant d'observations géologiques et spéléomorphologiques, nous avons entrepris une étude hydrologique du massif calcaire du Mont Cucco ; des traçages à la fluorescéine et des mesures de température ont conduit à définir les principales caractéristiques de ce massif. A l'intérieur de celui-ci, nous avons mis en évidence une réserve d'eau, dont le volume est de 300 000 m^3 et qui est alimentée par de nombreux collecteurs provenant de la zone d'infiltration. L'un de ces collecteurs conduit les eaux à proximité immediate de la source Scirca, au pied occidental du Mont Cucco. Cette source est à la fois le seul regard sur la circulation souterraine et l'exutoire de l'aquifère. Pour calculer le volume d'eau souterraine mis en réserve, nous avons utilisé deux méthodes, s'appuyant sur les mêmes bases théoriques ; ces deux méthodes ont donné des résultats concordants.

Abstract.

Departing from some information, deduced from geological and speleomorphological observations, hydrological research has been made, also by using fluorescein, and some thermometric hypogeal investigations have also been carried out ; these render possible the delineation of particular characteristics of the subterranean hydrographic system of the calcareous massif of Monte Cucco. In the interior of this calcareous massif (probably in a serie of partially flooded intercommunicating karst cavities) an hydric reserve (volume 300,000 m^3) has been theoretically singled out, fed by many natural water collectors coming from the zone of percolation. At last, one of these collectors flows into the immediate neighbourhood of the Scirca spring, placed at the foot of the western side of Monte Cucco, which is the only opening of the subterranean hydrographic system and, at the same time, is the overflow for the internal basin. In support of the conclusions deduced and to calculate the volume of water contained in hypogeal reserve, two diverse methods have been used, with one common theoretic base, which have given two concurring results.

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1. GEOLOGICAL SITUATION.

The geology of the karst area of Monte Cucco, above all from the viewpoint of the analysis of the relative dispositions of the various terrains according to their permeability, has been repeatedly treated by various authors (COLACICCHI and PIALLI, 1967 ; PASSERI, 1972,a, b ; CATTUTO and PASSERI, 1972) ; and so we shall only remember (fig. 1) that Monte Cucco is formed by a calcareous pyramid (massive limestone of the early Lias period) surrounded at the base by a mantle of impermeable marly rock and jaspar. The

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of the exit of coloured water being substituted by an equivalent quantity of percolation water.

Phase 1, taken between the time zero (putting in) and time t_1 (the moment in which the colouring appears at the spring) is characterized by a consistent increase of A without any decrease on account of the water coming out at zero concentration. The transport of mass by diffusion, with a logarithmical decreasing concentration along the axis of diffusion, clearly prevails. Phase 2 is influenced by A and by I; because of $A > I$, the curve rises. At the time t_2, the maximum is reached and therefore $A = I$. Afterwards, in phase 3, $A < I$; there are, in fact, some gradients of concentration still present, but are such that they cannot compete, with the consequent effect of enrichment, with the general dilution produced by the percolation water. At the time t_3, the basin does not show anymore gradients of concentration and stops all growth by diffusion. In zone 4, the only factor which modifies the concentration in the basin is the recession of the colourant on account of the outflow of the coloured water from the spring, which immediately reintegrates with other non-coloured water on all the free surface. During this phase, characterized by gradual variations of concentration in a succession of equilibrium states, one can suppose, without being too far from the truth, that the measured concentration in the spring is always the same as that found in every part of the basin. For this reason, the part of the descending curve included in zone 4 ($t_3 \longrightarrow \infty$) is that which lends itself to the simplest and most interesting observations.

7. EXPERIMENTAL CONFIRMATION OF THE PUT HYPOTHESIS AND CALCULATION OF THE WATER VOLUME STORED UP IN THE INTERNAL BASIN.

7.1. Method of concentration curves.

Based on all that has been said in the previous paragraph, let us suppose that we have arrived at time t_3 with a colouring concentration C_o in all the basin. From this point ($t = 0$ for phase 4) the concentration will gradually decrease in function of time t, of the concentration C_o of volume V and of discharge Q: just now, if one supposes the basin-colourant system always to be in an equilibrium state (without gradients of concentration), one arrives at a relationship which relates the concentration to the time, having as parameters C_o, V and Q.

Let us take into consideration two successive moments of phase 4: to time t will belong concentration C, while to time $t' = t + \Delta t$ will belong concentration $C' = C + \Delta C$. One will then be left with:

$$\Delta C = \Delta n / V, \qquad [1]$$

where Δn is the number of moles released from the spring in the interval Δt. Considering that

$$\Delta n = -\overline{C} . \overline{Q} . \Delta t, \qquad [2]$$

where C and Q are respectively the average concentration and the average discharge in interval Δt, is assumed to be:

$$\Delta C / \Delta t = -\overline{C} . \overline{Q} / V, \qquad [3]$$

passing on to the limit for $\Delta t \longrightarrow 0$, one gets:

$$dC/dt = -C . Q/V, \qquad [4]$$

that integrates with $Q =$ constant, gives:

$$\log (C/C_o) = -Q . t / 2.303 . V. \qquad [5]$$

In the case of a discharge, linearly varying in time, one can put:

$$Q = Q_o + \Delta Q . t, \qquad [6]$$

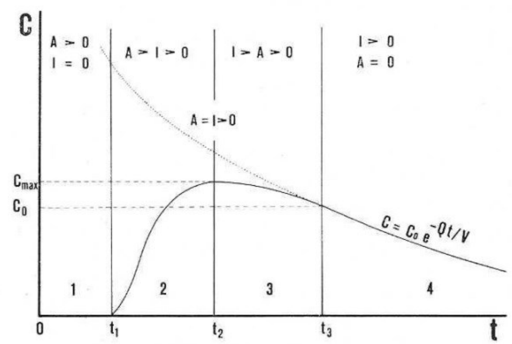

FIG. 2. — Schematic example of a theoretic curve of the concentration of the colourant issuing at the spring.

where Q is the discharge at time t, Q_o, the discharge at time zero (at the beginning of the interval of observation), $\Delta Q = (Q_o - Q_f)/t_f$, increase of discharge per unit of time and Q_f, the discharge at time t_f (the end of the observation interval). Under this new hypothesis, the integration of relationship [4] gives:

$$\log (C/C_o) = -\overline{Q}_{ot} . t / 2.303 . V \qquad [7]$$

Q_{ot} being intended as the average discharge during interval $O - t$.

The relationships [5] and [7] are different expressions of the same mathematical model which synthetizes the characteristics of the basin-colourant sys-

From the time intervening between the putting in and the first sight of the fluorescein at Scirca, it as been calculated that the dye has gone in the direction of the spring with an average speed of 8.5 m/h. This value is extremely low in relation to the data obtained in the preceding analogous experience (CASTANY, 1967 ; BOEGAN, 1938) in calcareous terrain. That is confirming that the transportation by diffusion of the colourant played a very important role in the homogenization of the internal water.

days of October still contained traces of fluorescein and, at that time, from the time of putting-in, 1 694 000 m^3 of water had passed through Scirca.

Based on that indicated in paragraph (7.1.) as the « method of concentration curves », the tract of the curve between the day 17th of July ($t = 0$) and the day 28th of August (t_f) has been examined on the hypothesis that this interval might be comprised completely in phase 4 (afterwards this will be amply

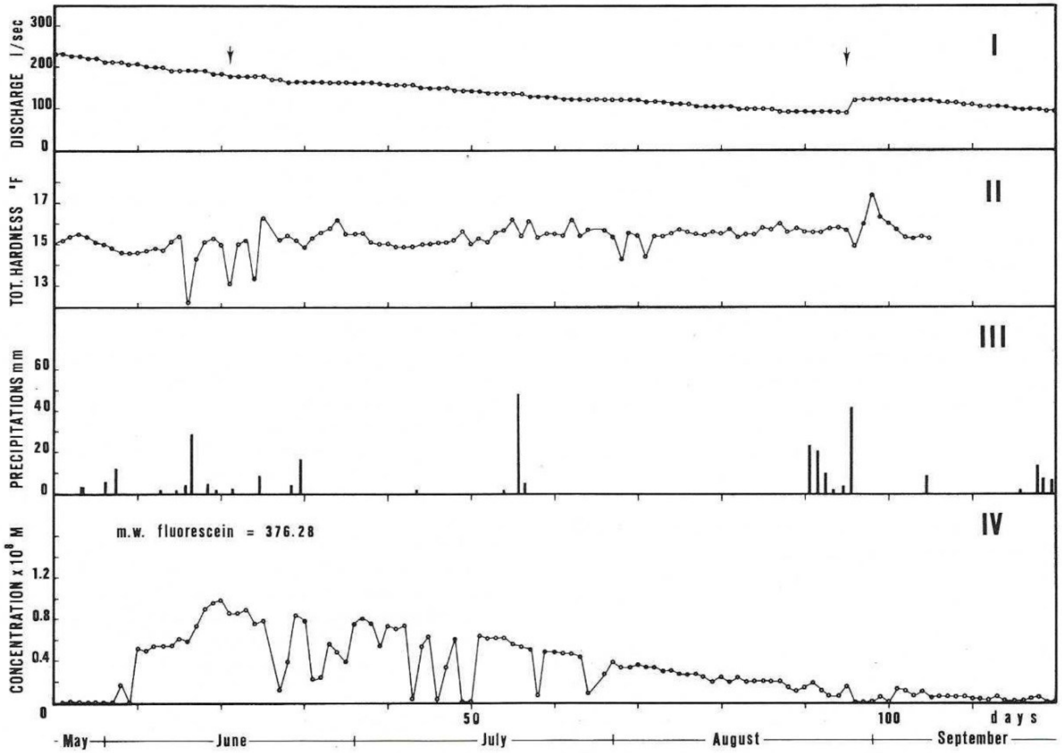

FIG. 3. — Comparative chronological table of the data collected during the second colouration, from the day 25 th may 1974 (date of the putting in of the colouring). The following reports on the Scirca spring have been made : (I) discharge, (II) total hardness, (IV) concentration of fluorescein. The precipitations registred on a pluviometer at Scirca, have been reported in (III). The arrows in (I) indicate the extremes of the interval with the discharge in linear dependence on the time.

The concentration has never been above the value 10^{-8} M, an extremely low concentration, justifiable only in a dilution in a great mass of water. After having reached the maximum (0.98×10^{-8} M), the curve decreases much more slowly and, only after 120 days from the putting-in, we observed values of concentration no longer measurable with the available instruments. The samples drawn in the first

confirmed) and also taking into consideration that the Scirca discharge in this period has varied, in the first approximation, linearly with the time. Using the relationship [7] taking for C_0 the concentration 0.61×10^{-8} M found on the 17th of July, some theoretical curves for different volumes have been drawn. The results are reported in figure 4 (I) for all the interval of observation : it is quite evident that in zone 4 the experimental curve faithfull follows the theoretical curve relative to V = 3 × 10⁸ litres, shifting only where the precipitation has determined semi-alignment of the experimental points along the curve (broken line) is very evident, that has a volume of about 3 × 10⁸ liters (6).

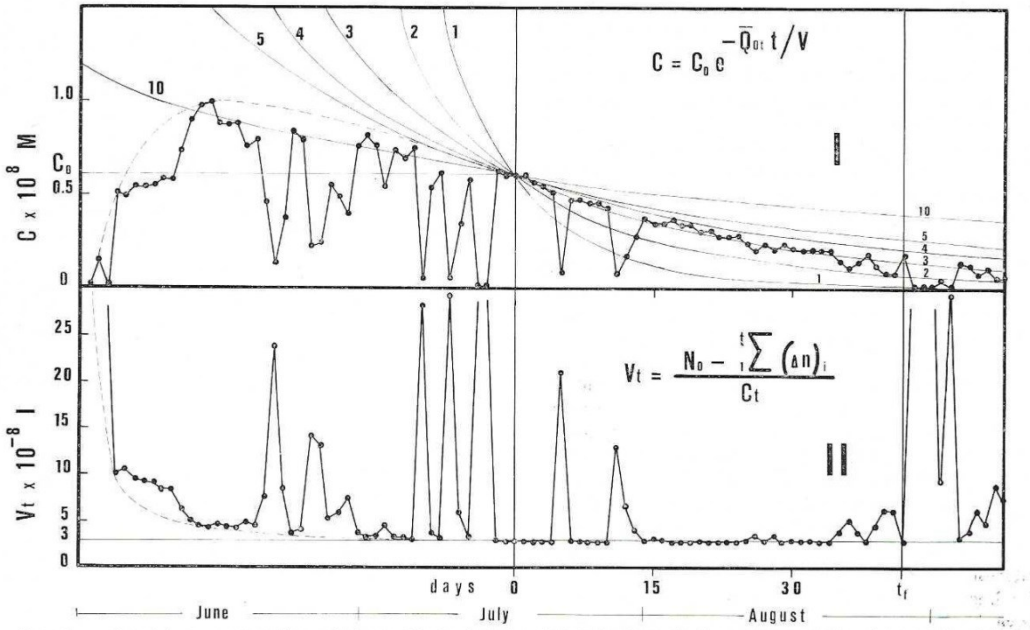

FIG. 4. — Graphic representation of the methods for the determination of the volume of the internal basin : (I) curves of concentration method, (II) index of stabilitation method. The broken curves delineate in (I) the concentration curve and in (II) the stabilization curve in the absence of deformations. In (I) the lightly sketched lines refer to theoretic curves at different volumes, the value of which — in litres — is obtained by multiplying the respective numbers that differenciate then for the factor 10^8.

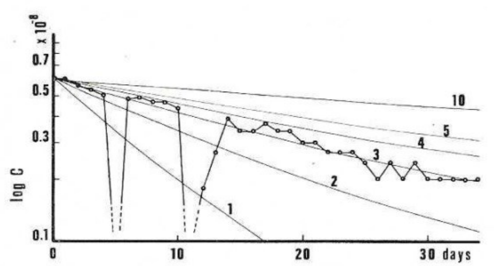

FIG. 5. — The graphic representation with semi-logarithmic co-ordinates of the « curves of concentration method » limited to the period 17th/July-20th/August. The theoretic curves of the various volumes have been reported with lightly sketched lines, the values of which are held with the same modalities indicated for figure 4(I).

some deformations. The same results, limited to the 17th of July to 20th of August have been reported in semi-logarithmic co-ordinates in figure 5. The

To give further confirmation to the hypothesis done and to calculate, by a different method ; the volume of the internal basin, the « index of stabilization method » has, therefore, been applied as delineated in paragraph 7.2. The value N_0 has been calculated by integrating almost completely graphically, the experimental curve of concentration in the interval from the 1st of June to 18 th of August, daily taking into serious account the average discharge, while for the remaining part the relationship [11] with $V = 3 \times 10^8$ liters has been used, which was found by the preceding method. It resulted from this that the dying teat has been made with 5.4 moles of fluo-

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(6) The geometric representation of the relationship [7] in semi-logarithmic co-ordinates is not a straight line because the function $\log C = f(t)$ is not linear ; neverthe less, given that, in our case, the values of the ratios $Q_0/\Delta Q$ and $V/2\Delta Q$ are relatively high, the graphic result being more evident than in figure 4(I).

rescein [7] that represent about 40 % of the moles put in the « Torrente Miliani » [8]. Successivly it has been calculated V_t for each experimental point in the zones 2, 3 and 4 ; the results have been reported in figure 4(II). The graph diminishes rapidly from the 1st of June and then gradually stabilizes itself at about the value 3×10^8 liters. Also in this case, it is therefore confirmed that the basin-colourant system at Monte Cucco arrives at a long phase of clear homogenization (zone 4) in which the ratio V_t represents the real value of the volume of the underground water reserve. Equally it is confirmed that V_t is an index of the entity of the concentration gradient : as the system moves away from complete homogenization, so V_t shifts away from V. This non homogeneity is a generalized fact in phases 2 and 3, and becomes very evident when there is a rapid input of percolation water near Scirca spring, while it is an exception in phase 4 where the slopes are found to testify to some temporary and extremely localized interuptions of the equilibrium state. It is hereby evident that the inertia of the system is stabilized in its basic structure : the great mass of the water blocks every action which tends to modify it. The fact that the final part of the graph of figure 4(II) might be formed from representative points put in a completely casual way, is imputable to the experimental errors in the calculation of the concentration and to the intense precipitation which fell in that period. We are, in fact, at the beginning of september and the concentrations have, by now, arrived at a value close to 10^{-10} M.

8. VARIATIONS OF AIR, WATER AND ROCK TEMPERATURE IN THE MONTE CUCCO CAVE IN FUNCTION OF DEPTH.

Based on the thermometric data collected during various research excursions and after particular studies (Moretti *et al.*, 1967), it was possible to assertain that the temperature of the air, of the water and of the rock along the principle axis of the cave of Monte Cucco vary with the depth. In figure 6, these value of temperature in function of the altitude above sea level have been reported from the « Cattedrale » (alt. 1390 m) until the terminal siphon (alt. 587 m). This data has been taken in almost always difficult situations and for this we consider, above all, the general course of the graph rather than its single temperature values.

The temperatures of the rock, of the water and of the air increase gradually as one descends in altitude, but with different increases : that of the rock increases at about the rate of 0.1°C each 100 m, that of the water increases, with stronger growth, but in a more linear way, that of the air increases at about the rate of 0.5°C every 100 m. The temperature of the water which comes out of the Scirca has a value from 10.8°C to 11.0°C. The annual average of the air in the zone around outside the spring has always, in the last 25 years, been more or less about 11.0°C.

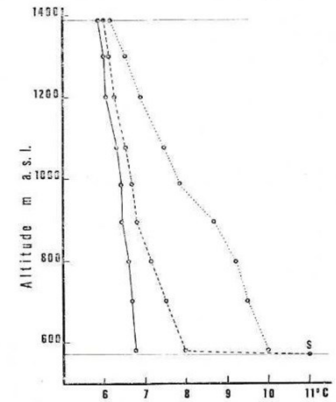

Fig. 6. — Variation of the temperature of the rock (continious line), of the water (broken line) and of the air (line of points) along the principle axis of the cave of Monte Cucco in function to the depth. The point S represents, analythicaly, the conditions of altitude and of the temperature of the Scirca spring.

This series of thermometric data gives a further confirmation of the existence below the siphon terminal of the cave of Monte Cucco (alt. 587 m) of an internal basin in which the water coming from the zone of percolation stagnates long enough to establish a thermic equilibrium with the air, never established during the speedy crossing of the zone comprised between the absorbing area outside and the level of the base. In fact, while it is explainable in terms of transformation of work in heat, that the temperature of the water increases in 2°C descending 800 m (Cigna, 1956), it is not possible to understand how « heating » might occur to a degree of 3°C along a horizontal distance of 1500 m. An explanation is that the water, along this distance, enters, easily and for a long time, into contact with the « warm » air coming

(7) 4.7992 moles were obtained by graphic integration and to which were edded 0.6 moles with the relationship [11].

(8) The remaining 60 % has probably been decomposed and/or absorbed by the walls, if they might not have been in part utilized to colour the water dispersed in the fine porousness of the « Calcare Massiccio » and/or in the rocks adjecent or beneath (*e. g.* the « Calcare Cavernoso » of Trias).

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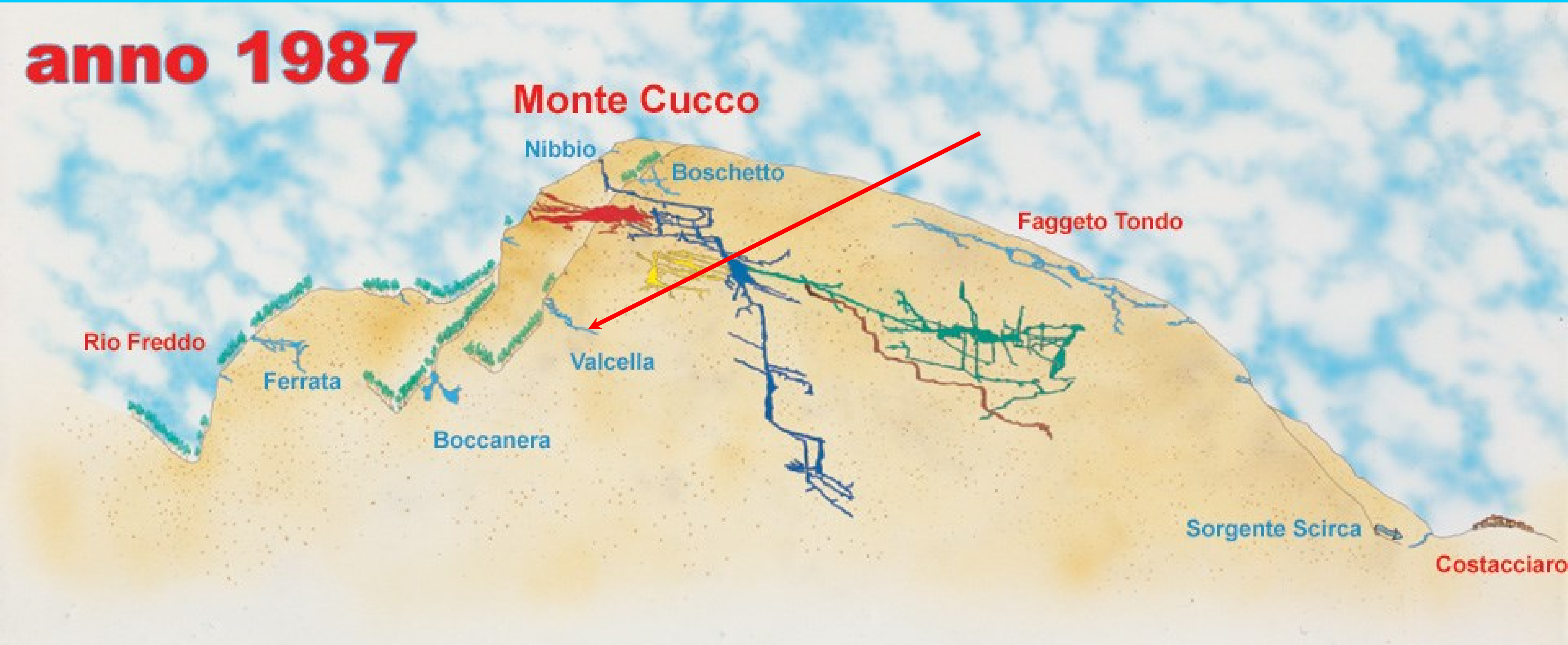

Un’altra grande scoperta: la Buca della Valcella e il suo torrente sotterraneo che non ha nulla da spartire con gli altri corsi d’acqua del massiccio

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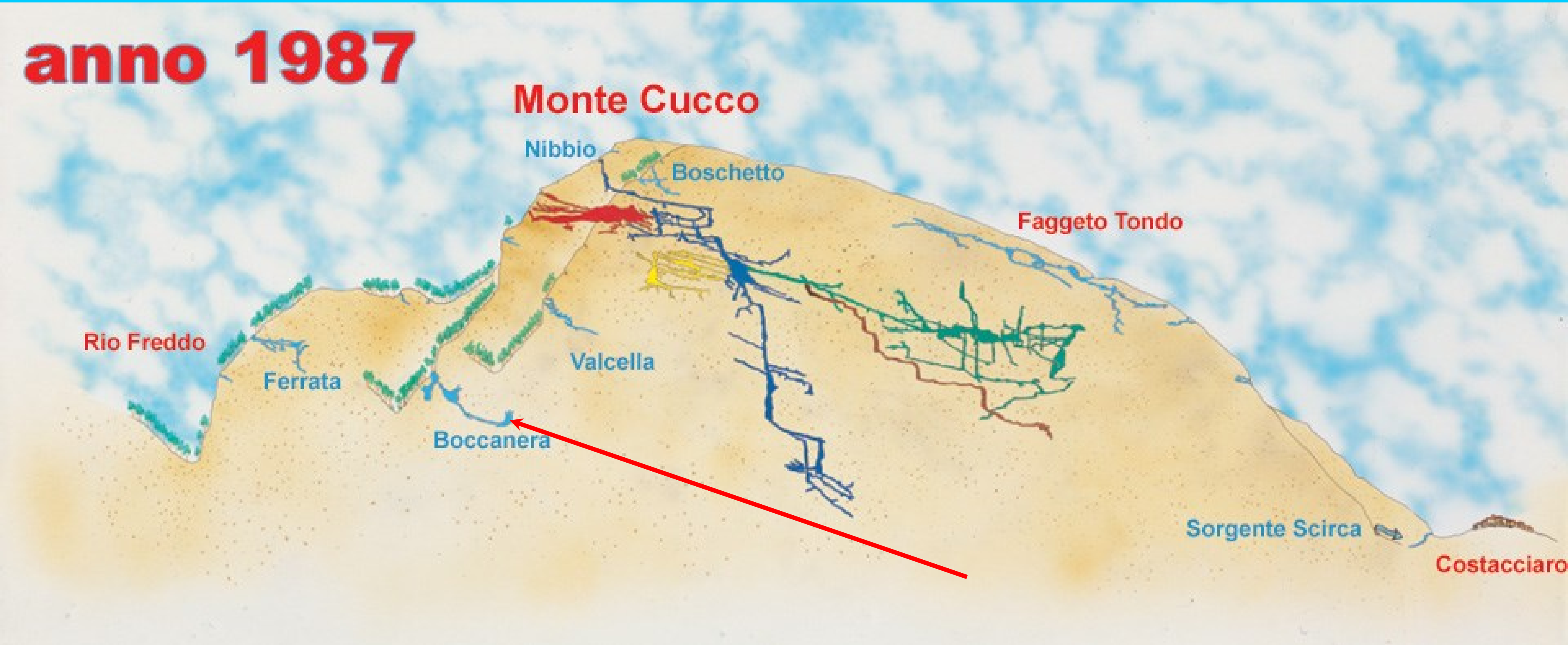

Gli speleologi del CNS fanno una grande scoperta nella Voragine Boccanera e trovano un nuovo torrente sotterraneo

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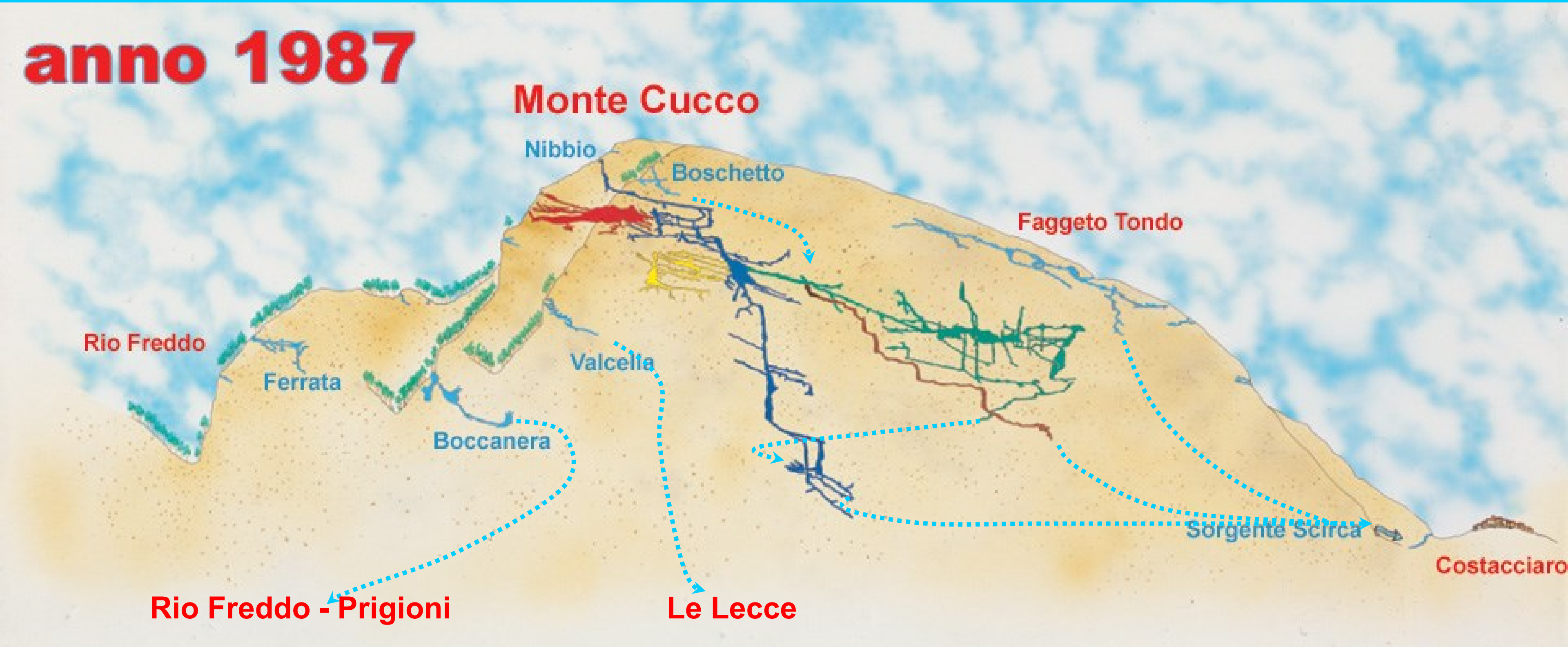
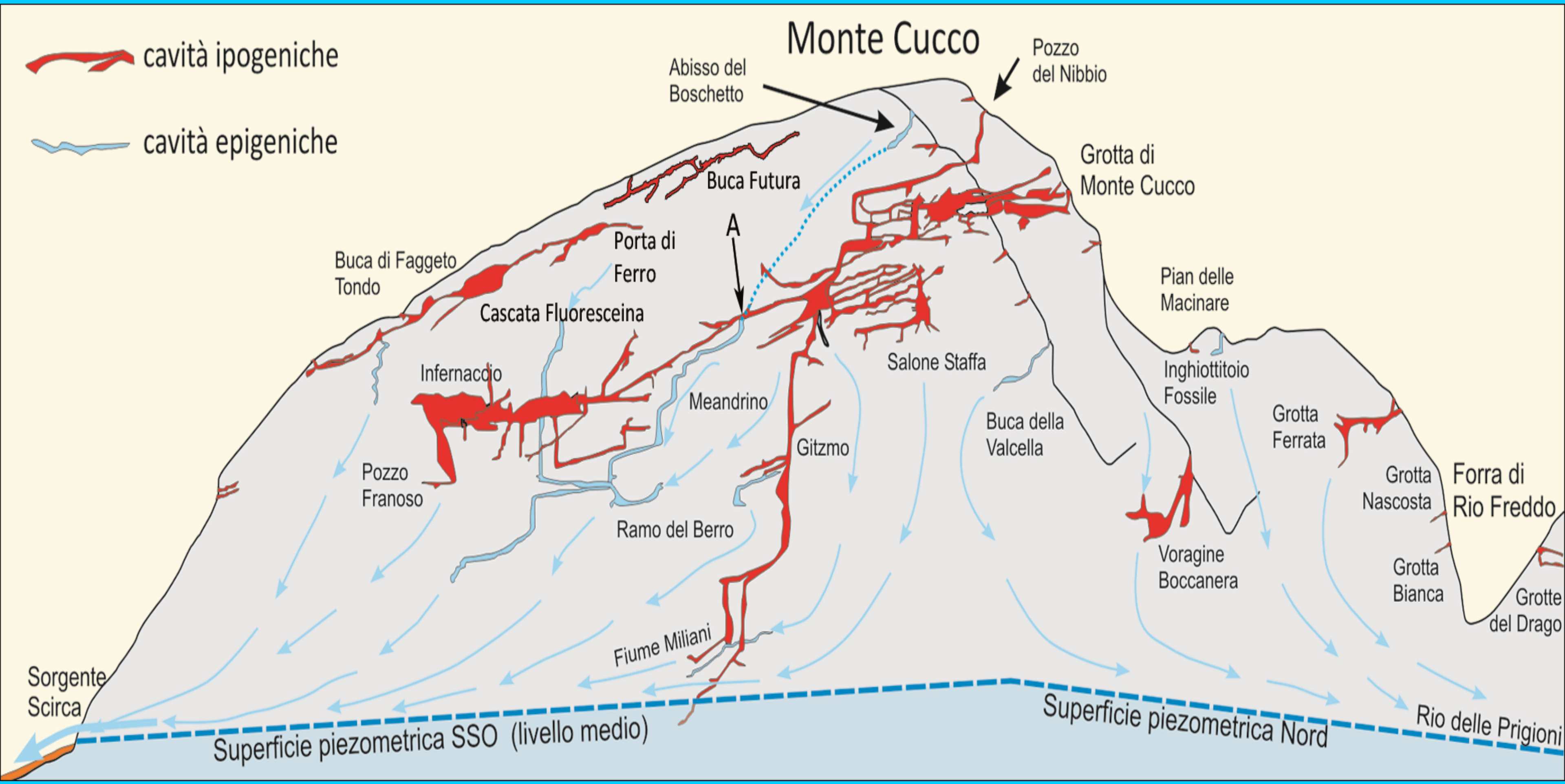
Speleo Club Gubbio



La ricerca continua per tutto il 1987 e parte del 1988, con analisi continuativa al fluorimetro delle acque di tutte le sorgenti circostanti il Massiccio


cavità ipogeniche
cavità epigeniche
Monte Cucco
Abisso del Boschetto
Pozzo del Nibbio
Buca Futura
Grotta di Monte Cucco
Porta di Ferro
A
Buca di Faggeto Tondo
Cascata Fluoresceina
Pian delle Macinare
Salone Staffa
Inghiottitoio Fossile
Infernaccio
Meandrino
Buca della Valcella
Grotta Ferrata
Gitzmo
Pozzo Franoso
Grotta Nascosta
Forra di Rio Freddo
Ramo del Berro
Voragine Boccanera
Grotta Bianca
Grotte del Drago
Fiume Miliani
Sorgente Scirca
Superficie piezometrica SSO (livello medio)
Superficie piezometrica Nord
Rio delle Prigioni