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Geomorphology, Paleohydrography and Karstification in the Karst of Trieste and Upper Istria.

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„Praise be to Thee my Lord for Sister Water, she is very helpful and humble precious and pure" (St. Francis, The Canticle of the Creatures).

1. In a paper published in 1941 (1), I drew the attention to the close correlation existing in the Trieste Karst between the geomorphological lineaments, here characterized by the presence of a network of clearly recognizable fossil valleys, and the topographic distribution of the primary karstic phenomena: large dolines and uvalas, large sinkholes and caves, systems of underground galleries. Such a close correlation obviously suggests a common origin of both the surface and the subterranean morphology; a general theory has therefore been proposed (2) attributing the formation of the primary karstic phenomena to the activity of the same ancient rivers that had modelled the general trends of the present topography. Geological evidence shows that in the Trieste Karst such rivers were active in the Miocene, and have since disappeared as a consequence of the combined effect of the sinking of the watertable relative to the ground and the karstification itself.

Once these views are accepted both the surface morphology and the primary karstification can therefore be regarded as coeval and fossil. As for the capability of the limestones of preserving the original morphology, this is a well known fact that finds in the Julian region spectacular confirmation in the *Vallone di Chiapovano* (Cepovan), a perfectly preserved fossil valley on the high Plateau of Ternova, truncated on both sides and suspended at a height of about 500 m above the present level of the Idria and Isonzo rivers, in the *Vallone di Doberdò*, and in the *Canale di Leme*. Such a capability is not in contradiction with the solubility of limestones by meteoric waters which originate secondary forms of karstism like e. g. the karrenfelder, but do not affect the general morphology.

I should not repeat the arguments put forward formerly in support of the theory, (1), (2), (3), if it were not for briefly recalling that the development of the primary karstification ist attributed to the chemical dissolution of the limestones underlying the alluvial beds permeated with the phreatic waters of the rivers. The proposed model provides for the uniform and uninterrupted action of the chemically active waters on all the sides of the cavities under formation, and is therefore apt to explain both the regular shape and the enormous size of many formations of this kind. The alluvial material filling the river beds plays an essential role in this model, inasmuch as it permits the slow and continuous vertical flow of the phreatic waters in the cavities under formation, by gradually taking the place of the dissolved limestone, and by allowing the sides of the cavities to be constantly kept under the chemical action of the descending active waters. On their turn, the levels of the horizontal galleries coincide with the successive levels of the ground water, where the flow changes from the vertical to the horizontal direction. It follows from the theory that the major karstic phenomena are to be found along the abandoned fluvial ways, and that the actual main underground drainage is to be found underneath these ways.

2. The theory, briefly summarized as it is has as early as in 1941 (1) been applied to the study of the *Paleotimavo*, the ancient waterway of the present *Timavo* river, the course of which is subterranean from the Cave of *San Canziano* (Skocjanska Jama) to the Adriatic sea. Since then new evidence has come to light, new geomorphological studies have been carried out and research work has been extended to the whole tributary system to which the *Paleotimavo* belongs, also in connection with the water supply problem of the City of Trieste. These studies are illustrated in the present paper.

The starting point of these studies is the accurate reconstruction of the fossil waterways of the Trieste Karst and of the *Vena* mountains in Upper Istria. Such a reconstruction was carried out by first drawing the transverse sections across the old valleys, using the Italian topographic map in the scale of 1 : 25.000 with contour intervals of 20 meters. In all 41 sections have been drawn at distances of about 2 km from each other for a total of about 900 km.

Once the transversal sections had been drawn, the old *talweg* was reconstructed on each section by extrapolating the profile of the valley in the areas in which the karstic action had obliterated its bottom. Having thus determined the *talweg*, the longitudinal profile was drawn for the *Paleotimavo*, the river flowing along the *Vallone di Castelnuovo* (Podgrad), and finally the river originating near the saddle of *Monte Maggiore* (Ucka) and flowing along the *Vena* mountains, which we shall briefly call *Paleosiaris*. It shall be noted that at the bottom of this last fossil valley, near the village of Raspo, one of the deepest existing sinkholes *(Abisso Bertarelli)* ist to be found. All these fossil valleys are without exception carved in the limestones.

It will also be noted that the *Val Rosandra* which presently has captured the valleys of *Castelnuovo* and *Paleosiaris*, was at that time still filled with flysch and was carved at a later stage.

The results of this morphological study are synthesized in the transversal and longitudinal sections shown on plates I-V. In the same plates the major dolines and uvalas are also shown; the correlation between their topographic distribution and the talweg is manifest. Special attention should be paid to the great dolines near *S. Lorenzo* at present at the very edge of the Karst plateau, in a position otherwise almost inexplicable but perfectly fitting into the proposed model instead.

3. Ever since the publication of papers (1) and (2), new facts have come to light.

In Istria Dr. CARLO D'AMBROSI (4) found a doline cut by a fault, thus proving that the primary karstic phenomenon is older than subsequent facts of very ancient geological date.

The best evidence for the fluvial genesis of the primary karstic phenomenon is obviously to be expected by finding sinkholes and caves which have still preserved alluvial material. Already in (1) it has been noted that near *S. Canziano* (Skocjan) a sinkhole (point C in Plate V an VI) was found at a height of 90 m above the present level of the Timavo, filled with fluvial alluvium; more recently alluvial deposits have been found (5), (6), (7) in karstic sinkholes along the SW edge of the Karst plateau in the positions indicated by A and B in Plate V and VI.

The first alluvial deposit (A) came to light during the excavation of a shrine (Tempio Mariano) near *M. Grisa*, at a height of about 300 m above sea level in a depression of the ridge that borders the SW slope of the *Paleotimavo* valley and marks at the same time the NE of the big fault that separates the Karst plateau from the Trieste basin (8). The gravel incorporated in the deposit is formed of limestones and partly of sandstone deriving from the flysch formations. The location of the deposit, considerably higher than the talweg of the *Paleotimavo* and the nature of its material suggest that the deposit stems from an affluent of the *Paleotimavo* that had its course through the sunken Trieste basin. Witnesses of the old topographic surface of the Trieste basin are the partly sunken ridges of *Monte Radio*, *Conconello-Scorcola*, *Cacciatore* and *Cattinara*, and the mountain on which the village of *Antignano* (Tinjan) is built. R. MALARODA (9) has shown that this surface has undergone a remarkable weathering as compared with the remaining flysch outcrops of the region.

The second alluvial deposit (B) came to light during the excavations in a quarry of *Italcementi*, near *Basovizza*, at a height of nearly 400 m a. s. l. and is located again at the edge of the Karst plateau. This time the gravels are of much bigger size, sometimes larger than 40 cm in diameter, proving the presence of quite a large river. Also in this case the material of the gravel are limestones and flysch sandstones.

4. In compliance with the proposed general theory the fossil valley of the *Paleosiaris* as well as that of *Castelnuovo* should be accompanied by a subterranean flow af karstic waters collecting the greatest part of the rainfall on the catchment basin over an area of approx. 453 sq. kms in Upper Istria. This flow should continue underground along the line *Basovizza, Padriciano* and *Trebiciano,* until it reaches the subterranean course of the *Timavo* at the latter place. The karstic waters of Upper Istria show leakages, some of which are perennial as of the source of *S. Maria del Risano* (Rizana, 70 m above sea level), while others are temporary, as for example at *Ospo* (90 m above sea level), where the leakage takes place only during periods of the heaviest rainfall. However, most of the waters must flow beneath the upper part of the present *Val Rosandra*. Here, the level of the flowing waters during draught periods, should be around 30 m above sea level (being 14 m above sea level in the cave of *Trebiciano*, 7,5 km downstream).

5. This flow of karstic waters, has been confirmed in various ways both in theory and practice.

The first confirmation results from the analysis of the water balance of the karstic waters in the cave of *S. Canziano,* the cave of *Trebiciano,* the source of *Aurisina* and of *S. Giovanni di Duino*. This balance, referring to the daily average flow, is summarized in the following table:

	Flow (thousands of cubic metres per day)
Timavo at S. Canziano	50—100
Cave of Trebiciano	400
Source of Aurisina	15
Source of S. Giovanni di Duino.	900

As may be seen, there is alread a water surplus in the cave of *Trebiciano* compared with that of *S. Canziano,* which amounts to 300.000 cubic metres per day; and this surplus raises to 800.000 cubic metres per day at *S. Giovanni.* The contribution through rainfall on the Trieste-Gorizia Karst is by far not sufficient to explain such a surplus, nor does it seem realistic to admit that at the sources of *S. Giovanni of Duino* there is a contribution of waters coming from the basin of the *Isonzo-Vipacco* rivers, because among others these sources are about two metres higher than the bottom waters which appear in the *Moschenizze* river and at the *Lisert* marsh.

It is therefore necessary to attribute the water surplus to a large catchment with heavy rainfall, such as that of Upper Istria. Assuming that the average yearly rainfall in this area is 1,200 mm equal to an average daily contribution of 3,285 cubic metres per sq. km, the total daily contribution of rainfall in the catchment amounts to an average of 1,488,000 cubic metres per day. Assuming an evaporation coefficient of 65%, and therefore an infiltration coefficient equal to 35%, there is a penetration of water which exceeds 500,000 cubic metres per day which all together feed the underground downflow.

When taking into consideration the losses by leakage which do take place in the subterranean system (e. g. at *Risano* and *Ospo*) and evaluating such losses at 100,000 cubic metres per day, the result is an average downflow of approx. 400,000 cubic metres per day which contributes to reducting the unbalance which we have pointed out.

6. Further confirmation comes from investigations carried out in 1963 (10) where tritium was used as a tracer in the waters of the *Timavo* (Nostranjska Reka) at *S. Canziano*, and the concentration of which was observed at the cave of *Trebiciano* and at the source of *S. Giovanni di Duino*.

The authors of this research work conclude by stating that at *Trebiciano* there is a very large and substantial contribution of waters others than from the upper *Timavo* (Nostranjska Reka). This contribution is calculated in 394,000 cubic metres per day in a normal period like that during which the investigation was carried out. As one can see, the estimate complies very well with the estimate based on the rainfall balance in the tributary basin of Upper Istria.

7. A more direct evidence of the expected underground flow was obtained during the research campaign for the supply of drinkable water for the City of Trieste; a specially adapted geophysical method has been applied here, intended to detect by means of high sensitivity geophones and recording instruments used in seismic exploration the vibrations induced in the ground by the turbulence of the flowing channeled waters. A description of the method used is given in (11).

As has been mentioned before the fossil valleys of the *Castelnuovo* and *Paleosiaris* are cut obliquely by the much more recent carving of the *Val Rosandra*, the bottom of which is now at an altitude of about 100 m above sea level. If we consider that the level of the Karst plateau is at about 450 m above sea level, we are in the fortunate position that nature itself has done the work that permits us to come so much closer to the expected underground flow taking place, as has been stated, at about 30 m above sea level. Here 3 boreholes were perforated in depths of 12,73 and 90 m, in which the geophones were put in operation at times of draught and of heavy rainfall. The results obtained in the first two boreholes are illustrated in (11); those for the third borehole have not yet been published.

In all cases a strong increase in the recorded vibrations was observed during periods of heavy rainfall.

8. The Karst region of Trieste represents an extremely clear model in which the correlation between karstic phenomena and morphology is apparent; this fact may be attributed to the uniformity of its lithological constitution, to the simplicity and stability of its past hydrographic system, at least in its last stages, and to the absence of later tectonic events that might have altered the original topography after the disappearance of the river system.

   In other cases the establishment of such correlation might be much more difficult; but once the principle is accepted, it offers a means for reconstructing, correlating and dating paleogeographic and tectonic events in many cases.

Summary

A detailed geomorphological analysis of the Karst Region of Trieste and Upper Istria clearly shows the existence of a paleohydrographic system, also confirmed by alluvial remains.

Two branches of the system form the old valleys which are followed at successive stages by the Timavo River: The Paleotimavo of Brestovizza and the Paleotimavo of Trebiciano. Two further branches originating in Upper Istria (Valley of Castelnuovo and Paleosiaris) converge in the latter.

The study confirms the strict correlation existing between the topography, the major karstic phenomena, and the present underground flow, suggesting a common genesis.

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Zusammenfassung

Wechselbeziehung zwischen ober- und unterirdischen Karsterscheinungen im Karst von Triest und Istrien

1. Schon im Jahre 1941 (1) hatte ich Gelegenheit, auf die enge Wechselbeziehung aufmerksam zu machen, die, zumindest im Triestiner Karst, zwischen der Morphologie der Oberfläche und der Karsterscheinung „im großen" besteht, und eine allgemeine Theorie aufzustellen, die dieses Phänomen auf die frühzeitlichen Gewässerläufe zurückführt.

   Ich werde hier die damals entwickelten Argumente nicht wiederholen, muß aber daran erinnern, daß die Bildung der unterirdischen Karsterscheinungen auf die Wirkung der starken Gewässer zurückgeführt wird, wo diese in das Kalkgestein des Laufes einzudringen begannen, verursacht durch die Absenkung des Grundwasserspiegels und die allgemeine Hebung des Gebietes. Die chemische Wirkung der Kalkauflösung in den Wasserläufen ist also nach dieser Theorie unter dem Alluvium der alten Täler erfolgt, was die teils großen Abmessungen der Dolinen und der Karstabgründe erklärt, deren Entstehung untertags, wie meist angenommen, sonst nicht ausreichend zu begründen wäre.

   Daraus ist zu folgern, daß die stärkere unterirdische Verkarstung als eine fossile betrachtet werden muß und ihre größte Dichte unter den alten, jetzt verlassenen Flußläufen aufweist.

2. Die früher dargelegte und hier kurz in Erinnerung gebrachte Theorie ist vom Autor zum Zweck des Studiums des Paläotimavo aufgestellt worden (2); seitdem sind aber neue Beobachtungen und neue Studien durchgeführt worden, die im folgenden kurz behandelt werden.

   Von diesen Beobachtungen möchte ich sowohl die Beschreibung einer von einer Verwerfung halbierten Doline [Dr. Carlo d'Ambrosi (3)] erwähnen als auch die Entdeckung eines sehr großen Abgrundes, der bei Grabungen an den Fundamenten des Marianischen Tempels auf dem Monte Grisa bei Triest aufgeschlossen wurde und der mit Anschwemmungen aus eozänem Sandstein angefüllt ist. Da sich der Abgrund an der Kante des Karstrandes in einer Höhe von ungefähr 300 m ü. M. befindet, in einer Lage, die heute weit entfernt von diesem Sandsteinstreifen ist, beweist sein Bestehen die Tatsache eines weitverbreiteten paläohydrographischen Netzes (4).

3. Die neuen Studien führten zur Rekonstruktion des paläohydrographischen Netzes des Paläotimavo und wurden im Rahmen von Untersuchungen für

die Wasserversorgung der Stadt Triest durchgeführt. Schon in (2) wurde ein Zufluß zum Becken des Paläotimavo im Talgraben von Castelnuovo festgestellt, der früher in tertiären mergelig-sandigen Böden oberhalb des jetzigen Rosandratales verlief.

Im Jahre 1961 hat der Verfasser neuerdings einen alten Talverlauf aufgezeigt, der in der Nähe des Sattels des Monte Maggiore beginnt und der, vorbei an Bergozza, Lanischie, Raspo (Bertarelli-Abgrund), Danne di Raspo und Piedimonte del Taiano in der Höhe von Botazzo gerade in Übereinstimmung mit der Mitte des Rosandra-Tales in ein ehemaliges Tal einmündet.

Der Talgrund des sogenannten Paläosiaris, der an einigen Stellen sehr gut erhalten, an anderen Stellen aber größtenteils zerstört ist, wurde in Verbindung mit anderen Talgründen mit geringen Zuläufen studiert, wobei eine Reihe von Querschnitten im Maßstab 1 : 25.000 mittels der Karte des Militärgeographischen Instituts gemacht wurde. Aus diesen Abschnitten wurde die alte Spur des Talgrundes rekonstruiert, der heute durch äußere Einflüsse teilweise zerstört ist (s. Tafeln I—V). Der rekonstruierte Längsschnitt des alten Tales zwischen dem Sattel des Monte Maggiore und Botazzo beträgt ungefähr 45 km (ohne Zuflüsse).

Die betreffenden Böden sind ohne Ausnahme kalkig und haben an der tonhaltigen Eozänreihe Anteil, die die aufsteigende Geländefalte der Vena-Berge bildet.

4. In Übereinstimmung mit der allgemeinen, anfangs angedeuteten Theorie muß der Graben des Paläosiaris gemeinsam mit jenem von Castelnuovo von einer unterirdischen Abflußader von Karstgewässern begleitet sein, die den Großteil der Niederschläge von ungefähr 453 km² in Oberistrien sammelt. Diese Abflußader verläuft dann im Untergrund von Basovizza, Padriciano und Trebiciano, bis sie in der Höhe der letztgenannten Ortschaft in den unterirdischen Lauf des Timavo mündet, um dann endlich beim Wiederauftauchen des Timavo-Unterlaufes in S. Giovanni di Duino ans Licht zu kommen.

   Diese Karstgewässer führen große Wassermengen, haben aber dauernde oder zeitweise Verluste, wie jene von S. Maria del Risano (70 m ü. M.) und jene von Ospo (90 m ü. M.), längs des SW-Randes der Venaberge. Der Großteil der Karstwässer muß aber ins Unterirdische des heutigen mittleren Rosandra-Tales abfließen. In diesem Fall muß sich die Grundwasserquote in wasserarmer Zeit etwa 30 m über Meeresniveau bewegen (sie liegt in der Grotte von Trebiciano 7,5 km taleinwärts 14 m ü. M.).

5. Die Existenz dieses Abflusses, der, wie ersichtlich, rein induktiv nachgewiesen wurde, hat zahlreiche Beweise. Die erste Bestätigung resultiert aus der Mengenbilanz der Karstwässer in der Grotte von S. Canziano, in der Grotte von Trebiciano, an den Wiederaustrittsstellen von Aurisina und von S. Giovanni di Duino. Diese auf die normale Tagesmenge bezogene Bilanz ist in folgender Tabelle schematisch dargestellt:

	Wassermenge in 1000 m³/Tag
Timavo bei S. Canziano	50—100
Grotte bei Trebiciano	400
Wiederaustrittsstelle von Aurisina	15
Wiederaustrittsstelle von S. Giovanni di Duino	900

Wie man sieht, besteht schon in der Grotte von Trebiciano ein Wasserzuwachs im Vergleich zu S. Canziano, der 300.000 m³/Tag ausmacht. Und dieser Zuwachs steigt auf 800.000 m³/Tag bei S. Giovanni. Um sich das zu erklären, genügt es nicht, den Zulauf der Niederschläge im Triestiner-Görzer Karst heranzuziehen, wie es auch nicht real erscheint, einen wesentlichen unterirdischen Zulauf von Gewässern bei S. Giovanni di Duino aus dem Isonzo-Vipacco-Becken anzunehmen, da die Wasseraustrittsstellen von S. Giovanni unter anderem fast 2 m höher liegen als die Grundwässer, die im Lisert ans Licht kommen.

Es ist also nötig, dem Wasserzuwachs ein weites Gebiet starker Niederschläge zuzuschreiben, und zwar jenes von Oberistrien. In der Annahme, daß der mittlere Jahresniederschlag in diesem Gebiet bei 1200 mm liegt, was einem mittleren Tageszulauf von 3285 m^3 pro Quadratkilometer gleichkommt, beträgt der tägliche Gesamtzulauf an Regenwasser in dem Becken 1,488.000 m^3 im Mittel. In der Annahme eines Verdunstungsfaktors von 65%, eines oberirdischen Abflußfaktors Null und daher eines Versickerungsfaktors von 35% ergibt dies eine Wasserzufuhr in der Summe, die 500.000 m^3/Tag übersteigt und im gesamten den unterirdischen Zufluß speist.

Wenn man nun die Verluste durch Übertritte in andere Systeme in Rechnung stellt, die im unterirdischen Wassersystem sicherlich bergseits des Rosandra-Tales stattfinden (z. B. Risano und Ospo), und wenn man diesen eine Menge von 100.000 m^3/Tag zuschreibt, erhält man eine mittlere Abflußmenge von ungefähr 400.000 m^3/Tag, die dazu beiträgt, die kurz vorher aufgezeigte Ungleichheit aufzuwiegen.

Der zweite Beweis resultiert aus den Forschungen, die 1963 durch Beimengungen von Tritium in die Gewässer des Timavo-Oberlaufes erfolgten (5). Die Autoren dieses Experimentes schließen auf die notwendige Existenz eines sehr großen und wesentlichen Zuflusses von Gewässern bei Trebiciano, die von jenen des Timavo verschieden sind. Dieser Zufluß wird dabei auf 394.000 m^3/Tag berechnet, und zwar in normalen Perioden wie jenen, während der die Ermittlungen vorgenommen wurden. Eine solche Berechnung ist sicherlich in sehr gutem Einklang mit jener, die aufgrund der Niederschläge im Sammelgebiet Oberistriens gemacht wurde.

Der dritte Beweis, diesmal direkt, resultiert aus den geophysikalischen Untersuchungen, die im Rosandra-Tal durchgeführt wurden.

Dieses Tal ist, wie bereits erwähnt, ein tiefer Einschnitt, dessen Grund im tiefsten Punkt eine Höhe von 103 m ü. M. erreicht. Wir befinden uns hier also um nicht mehr als 70 bis 80 m höher als der vorausgesetzte unterirdische Zufluß, der aus Oberistrien kommt.

In diesem Bereich wurde eine Bohrung mit einem Durchmesser von 105 mm und einer Tiefe von 37 m niedergebracht, die dann mit 60 mm Durchmesser bis auf eine Tiefe von 73 m fortgeführt wurde. Darin wurde ein Eisenrohr mit einer Länge von 38 m versenkt, auf das ein Geophon aufgesetzt wurde, welches dann elastische Schwingungen ergab, die von der Turbulenz der Gewässer in 73 m Tiefe herrührten. Vergleichsmessungen wurden an der Oberfläche unter identischen Bedingungen vorgenommen.

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Plate I

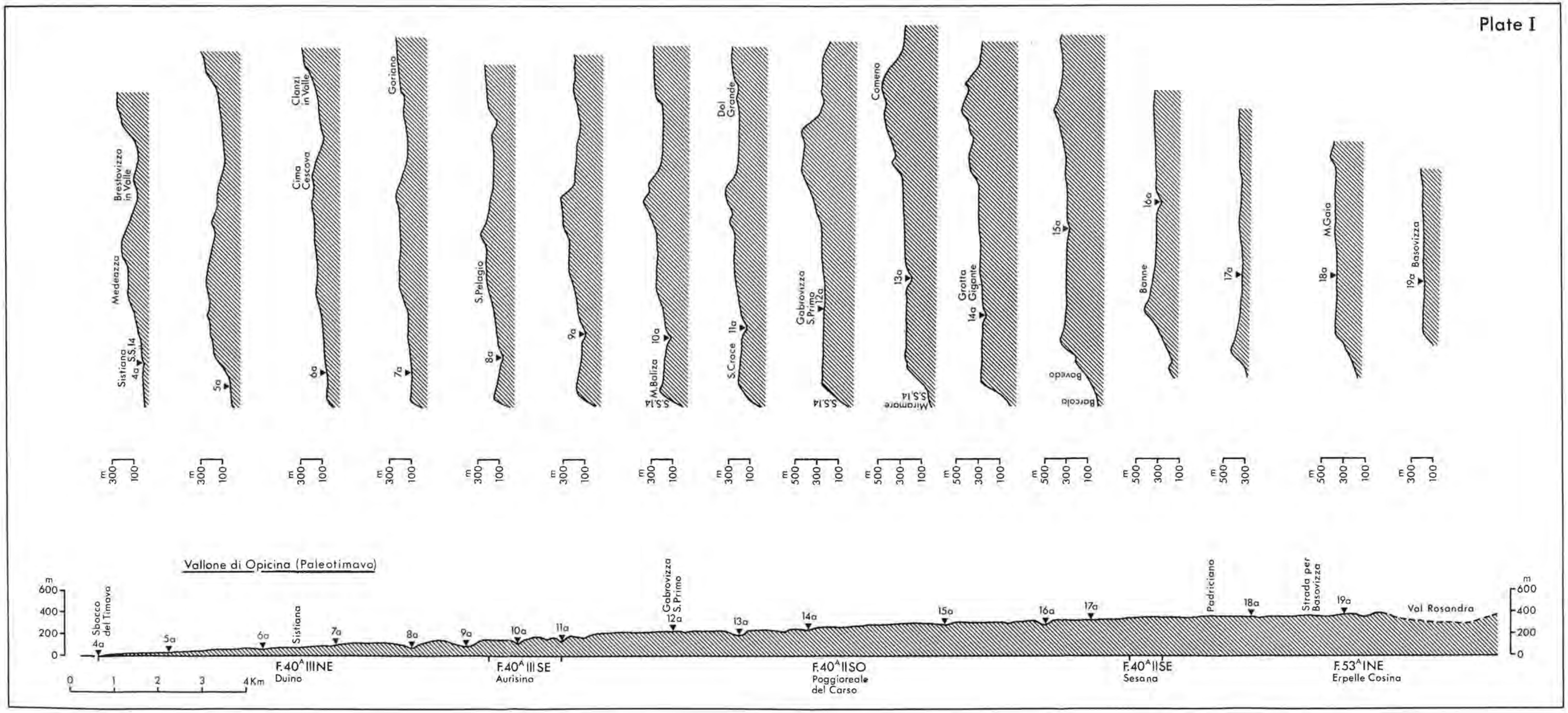
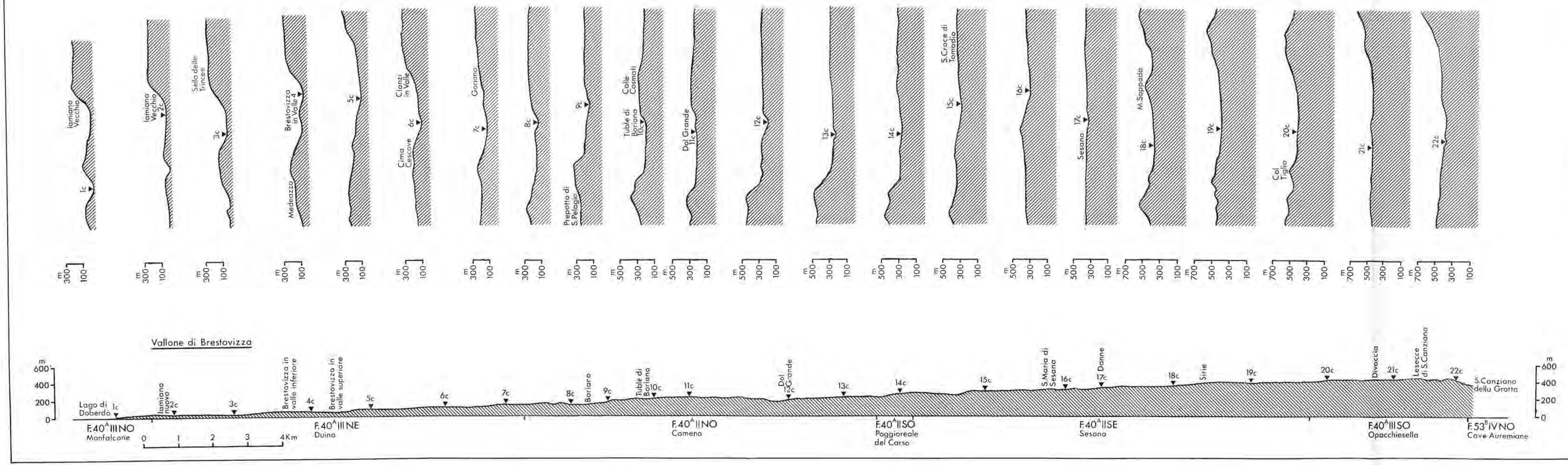
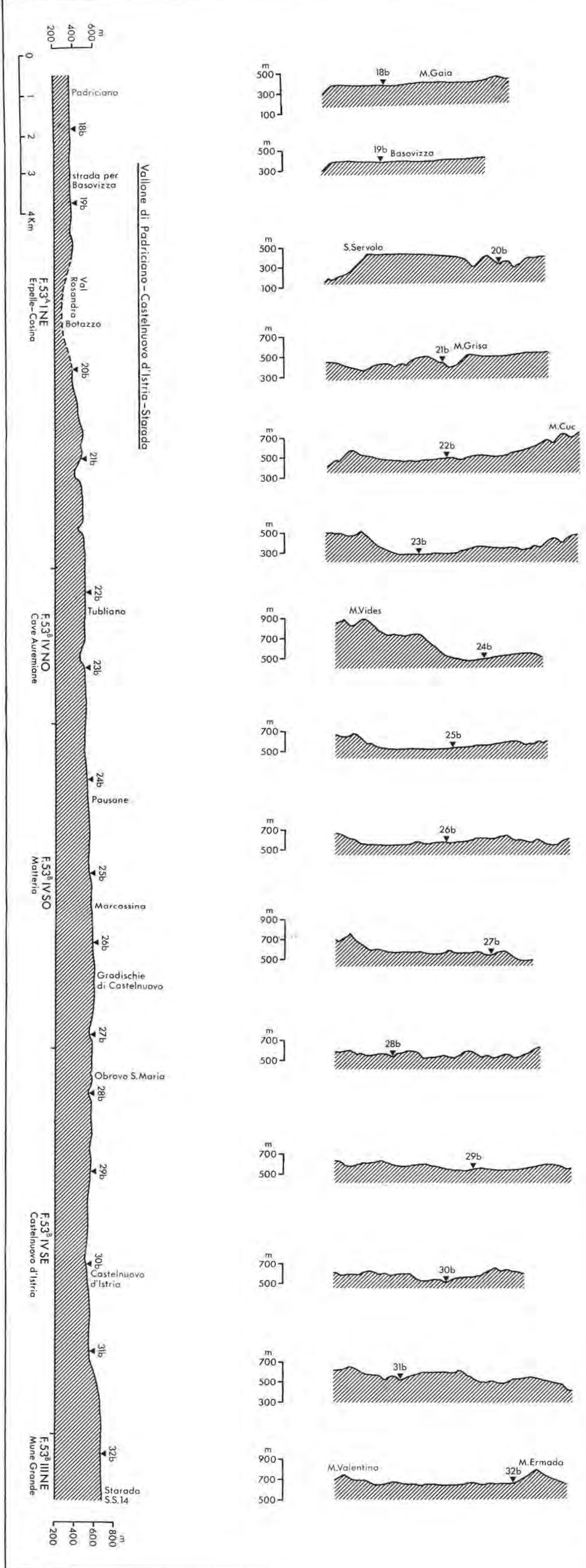

Brestovizza in Valle
Medeazza
Sistiana S.S.14
4a
5a
Clanzi in Valle
Cima Cescova
6a
Goriano
7a
S.Pelagio
8a
9a
10a
M.Boliza
S.S.14
Dol Grande
11a
S.Croce
Gabrovizza S.Primo
12a
S.S.14
Comeno
13a
Miramare S.S.14
Grotta Gigante
14a
15a
Bovedo
Barcola
16a
Banne
17a
M.Gaia
18a
Basovizza
19a
Vallone di Opicina (Paleotimavo)
Sbocco del Timavo
Sistiana
Gabrovizza S.Primo
Padriciano
Strada per Basovizza
Val Rosandra
F.40^A III NE
Duino
F.40^A III SE
Aurisina
F.40^A II SO
Poggioreale del Carso
F.40^A II SE
Sesana
F.53^A I NE
Erpelle Cosina
4 Km

Plate II


Iamiano Vecchio
1c
2c
Sella delle Trincee
3c
Medeazzo
Brestovizza in Valle 4
5c
Cima Cescove
6c
Clanzi in Valle
7c
Goriano
8c
Prepotto di S.Pelagio
9c
Tuble di Boriano
10c
Colle Cosmati
Dol Grande
11c
12c
13c
14c
15c
S.Croce di Tomadio
16c
Sesana
17c
18c
M.Soppada
19c
Col Tiglio
20c
21c
22c
m
700
500
300
100
Vallone di Brestovizza
Lago di Doberdò
Iamiano nuovo
Brestovizza in valle inferiore
Brestovizza in valle superiore
Boriano
Dol Grande
S.Maria di Sesana
Danne
Sirie
Divaccia
Lesecce di S.Canziano
S.Canziano della Grotta
600
400
200
0
F.40^A III NO
Monfalcone
0
1
2
3
4Km
F.40^A III NE
Duino
F.40^A II NO
Comeno
F.40^A II SO
Poggioreale del Carso
F.40^A II SE
Sesana
F.40^A III SO
Opacchiesella
F.53^B IV NO
Cave Auremiane



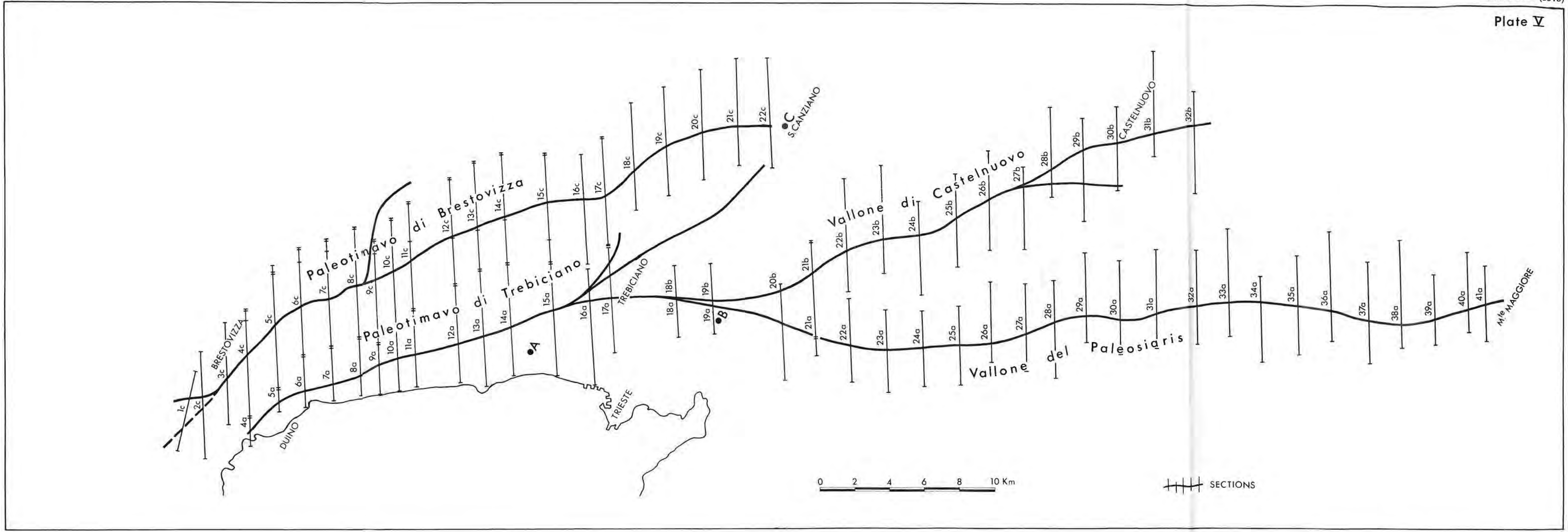
Vallone di Padriciano – Castelnuovo d'Istria – Starada
Padriciano
18b
strada per Basovizza
19b
Val Rosandra
Botazzo
20b
21b
22b
Tubliano
23b
24b
Pausane
25b
Marcossina
26b
Gradischie di Castelnuovo
27b
Obrovo S.Maria
28b
29b
30b
Castelnuovo d'Istria
31b
32b
Starada S.S.14
F.53^A I NE Erpelle-Cosina
F.53^B IV NO Cave Auremiane
F.53^B IV SO Matteria
F.53^B IV SE Castelnuovo d'Istria
F.53^B III NE Mune Grande
0 1 2 3 4 Km
M.Gaia
Basovizza
S.Servolo
M.Grisa
M.Cuc
M.Vides
M.Valentina
M.Ermada

Plate III

Plate IV


Vallone di Basovizza – Lanischie – M. Maggiore (Paleosiaris)
Strada per Basovizza
Val Rosandra
Beca
Linea ferroviaria
Danne
Racia
Lanischie
Sella M. Maggiore
F. 53A I NE Erpelle - Cosina
F. 53A I SE S. Sergio
F. 53B IV SO Matteria
F. 53B III NO Silun Mont'Aquila
F. 53B III NE Mune Grande
F. 65B III SE Lanischie
F. 65B IV NE Bogliuno
F. 65B I NO Laurana
M. Gaia
Basovizza
M. Castellier
M. Soligrado
M. Sega
Mna della Neve
M. Tiglio
Col Grosso
Janpronih
M. Taiano
M. Gnoina
M. Calvo
M. Grizano
M. Caulizza
M. Peloso
M. Testino
M. Progan
M. Silevaz
M. Rasusizza
M. S. Bartolo
M. Roccia
M. Gradina
M. Glavizza
M. Scecorica
M. Biscignacco
M. Cozarischie
M. Spigo
M. Logugnacco
M. Peci
M. Gomilla
M. Acuto
M. Debeli
Lanischie
M. Trebenizza
M. Braico
M. Sticovici
Schirlenica
M. Cupici
Alpe Grande
M. Croce
M. Gradaz
Zagobrie
Vecchia Dolina
0 1 2 3 4 Km

Plate V



Paleotimavo di Brestovizza
Paleotimavo di Trebiciano
Vallone di Castelnuovo
Vallone del Paleosiaris
BRESTOVIZZA
DUINO
TRIESTE
TREBICIANO
S. CANZIANO
CASTELNUOVO
M^te MAGGIORE
A
B
C
0 2 4 6 8 10 Km
SECTIONS

Plate VI


N
S. CANZIANO
DIVACCIA
C
CASTELNUOVO D'ISTRIA
STARADA
DUTTOGLIANO
MATTERIA
MUNE
BRESTOVIZZA
OPICINA
BASOVIZZA
B
A
BRESENZA DEL TAIANO
M. TAIANO 1028
GELOVIZZA
DANNE
RASPO
LANISCHIE
ALPE GRANDE 1271
SELLA M. MAGGIORE
DUINO
TRIESTE
OSPO
S. MARIA
100
200
300
400
500
600
700
DOLINE AND UVALA
ZONE OF RELATIVE ELEVATION
MARGINAL FAULT
0 2 4 6 8 10 Km