Mem. Soc. Geol. It.,
45 (1990), 807-814, 3 ff., 2 tavv.

PALEOGEOGRAPHIC RELATIONSHIPS DURING CRETACEOUS BETWEEN THE NORTHERN ADRIATIC AREA AND THE EASTERN SOUTHERN ALPS

P. CASERO (*), A. RIGAMONTI (**) & M. IOCCA (**)

ABSTRACT

On the basis of the integration of bibliographic, surface, seismic and well information, a paleogeographic sketch of the Cretaceous of the area is proposed.

It is subsequently discussed the role played by the Cretaceous paleogeography itself on the following Tertiary paleogeographic evolution and on the style of structural deformation during the Dinaric-South Alpine orogenic phases.

KEY WORDS: *North Adriatic, Eastern South-Alpine, Cretaceous, paleogeography, tectonics, seismic, wells.*

RIASSUNTO

Sulla base dell'analisi integrata di dati bibliografici, di superficie, sismici e di perforazione, viene proposto uno schema paleogeografico del Cretacico della regione.

Viene quindi discusso il ruolo di controllo giocato dalla paleogeografia cretacea sulla successiva evoluzione paleogeografica terziaria e, soprattutto, sullo stile di deformazione strutturale delle fasi dinarico-sud alpine.

INTRODUCTION

In the northern Adriatic region, from the Friuli-Venetian area to the Dalmatian islands, a major facies change occurs during Cretaceous time between shelf carbonate and deeper water pelagic sequences.

This facies variation is well known and described in the outcrops, for istance in the Cansiglio area (NW Friuli border), where the roughly bedded shelf series of the Cellina limestones formation (lower part of upper and lower Cretaceous essentially) range to well bedded basinal calcareous sequences of the Belluno basin through the reef-talus complex of the M. Cavallo formation.

(*) Total Mineraria, Rome.
(**) Lasmo Intern. Oil Dev., Rome.

Yet the facies change occurs for the largest extent in the subsurface, both onshore and offshore. As it involves average thickness in the order of 1500 to 2500 m it is in general detectable on the seismic lines.

The integration of:

– the lithostratigraphic study of numerous composite well logs;

– the analysis of the seismic character of regional seismic lines calibrated on the wells;

– the review of the published geologic maps and bibliography has allowed to draw in good details the boundary of the carbonate shelf domain and its slope to the deeper water areas. In some extent it has also been possible to precise different ways of facies change.

CRETACEOUS PALEOGEOGRAPHY (pl. 1)

As anticipated, the shelf basin transition displays different patterns within the considered region: from this point of view one can thus distinguish different sectors.

A) CENTRAL AREA (OR ISTRIA PLATE)

The Istria shelf extends from about the latitude of Trieste towards the South; it appears as a rather homogenous and «massive» shelf domain. Its western slope towards the basin is well defined on the seismic lines and it runs quasi N-S, not far from the Italian-Yugoslavian border, from the mouths of th Isonzo river to the Andrea-Andreina wells zone. The shelf to basin transition appears rather simple and represents the typical reference case (see fig. 1). The lower Cretaceous shelf limestonces section (Cellina formation about 1000 m thick) wedges out to the West forming a talus about 3 to 4 km

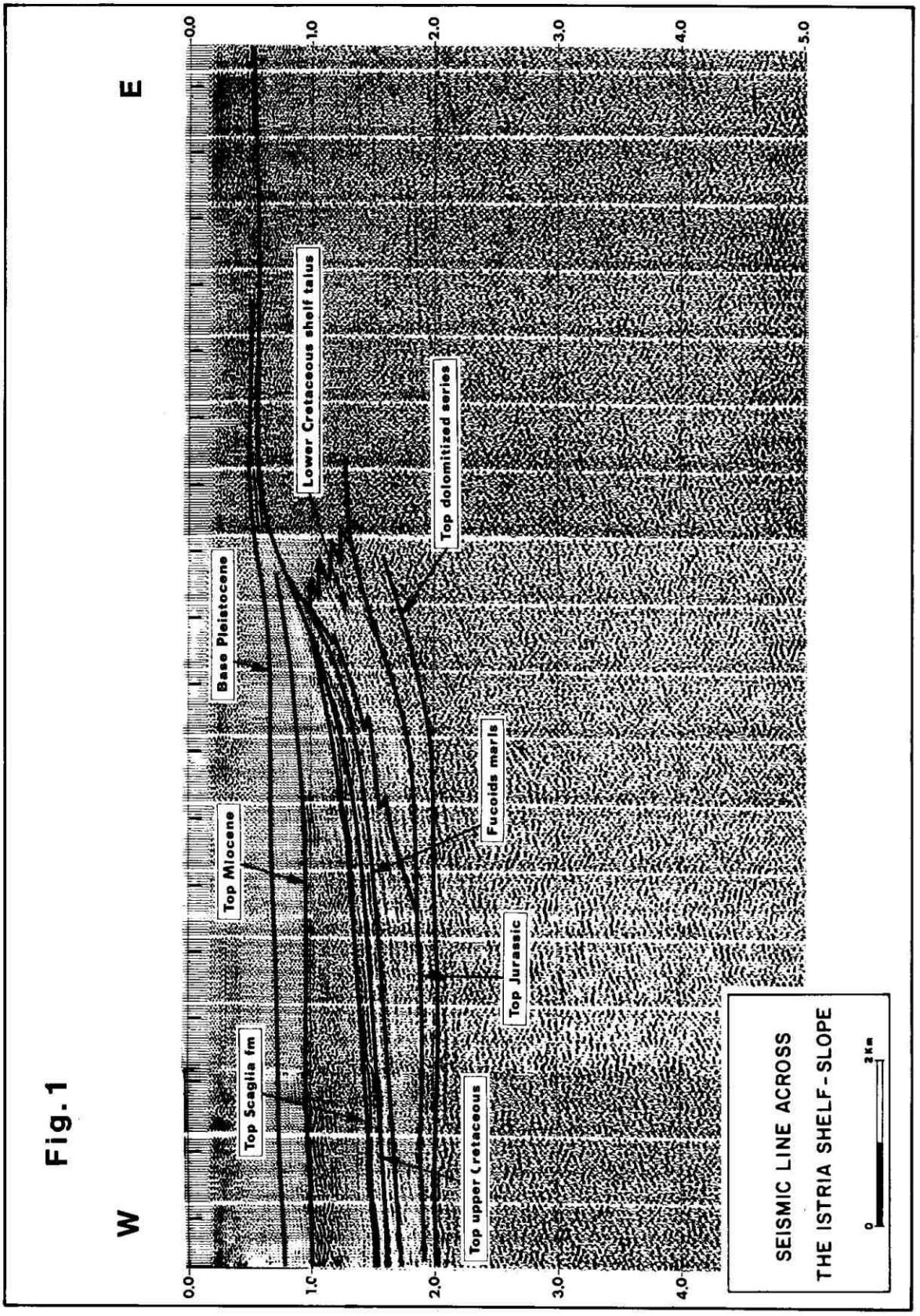


Fig. 1 - Seismic line across the Istria Shelf Slope.

wide within the Maiolica (Biancone) basin. The Maiolica tends to progressively increase in thickness towards the talus.

Along the margin of the shelf the upper Cretaceous sequence is, on the contrary, reduced (to the Cenomanian in general) or entirely missing, due to both low subsidence/accretion and subsequent erosion. The basinal Scaglia calcarea formation shows a gentle, long distance, increase in thickness from the West (about 200 m) towards the talus (about 800 m); then it thins out rapidly along the lower Cretaceous wedge.

The middle-upper Eocene section is represented by some tens m of marly-calcareous beds, containing resedimented Nummulitic limestones levels (Scaglia variegata formation). The Nummulitic interbeds become progressively more abundant towards the shelf edge till they form at the top of the talus Nummulitic shore-bars (Calcari di Peschici formation). The section is missing in the shelf area and it is the time equivalent of the North-Istria flysch. The Paleogene section follows up in stratigraphic continuity in the basinal area, where it is represented by a thick marly series (up to 700 m-Gallare formation). The entire section on-laps rapidly on the shelf talus and is missing on the shelf area.

Lower-middle Miocene interbedded glauconitic sandstones and marls (some 200 m thick-Glauconie di Cavanella formation) of shallow water environment disconformably transgress the peneplanated Cretaceous shelf area.

During middle-upper Miocene time the Istria shelf is again emerged. A new erosional phase takes place.

Plio-Quaternary clays and sands unconformably cover the differentially eroded sections on the entire northern Adriatic area.

B) Southern sector (Northern Dalmatia offshore)

Starting from the Andrea-Andreina wells area, the shelf basin slope changes abruptly its general orientation from quasi N-S to grosso-modo NW-SE. The boundary appears clearly brocken into mega-steps (10 to 25 km in length), defined by the interaction of two main systems of synsedimentary faults (trending W-SW/E-NE and NW/SE respectively).

The draw back of the slope gives progressively place to the Dugi Otok basin. In addition to the seismic evidence, the existence of thick Cretaceous deeper water sections (from several hundreds to 1000 m) has been controlled by the wells Jadran 1-2 and 10. Resedimented talus facies have been found by the well Jadran 3 (about 18 km off the Dugi Otok Island).

The Dugi Otok basin is bounded on its S-W flank, over about 200 km (from the Calpurnia-Scorpena wells zone to the Jabuka-S.Andrea Islands), by an almost continous structural high, having a clear Dinaric trend, which represents the northern part of the so-called Middle Adriatic Ridge. This structural trend seems to continue South-Eastward the Istria shelf slope of the central sector. As a matter of fact we deal with a complex narrow high structural belt that commenced to be active probably only from uppermost Cretaceous time as a non-vergent feature; at places a diapiric origin is proved while elsewhere (Jabuka island) a volcanic one seems more likely; somewhere else still (Scorpena, Carlo wells) it appears simply as a horst-like feature.

During middle-upper Eocene the trend persisted as a high: thick Nummulitic series are deposited there.

Subsequently, mostly during Oligocene time, the trend was involved in the outer Dinaric compressional tectonics and re-activated as a S-W vergent thrust fold. It has to be remarked how a late dolomitization of the calcareous section can occur along this trend: the dolomitization can rise up to the nummulitic limestones series (Scorpena and Carlo wells). One must therefore conclude for a substantial continuity between the Dugi Otok basin and the outer Umbro-Marchigiano basin through mesozoic time with the only separation of sea-floor high trends eventually reaching the photic zone only during uppermost Cretaceous.

As far as the Dalmatia carbonate shelf itself is concerned, it has to be remarked that the upper Cretaceous part of the section is, as a general rule, stratigrafically more complete, in the upper terms, and consistently thicker (about 1500 m in SUS 1; over 2500 m in PRE 1 and RK 3, against the few hundreds m of PU 1 in southern Istria), probably due to lesser erosion.

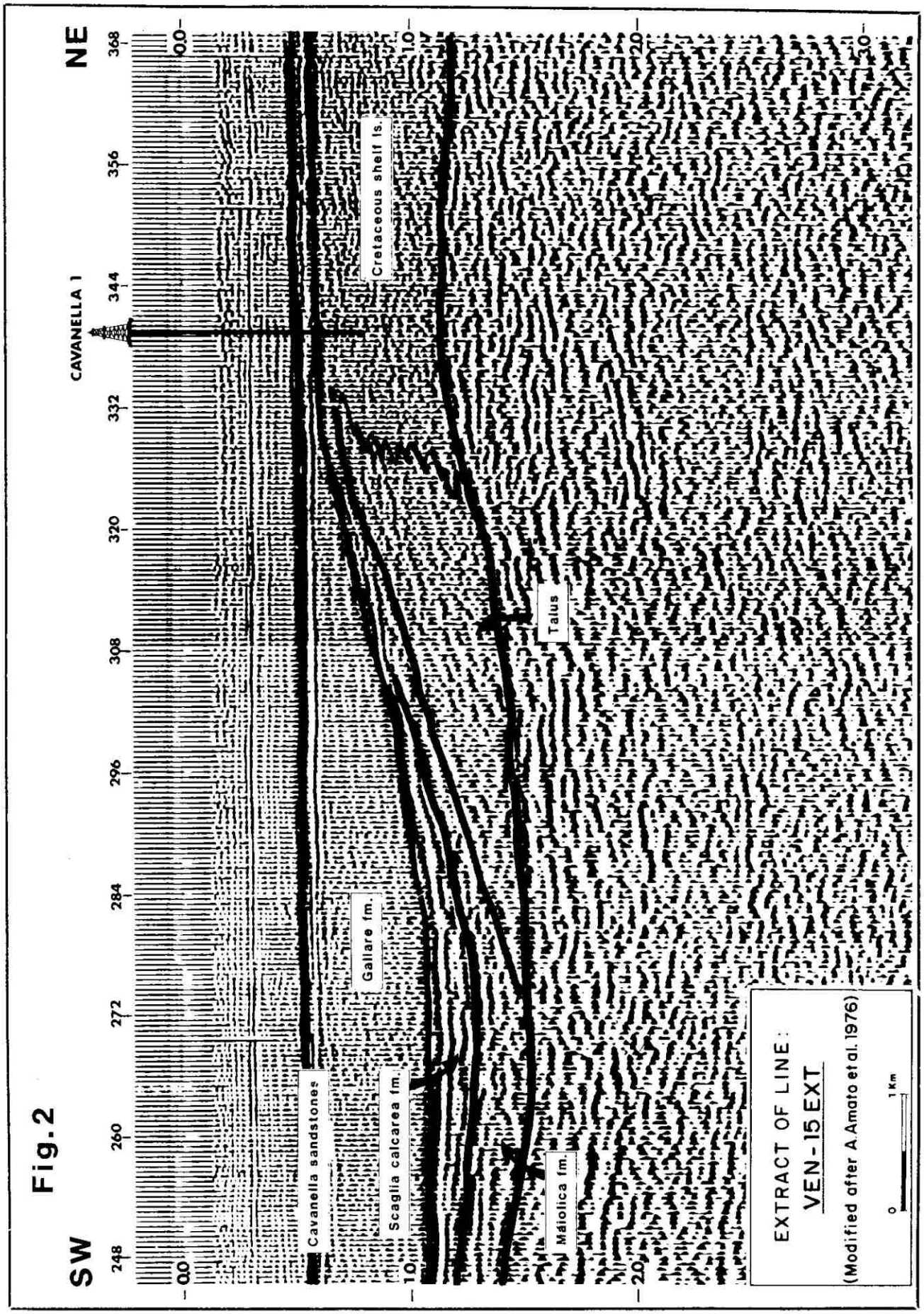


Fig. 2 - Extract of line: VEN-15 EXT (Modified after A. AMATO *et alii*, 1976).

C) THE BARBARA PLATE

A large patch of Cretaceous carbonate shelf is seismically well recognizable and controlled by Barbara, Malachite and Judith wells. This paleogeographic «island» is separated from the main Istria plate by a deeper water sea-way (controlled by the well Jadran 7). The stratigraphic sequence consists there typically of middle-upper Eocene Peschici limestones disconformably overlying peneplanated Cenomanian shelf limestones. The outer talus of the Barbara plate also recalls in characters the main Istria one.

D) THE NORTH-WESTERN AREA (FRIULI-VENETIAN PLANE AND EASTERN SOUTHERN-ALPS)

Through a large belt set roughly across the Yugoslavian-Italian border the Istria carbonate plate loses rapidly its transversal paleogeographic continuity. From the S-E to the N-W, along an arched overall area, a deep indentation of triangular carbonate shelf and pelagic deeper water wedges takes place through Cretaceous.

Along the northern (inner) margin of the arch, from South of Tolmino to the wells Arcade and Merlengo, an almost continous shelf ridge can be drawn.

The ridge integrates the so-called Ruga Friulana (Cellina river), the Ciaurlec Mt. and the Bernadia Mts. Throughout its northern talus a facies transition to deeper water (Scaglia-Maiolica type) section occurs. Basinal sediments are known, almost continously, from the well Volpago 1, through the Belluno basin, up to the Sloveno basin.

South-West of the well Merlengo 1 the northern ridge seems to disappear, being drowned in a basinal domain.

The southern (outer) margin of the shelf area can be as well defined based on seismic and well data.

Through the Gulf of Trieste the talus seems to be connected with the main western slope of the Istria platform (but we could also deal with an isolated plate as Barbara).

From here a carbonate shelf dorsale takes an E-W direction as indicated both by the wells Cesarolo, Cavanella and S. Donà di Piave and by the seismic data.

The southern slope of the shelf is well defined on the seismic lines (fig. 2).

As for the northern ridge the southern shelf wedge seems progressively drowned in a basinal area (West of the well S. Donà di Piave).

In the area between the two shelf ridges, despite the lack of well control, the analysis of the seismic data allows to admit the existence of sequences which are stratigraphically more continous (through Paleocene) and that show a clear «bedded» character of the Cretaceous section (fig. 3).

A «Friuli basin» area can thus be defined. The existence of a Friuli basin element has already been suggested in CATI *et alii*, '87 based on integrated geophysical data but a much lesser paleogeographic importance, a substantially different basin physiography and different relationships with the surrounding paleogeographic elements were assumed.

The northern slope between the southern shelf ridge and the Friuli basin (fig. 3) shows different characters compared to the main istria boundary. In particular, no evidence for a true talus wedge is visible. Most probably the Friuli basin was a low energy, intra-shelf flat deeper water area (with predominant chalky limestones sedimentation?).

The communication with the open pelagic domain (Belluno basin) was limited to the sea-ways between the Merlengo-Arcade and the S.Donà Di Piave highs (we should so prefer to talk in terms of «Friuli Gulf»).

The Friuli basin can be considered as the homologous of the Dugi Otok basin on the opposite site of the Istria platform.

As already mentioned, the eastern part of the Friuli basin was deeply subdivided into minor gulfs by the indentation of shelf wedges.

Along these dipping dorsales, during uppermost Cretaceous and middle Eocene times, important short distance resedimentation of coarse shelf material occurred.

Thick breccias of neritic material in relatively deeper wate environment are common (wells Terenzano, Buttrio, Bernadia and in the outcrops) and it is often difficult to distinguish between shelf and talus environment.

STRUCTURE

The general structural framework of the considered region is strictly controlled by the main Mesozoic paleogeographic features.

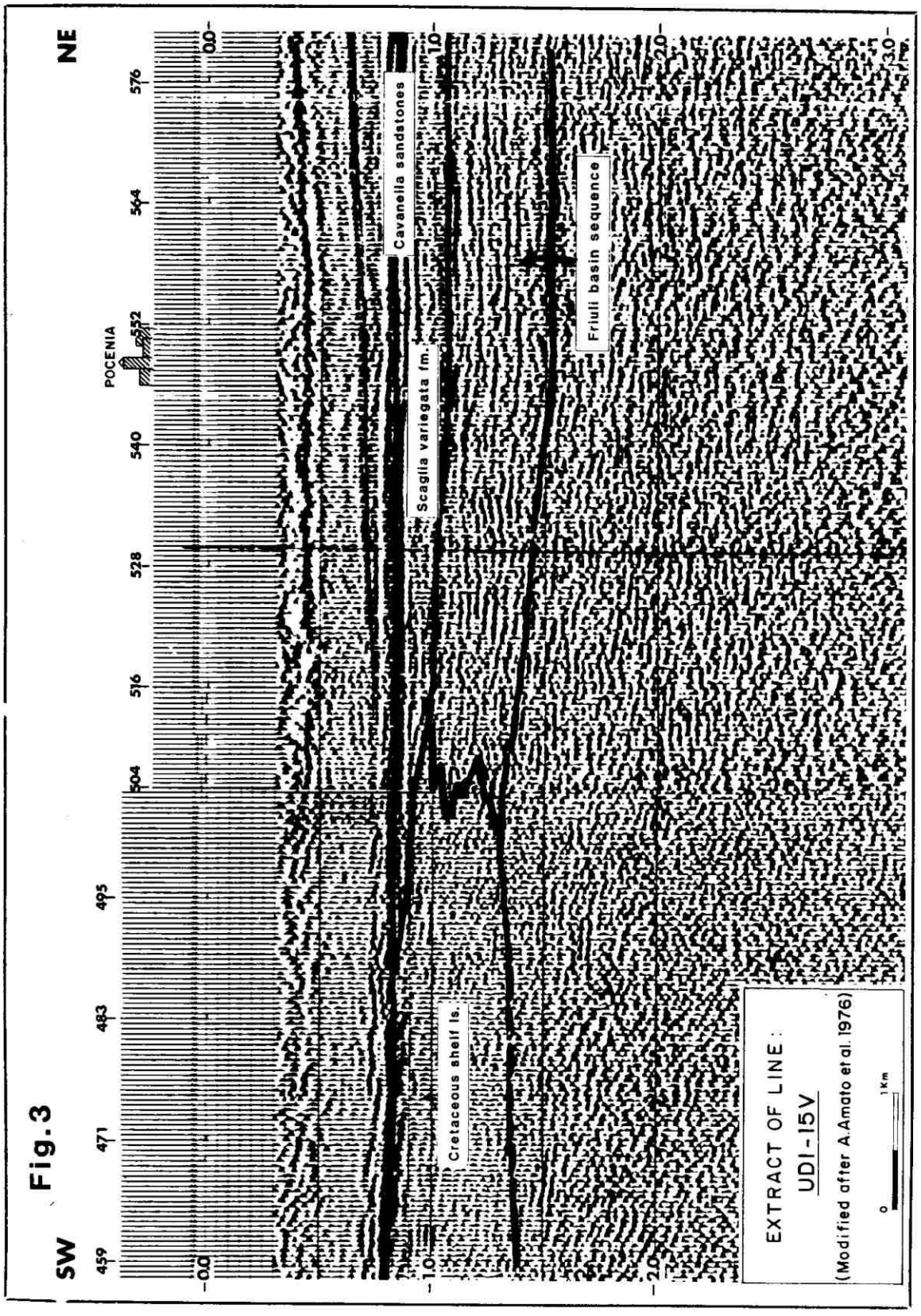


Fig. 3 - Extract of line: UDI-15V (Modified after A. AMATO *et alii*, 1976).

The tectonic style varies therefore substantially in the different described sectors.

With reference to pl. 1 and 2 the following main comments can be done.

The central (Istria platform) area shows a tabular overall setting with large scale bulging.

In the offshore area a gentle west dipping is at times broken by Plio-Quaternary grabens. The outer slope to the basin is only flexed during Oligocene time and essentially no compressional dinaric deformation reach the northern Adriatic area.

The Dugi Otok basin area is tectonically more characterized.

The talus belt is often involved into thrust folds (i.e. Jadran 3).

As already mentioned non-vergent diapiric and volcanic features rise up the carbonate substratum. High angle thrust-fold occurs on the outer flank of the basin (i.e. Jadran 2). They can evolve laterally to double vergent up thrust like features (i.e. Corinna 1).

In the reality, in this case we are dealing with a Dinaric SW vergent thrust-fold, of Oligocene age, re-involved during the Upper Pliocene Apenninic phase in a NE vergent thrust-fold.

Quasi N-S transcurrent faults are likely present.

The North-western area, due to the more differentiated paleogeography, shows a more complex tectonic setting.

The Belluno basin and the Sloveno basin sequences are deeply deformed and thrusted, with rather low angle, against the northern slope of the Friuli shelf (i.e. Monte Cavallo zone).

In its turn the Friuli-Ciaurlec-Bernadia shelf ridge series are stacked into a complex high angle thrust fold prism, trending NE-SW and producing a cumulate vertical displacement of over 4500 m. The deformation is essentially of middle-upper Miocene age.

The innermost part of the Friuli basin is partly overthrusted by the folds.

The Friuli basin is tectonically very quiet and only affected by the Oligocene-Miocene flexuration in its inner part.

Nevertheless, to the East, in the area of facies indentation, well arranged thrust-fold trends with NW-SE orientation, involve the carbonates (i.e. Terenzano and Lavariano). The age of deformation is essentially Oligocene and no Miocene foredeep exists in this southestern province.

The boundary between the two tectonic provinces (respectively described as «south-alpine» and «dinaric» in the literature) is sharp: it is oriented N 30° and runs through the middle Tagliamento river valley: it most likely represents a deep seated trascurrent fault.

Manoscritto pervenuto il 19 febbraio 1991.
Testo approvato per la stampa il 24 aprile 1991.
Ultime bozze restituite il 28 maggio 1992.

REFERENCES

AGIP (1977) - *Temperature Sotterranee.*

AMATO A., BARNABA P.F., FINETTI I., GROPPI G., MARTINIS B. & A. MUZZIN (1977) - *Geodinamic outline and seismicity of Friuli-Venezia Giulia Region.* Boll. Geof. Teor. Applic., **72**, 217-256.

BARIC G., MARCIC M. & RADICI J. (1988) - *Geochemical characterization of organic facies in the Dugiotok Basin, the Adriatic sea (Jugoslavia).* Org. Geochem., **13** (1-3), 343-349.

CAROBENE L. & CARULLI G.B. (1981) - *Carta tettonica delle Alpi Meridionali. Scala 1:200.000.* Castellarin A.Edit.

CASSANO E., ANELLI L., FICHERA R. & CAPPELLI V. (1986) - *Pianura Padana, Interpretazione integrata di dati geofisici e geologici.* 73° Congresso Soc. Geol. Roma.

CASTELLARIN A. & VAI G.B. (1982) - *Guida alla Geologia del Sud Alpino Centro-orientale.* 1° Cent. Soc. Geol. It. Bologna.

CATI A., FICHERA R. & CAPPELLI V. (1987) - *North-eastern Italy, integrated processing of geophysical and geological data.* Mem. Soc. Geol. It., **40**, 273-288.

CATI A., SARTORIO D. & VENTURINI S. (1987) - *Carbonate platform in the subsurface of the Northern Adriatic sea.* Mem. Soc. Geol. It., **40**, 295-308.

C.N.R. - *Structural model of Italy 1:500.000.* Progetto finalizzato geodinamica.

COUSIN M. & FOURCADE E. (1980) - *The Cretaceous facies of the Friuli-Karst platform and their paleogeographic environment, southern Alpes and Dinarids.* 26° Congr. Geol. Int., Paris.

COUSIN M. (1980) - *Les rapports Alpes-Dinarides. Les confin de l'Italie et de le Jugoslavie.* Sci. Paris, **6**.

CUCCHI F., RADRIZZANI C., PIRINI C. & PUGLIESE N. (1987) - *The carbonate stratigraphic sequence of the Karst of Trieste (Italy).* Mem. Soc. Geol. It., **40**, 35-44.

DRAGASEVIC T. (1983) - *Oil geologic exploration in the Montenegro offshore in Yugoslavia.* Naft, **34** 397-403.

DROBNE K., OGORELEC B., PLENICAR M., BARATTOLO F., TURNSEK D., ZUCCHI & STOFZA M.L. (1987) - *The Doloneja Vas section, a transition from cretaceous to paleocene in the NW dinarides, Jugoslavia.* Mem. Soc. Geol. It., **40**, 73-84.

FERRASIN F. (1958) - *Il complesso di scogliera cretaceo del Veneto Centro-Orientale.* Mem. Ist. Geol. Univ. Padova, **21**, 1-54.

FINETTI J., BRICCHI G., DELBEN A. PIPAN M. & XUAN Z. (1987) - *Geophysical study of the Adriaplate.* Mem. Soc. Geol. It., **40**, 335-344.

FRANK G., KRIZ J. & VLASIC B. (1983) - *Results and directions in hydrocarbon exploration of Adriatic offshore.* NAFT, **34**, 387-396.

HERAK M. (1987) - *Relationship between Adriatic and Dinaric carbonate platform.*Mem. Soc. Geol. It., **40**, 289-293.

JACOB M., JENKO K. & SPAIC V. (1983) - *About dispersive, solid to semisolid, national oil bitumens of the Jugoslavic adriatic coastal area (outer Dinarides).* NAFT V. **34**-12, 698-700.

JELASKA V., JOSIP T. & IVOV (1984) - *Upper cretaceous carbonate platform units of the Jugoslavic Adriatic area.* Intern. Geol. Cong., III, **27** (2), 80-81.

JUGOSLAVIA GEOLOGICAL MAP SCALE 1:500.000 (1970) - *Federal Geological Institute Beograd.*

MILJUSH P. & PENSA J. - *Jurassic-Cretaceous model of sedimentation and structure of Ravin Kotari and Podvepeite geotectonic units.* NAFT XXV Congr. and Plan. ass. of ICSEM.

PIERI M. & GRUPPI G. (1981) - *Subsurface geological structure of the Po plain, Italy.* Progetto finalizzato geodinamica, Pubbl., 414.

PLENICAR M. & PREMRU U. (1983) - *Evolution of the cretaceous beds of Slovenia, Northwest Yugoslavia Zitelliana 10, 191-194,* Fak. Geol. Paleont. Ljubljana 2° Symp. Kreide 1982.

SARTI M. (1982) - *Guida geologia al Sudalpino Centro-Orientale.* Soc. Geol. It., **100**. Bologna 321-328.

TISLJAR J. (1980) - *Sketch map – proceeding of the third conference on sedimentation in Jugoslavia.* Geol. VJESN, **32**, 255-263.

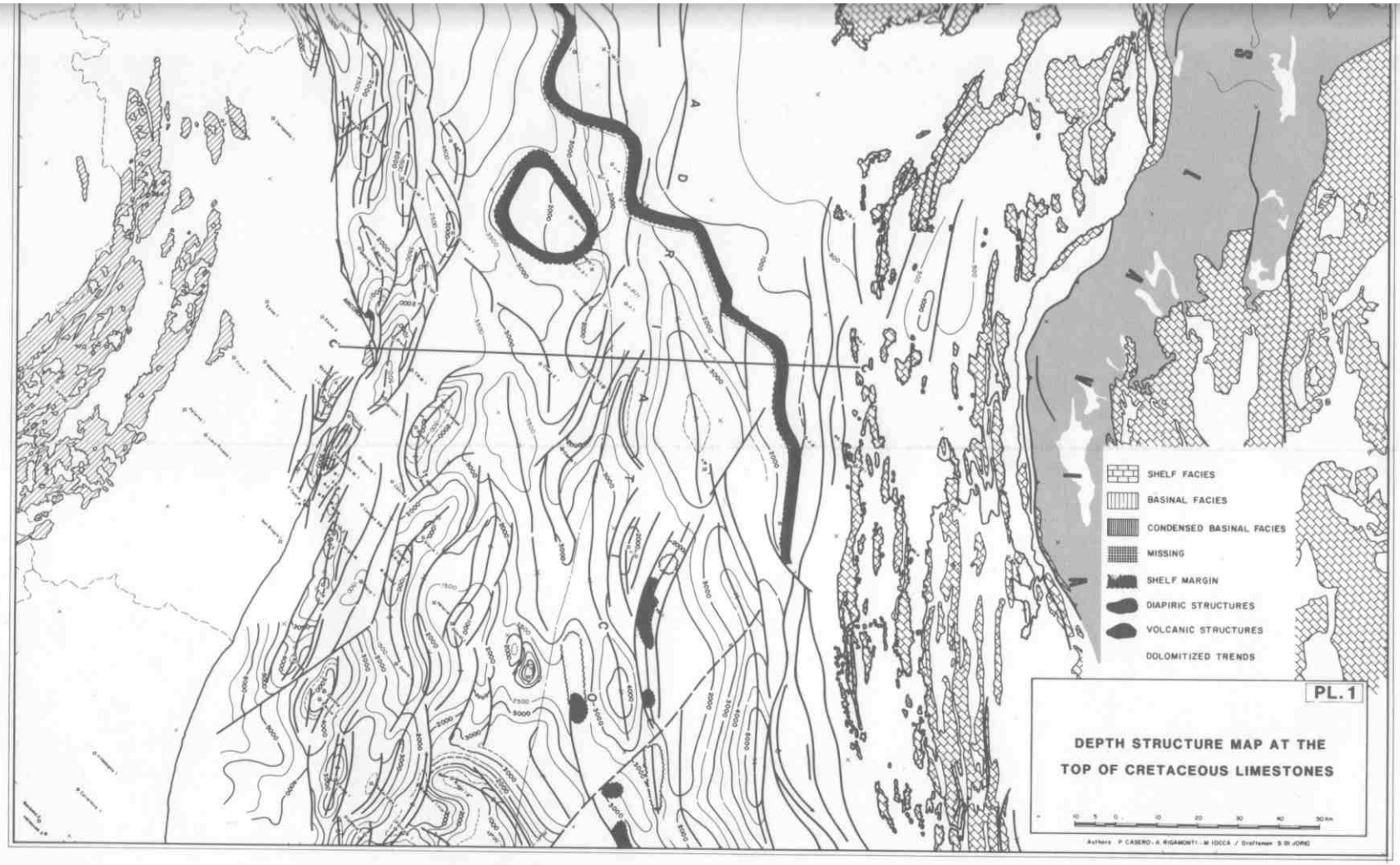
TISLJAR J., VELIC I. & SOKAC B. (1983) - *Shallow water cretaceous carbonates in Dinaric Karstic zone along the Adriatic coast of Jugoslavia Zitteliana 10. 201-206.* 2° Sympos. Kreide.

TISLJAR J. & VELIC I. (1987) - *The Kimmeridgian tidal – bar calcarenite facies of Western Istria (Western Croatia, Jugoslavia).* Facies V 17, 277-283.

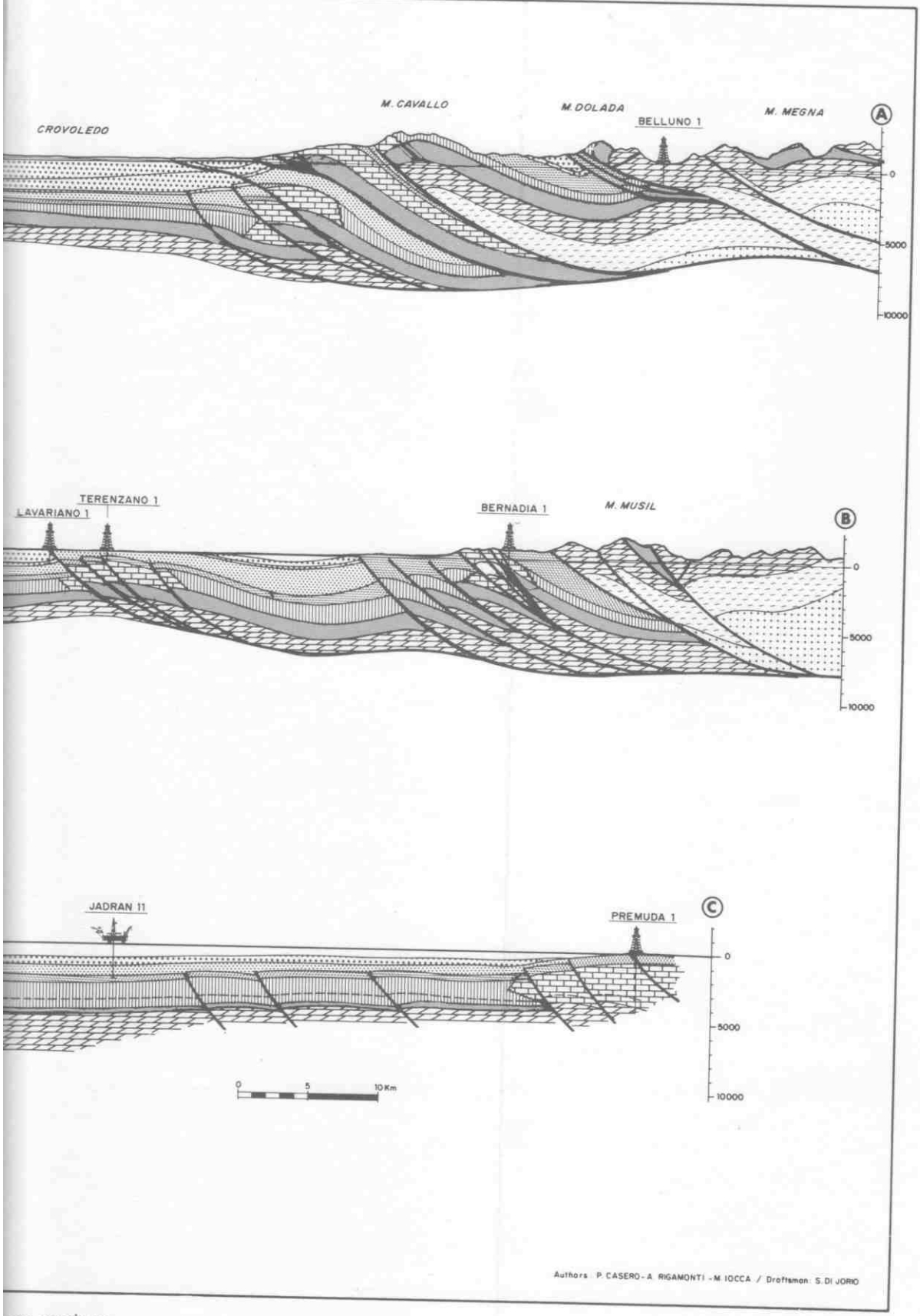
TUNIS G. & VENTURINI S. (1987) - *New data and interpretation of the geology of the southern Julian Prealps (Eastern Friuli).* Mem. Soc. Geol. It., **40**, 219-229.

VELIC I., TISLJAR J. & SOKAC B. (1987) - *The variability of thickness of the Barremian Aptian and Albian carbonates as a consequence of changing deposition and environments and emersion in western Istria (Croazia, Jugoslavia).* Mem. Soc. Geol. It., **40**, 209-218.

VLASIC B., KADIJA N. & RASKOVIC M. (1981) - *Ina Nafta. Zagreb.*



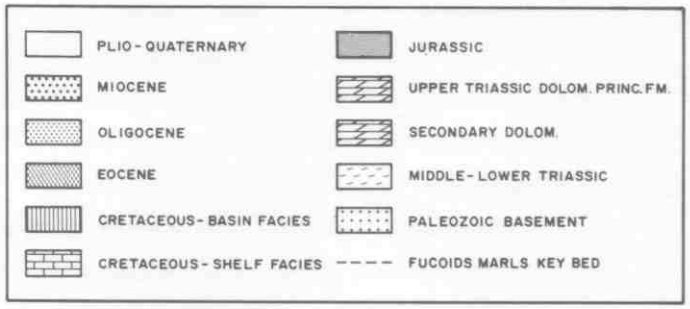
Depht structure map at the top of Cretaceous limestones.

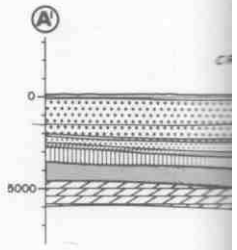


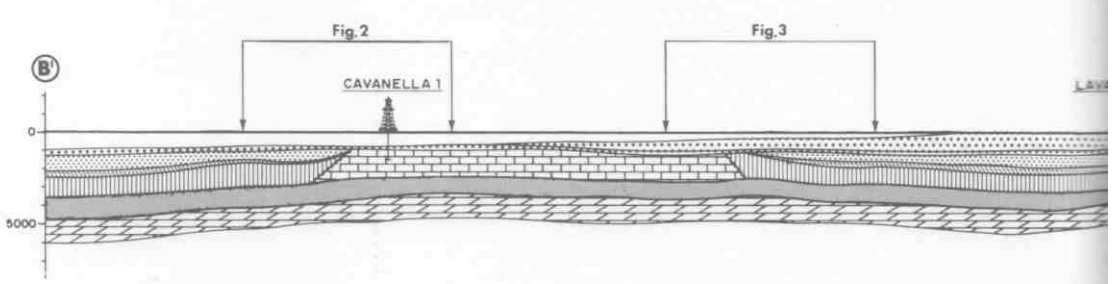
oss sections.

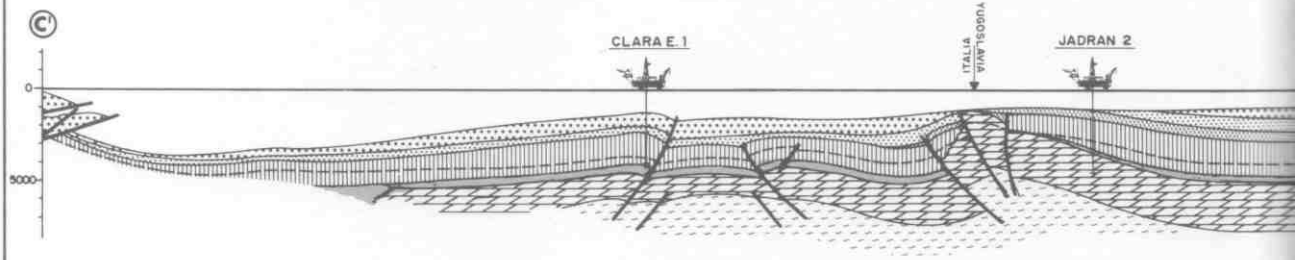
PL. 2

REGIONAL SCHEMATIC CROSS SECTIONS

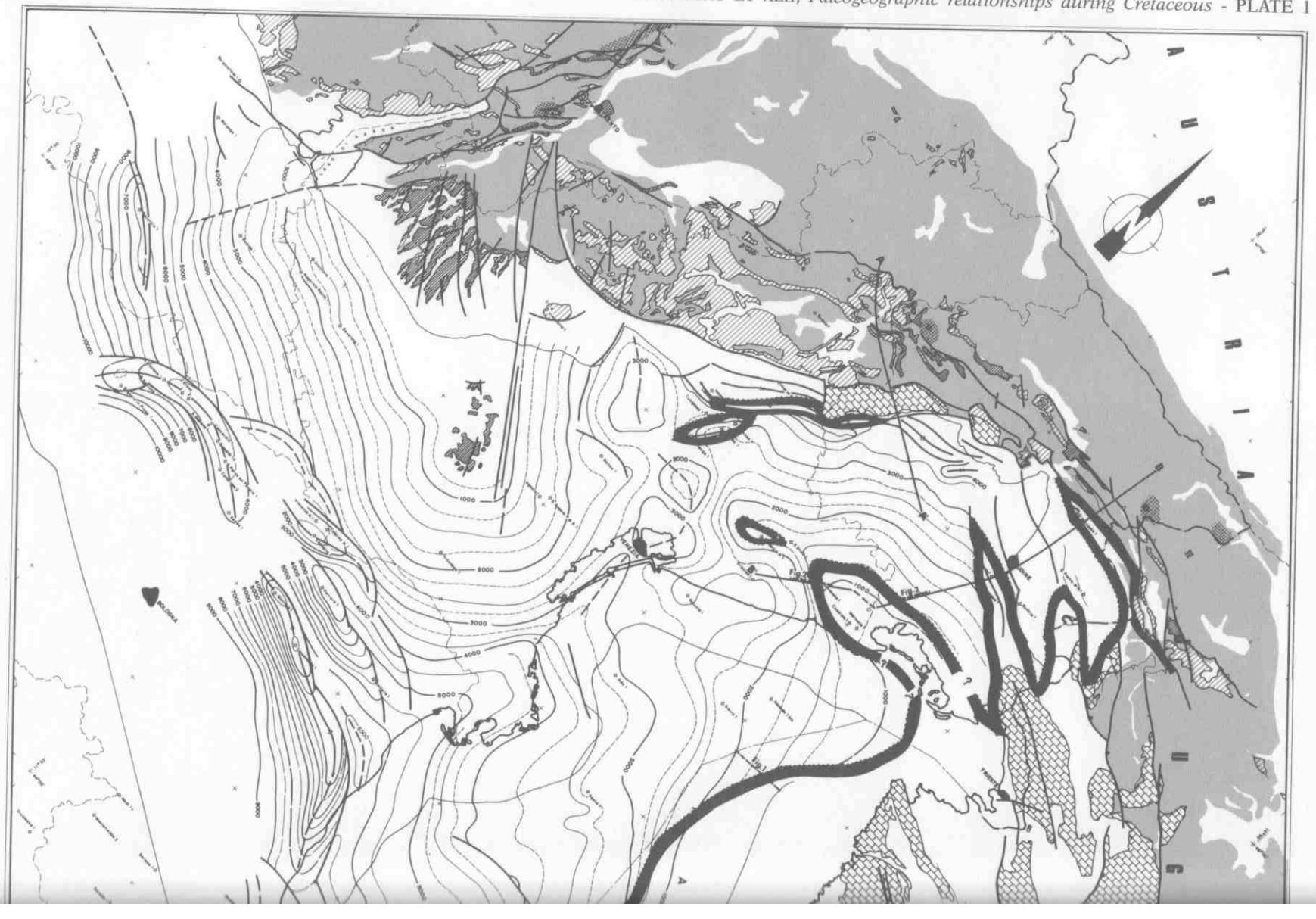








Regional schematic cros


AUSTRIA
BOLOGNA