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ERNO DEL MUSEO GEOLOGICO PALEONTOLOGICO MONFALCONE
. GARIBALDI 23, 34074 MONFALCONE (GO), ITALIA

Drobne K.¹, Ogorelec B.², Barattolo F.³, Dolenec T.⁴,
Pleničar M.¹, Turnšek D.¹, †Zucchi-Stolfa M.L.⁵,
Marton E.⁶

STOP 1: THE DOLENJA VAS SECTION (UPPER MAASTRICHTIAN, LOWER AND UPPER DANIAN, THANETIAN)

Introduction

In the northwestern part of the Adriatic promontory, the Upper Cretaceous and Paleocene limestones were deposited on small carbonate platforms: the Friuli carbonate platform in the north (CATI *et al.*, 1989) passes southeastwards into the Adriatic carbonate platform (HERAK, 1989). Clastic sedimentation surrounded the northern part of this platform, and was deposited in an environment with increasing depth (PAVŠIČ & HORVAT, 1988). On the southern side this small carbonate platform bordered a land, documented with bauxite deposited on karstification surfaces.

In this region, 100 years ago, GUIDO STACHE (1889) created "die Liburnische Stufe". He knew that the K/T boundary existed within it. Last ten years more and more detailed investigations have been carried out to gather paleontological, sedimentological, geochemical, and data facies during the crises time at the end of the Maastrichtian and at the beginning of reconstruction of the environment and reanimation of the marine life in the Paleocene. The carbonate section of Dolenja Vas was one of the first possibilities to study these phenomena (DROBNE *et al.*, 1988, 1989).

¹ZRC SAZU, Gosposka 13, 61000 Ljubljana, Slovenia

²IGGG, Dimičeva 14, 61000 Ljubljana, Slovenia

³Dipartimento di Paleontologia, Largo S. Marcellino 10, 80138 Napoli, Italia

⁴Geološki Oddelek FNT, Aškerčeva 12, 61000 Ljubljana, Slovenia

⁵Istituto di Geologia e Paleontologia, via E. Weiss, 34127 Trieste, Italia

⁶Eotvos Lorand Geophysical Institute of Hungary, Columbus u. 17-23, 1145 Budapest, Hungary

Position of the Dolenja Vas section

Geology

The section belongs to the Trieste - Komen plateau built of Lower and Upper Cretaceous limestones. In the north it is bordered by Paleogene limestones and clastic flysch sediments. The Dolenja Vas section shows a sequence of carbonates with rudists at the base, and the Paleocene conical foraminifers at the top. The K/T boundary is documented by a hardground surface or a debris flow (PLENIČAR *et al.*, 1992; DROBNE *et al.*, 1994; HANSEN *et al.*, 1995) (Figs. 1, 2).

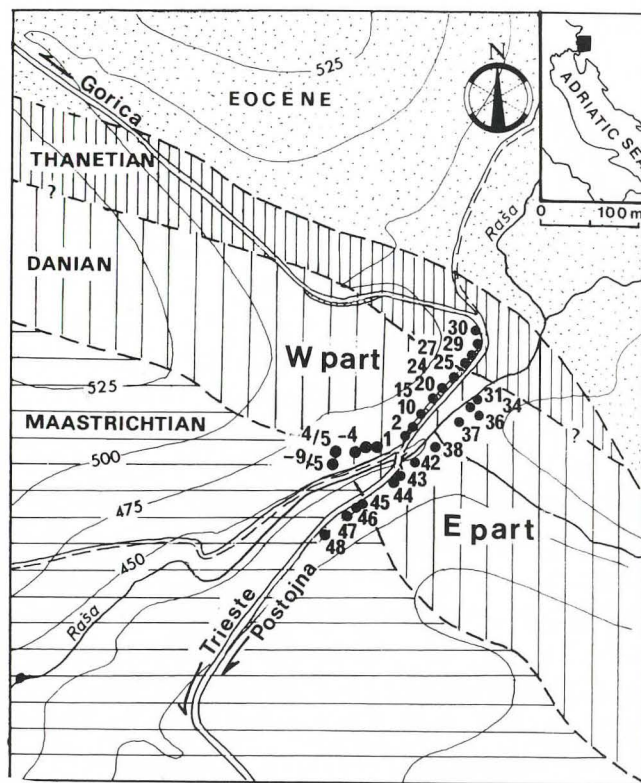


Fig. 1 - Location map of the section Dolenja Vas; E and W part with the position of samples and Cretaceous/Tertiary boundary (after DROBNE *et al.*, 1988). Geological map simplified after BUSER, GRAD & PLENIČAR (1967).

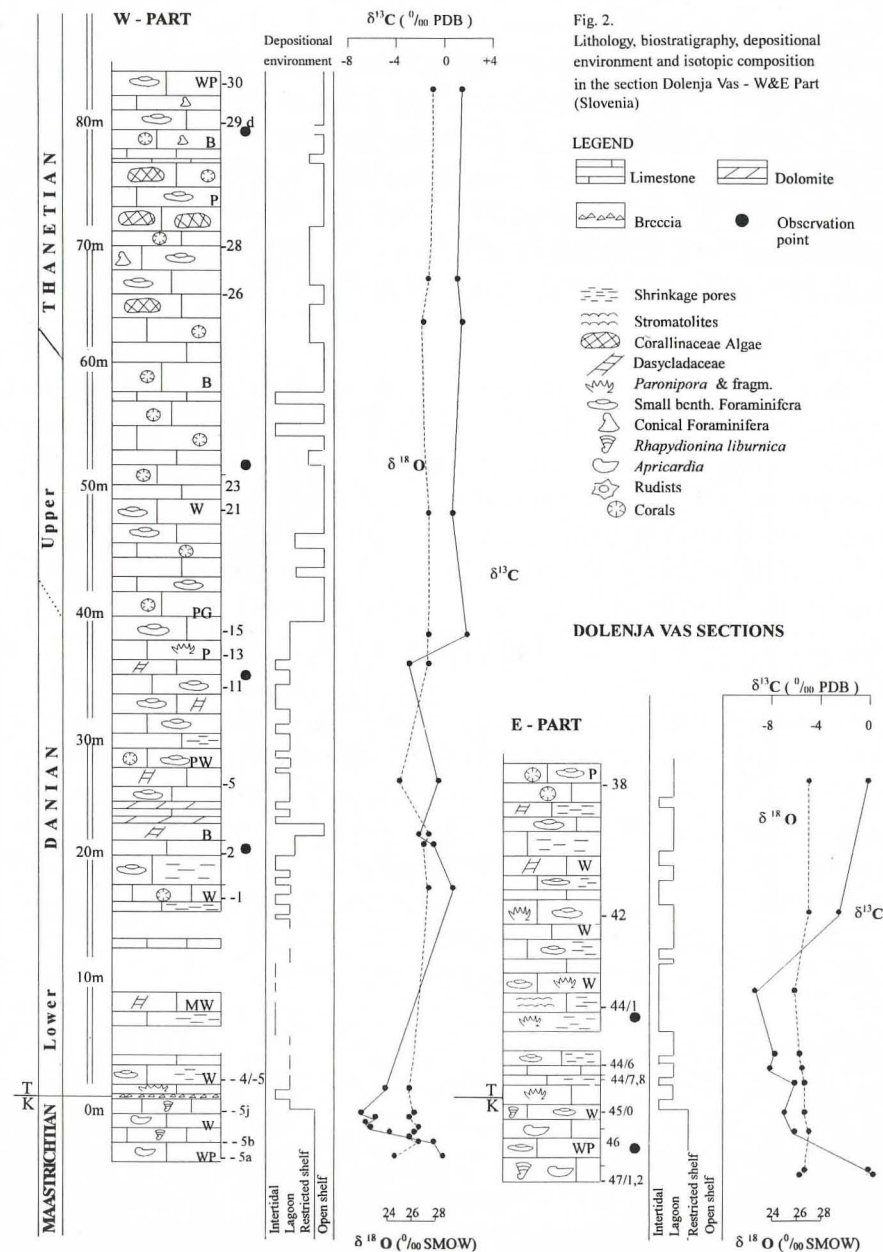


Fig. 2. Lithology, biostratigraphy, depositional environment and isotopic composition in the section Dolenja Vas - W&E Part (Slovenia)

Geography and structure

The Dolenja Vas section is situated north of the main road Postojna - Trieste along the local road between villages Dolenja Vas and Vrabče, where the bridge crosses the rivulet Raša (Fig. 1). The eastern part of the profile shows beds between samples Dv/49 and Dv/31, with a thickness of about 55 m. The western part of the profile begins in the forest, about 100 m far from the road with samples Dv/-9 to Dv/-1. It continues along the road with samples Dv/+1 to Dv/30. These beds are about 100 m thick. All strata dip toward the north and northeast with an angle of 15-20 ° (Figs. 1, 2).

Age

The lower part of the section contains algae, foraminifera, rudists, ostracodes and, in the correspondence of the K/T boundary of some localities, the debris flow (Pl. 1: Fig. 1). The age of the sequence is interpreted as the uppermost Maastrichtian, documented by numerous species of such genera as *Bournonia* and *Biradiolites*, *Rhapydionina liburnica* (STACHE) and *Fleuryana adriatica* DE CASTRO, DROBNE, GUŠIĆ (DE CASTRO *et al.*, 1994; PLENIČAR *et al.*, 1995; PUGLIESE & DROBNE, 1995) (Pl. 1: Figs. 2-14).

Paleocene sequence is characterized first by the absence of Cretaceous fauna as found below the boundary, the first appearance of "*Protelphidium*" sp., a *Cymopolia* assemblage and later, in the Upper Danian, by the corals as *Stylocoenia montium* (OPPENHEIM) and, in the Thanetian, *Miscellanea juliettae villattea* Leppig and agglutinated conical foraminifera as *Fallotella alavensis* Mangin and *Coskinon rajkae* (HOTTINGER & DROBNE) (DROBNE *et al.*, 1988, 1989; DROBNE & BARATTOLO, 1995) (Pl. 2).

Environment

The microfacies of the carbonate sequence shows lagoonal conditions with episodic connection to the open sea and predominant supratidal environment during the uppermost Maastrichtian and Lower Danian. The limestones are composed of rare dolomite intercalations, stromatolites and frequent bioturbation structures. Less restricted conditions admitting small coral patch reefs, dasycladacean vegetation covers and very frequent

corallinean algae as well as foraminifera, document more agitated conditions during the Upper Danian and Thanetian (PLENIČAR *et al.*, 1992).

Isotopes

Oxygen and carbon isotope analyses have been carried out in 18 samples in the limestone close to the K/T transition in the E and W part of the Dolenja Vas section.

Extreme depletion in the $\delta^{13}\text{C}$ content were found in the boundary micritic limestone at both localities. The $\delta^{13}\text{C}$ values abruptly shift from Late Cretaceous level of about -0,36‰ and -0,43‰ to -6,82‰ in the boundary interval, then it returns to less negative values of about -4,00‰. We suppose that these isotopic anomalies are related to climatic changes, caused by impact of an extraterrestrial body followed by the destruction and combustion of terrestrial plants on the adjacent continental area. These changed also sedimentary environments (closed lagoon and supratidal), during a long time interval (DROBNE *et al.*, 1994; DOLENEC *et al.*, 1995).

Paleomagnetic directions

In the years 1993 and 1994 fifty-seven paleomagnetic samples were collected from the Dolenja Vas section close and across the K/T boundary. The 17 samples represent the exact K/T boundary bed from the Late Maastrichtian and earliest Tertiary beds from the E and W site at the Dolenja Vas section. All samples are of reversed polarity, thus confirming the existence of a reversed polarity zone at the K/T boundary.

Algae

In the Dolenja Vas section it is possible to recognize different algal assemblages. Some floristic changes are probably linked to variations in the water energy. Such an ecological factor can be invoked to explain the rather sharp change from the *Cymopolia* interval to the corallinean interval (after the Dv 23 sample approx.) (Figs. 1, 2, Pl. 2: Figs. 8a,b).

Below this boundary the sequence apparently shows an environmental homogeneity in respect to the algal content. This

means that environmental modifications as emersion episodes, more or less restricted circulation, variation in salinity, did not influence significantly the algal composition.

Three main algal intervals have been individuated: *Acroporella chiapasis* interval, *Cymopolia* interval and corallinean interval.

Acroporella chiapasis interval (Dv 47- 45A; Dv - 41)

Very small thin walled tubes usually occur; they can be probably referred to calcified stem parts of charophytes. Rare thalli of *Thaumatoporella* as well as filaments of *Aeolisaccus barattoloi* DE CASTRO can also be observed. An infrequent but characteristic dasyclad is *Acroporella chiapasis* DELOFFRE, FOURCADE & MICHAUD. This is a little dasyclad species found in the Chiapas region (Mexico) in the uppermost part of the Ocozocuaulm Fm. This unit, 70 m thick, consists of biomicrite and biosparite containing abundant rudist shells and large forams such as *Pseudorhapydionina* sp., *Chubbina jamaicensis* ROBINSON, *Chubbina* cf. *macgillavryi* ROBINSON, *Kathina delseota* SMOUT, *Smoutina* cf. *crusi* DROOGER. According to the fossil content a Maastrichtian age can be inferred for the type level of *A. chiapasis*.

Together with *A. chiapasis*, other dasyclads, such as *Acicularia* sp. (Dv 43) and *Clypeina* (?) sp. nov., are present above the K/T boundary (Fig. 2); the latter also occurs in the lowest part of the subsequent interval and closely resembles the informal taxon "S5" in DIENI, MASSARI & RADOIČIĆ (1985).

Cymopolia interval (Dv 40-31; Dv 1-23), (Pl. 2: Figs. 8a,b).

It represents the middle and most important algal interval at Dolenja Vas. The algal assemblage is dominated by *Cymopolia* (*Cymopolia paronai* RAINER, *Cymopolia* cf. *elongata* DEFRANCE, *Cymopolia frugifera* SEGONZAC, *Cymopolia* sp. nov.). In the lower-middle part of this interval two taxa, doubtfully referable to the genus *Clypeina*, commonly occur. They have been pointed out as "*Clypeina* sp. 2" in RADOIČIĆ (1991) and "*Clypeina* nov. sp." in BUSER & RADOIČIĆ (1987). In the same interval two microproblematica are present: "*Microproblematicum*" in DROBNE *et al.* (1988) and "DS2" in BUSER & RADOIČIĆ (1987). The first of them can probably be referred to charophytes. Other dasyclads

present in this interval are *Jodotella veslensis* MORELLET & MORELLET and *Jodotella sloveniaensis* ? DELOFFRE & RADOIČIĆ. The upper part of this interval is enriched by other taxa such as *Orioporella villattae* SEGONZAC and *Clypeina liburnica* BUSER & RADOIČIĆ. *Pseudocymopolia* sp., *Pycnoporidium levantinum* JOHNSON, *Pseudolithothamnium album* PFENDER, *Sandalia multipora* DIENI, MASSARI & RADOIČIĆ and *Terquemella* sp. are rather rare.

Orioporella villattae SEGONZAC, *Cymopolia frugifera* SEGONZAC and *Cymopolia paronai* RAINERI are rather widespread algae. All of them are present in the French Pyrenees (DELOFFRE & GENOT, 1982) and the first taxon also in many other localities of the Tethyan realm (BARATTOLO: personal data).

Corallinean interval (Dv 24-28)

The algal content consists mainly of red algae (usually corallineans but also solenoporaceans and squamariaceans), both in massive thalli (*Elianella elegans* PFENDER & BASSE, *Pycnoporidium levantinum* JOHNSON) and in crustose to subramose thalli (*Pseudolithothamnium album* PFENDER, *Sporolithon* sp. and other non-geniculate corallinean genera); even geniculate corallineans are recorded in this interval.

Excursion stops

Maastrichtian: stop Dv/49 - 45 (E part)

The limestone is moderately thick bedded and presents light to moderate olive grey colour. According to its texture, the rock is a biomicrite of the wackestone- packstone type. Characteristic for the succession is *Rhapydionina liburnica* (STACHE) with the cylindrical-uniserial A form. *Cuneolina ketini* INAN, *Cuneolina* sp., *Massilina* sp., "*Dargenioella*" sp., and a very frequent small planispiral form of *Fleuryana adriatica* DE CASTRO, DROBNE & GUŠIĆ (ex *Moncharmontia* sp.) also occur (Pl. 1: Fig. 2-4). The rudists, among them the genera of *Bournonia*, *Biradiolites*, *Apricardia*, are accumulated in several beds. Their accumulation is characteristic of the top of the Maastrichtian sequence (Pl. 1: Fig. 5-14). The limestone of the oldest unit was deposited in shallow water

on a restricted shelf, with a low energy index which periodically also increases.

Danian : lower part, stop Dv 44/8-0 (E part)

The limestone becomes dark, olive grey to black. By texture it is biomicrite with an increased amount of organic matter, and with slight bituminous smell. The first appearance of *Paronipora* sp. is observed. Calcite pseudomorphose after gypsum crystals in micritic limestone characterizes a supratidal facies.

In the lagoon environment foraminifers with tests of extremely small dimensions and thin walls from groups of discorbids and ataxophragmiids, among the nonionids the genus "*Protelphidium*" (Pl. 2: Fig. 2) and also gastropods appear. In the facies with washed micritic matrix the assemblage of small miliolids, *Pseudochrysalidina* sp., *Valvulineria* sp. are present.

The environment is characterized by numerous shrinkage pores, the stromatolitic laminae and locally thin breccias with mud pebbles which reflected the intertidal regime and emersion.

Danian : lower part, stop Dv 3 - 12 (W part)

Individual beds are 10 to 50 cm thick. The wackestone and packstone types prevail. The carbonate component varies between 98.2 and 99.6. The micritic matrix is washed out, entirely or partly, only in samples which were deposited along the shore "beach rocks" (Dv 3) or in tidal channels (Dv 4, 11, 16) within lagoons where daily movements of sea water occurred. In light colour limestone, "*Scandonea*" (Pl. 2: Fig. 3), *Bolkarina* sp., a new complex miliolid and large *Periloculina* sp. occur. The corals *Haimesastraea peruviana* VAUGHAN, *Dendrophyllia candelabrum* HENNIG, *D. dendrophylloides* MILNE EDWARDS & HAIME, *Siderastraea* sp. and *Rhizangia* sp., were found (Pl. 2: Fig. 1-3). The environment is characterized by shallow restricted lagoons interrupted by short phases of intertidal regime and emersion.

Danian : upper part, stop Dv 20 - 23b (W part)

This sequence is about 15 m thick. In the lower part the limestone is moderately thick bedded and grey, in the upper part it becomes thick bedded and very light in colour. The packstone and boundstone

types are frequent. Limestones of the biosparite type prevail over biomicrite. Among the foraminifera, agglutinated tests predominate, followed by small forms of helenalveolinids and rare *Idalina*. Numerous dasycladaceans also occur. Corals become more abundant for the first time, with *Stylocoenia montium* (OPPENHEIM), *Actinacis cognata* OPPENHEIM, *Goniopora elegans* (LEYMERIE), *Litharaeopsis subepithecata* (OPPENHEIM) (Pl. 2: Figs. 1-3) and *Plocophyllia karstica* TURNŠEK whose type locality is here (Dv 23b). In the area of Dolenja Vas, starting in the upper part of the Danian, a submerged, well aerated carbonate platform was established. Within the platform, there existed places where smaller coral patches grew.

Thanetian : lower part, stop Dv 25 - 30 (W part)

The limestone becomes moderately thick bedded and darker. The texture types of limestone, wackestone to packstone predominate. Where foraminifera and algal clasts are more abundant the rock assumes a biocalcarenitic character. Numerous small-sized rotaliids occur, such as *Kathina selveri* SMOUT and *Miscellanea juliettae villattae* LEPPIG (Pl. 2: Fig. 4). Rare forms include *Discocyclus seunesi* DOUVILLÉ and sessile *Planorbulina* sp., *Haddonina* sp., *Schlosserina* sp. In younger horizons, *Idalina sinjarica* GRIMSDALE, *Coskinon rajkae* HOTTINGER & DROBNE, *Cribobulimina carniolica* HOTTINGER & DROBNE are frequent. Coral accumulations of *Goniopora* and *Rhizangia* are abundant. The dendroid corals, like *Dendrophyllia*, still persist. In this interval the red algae have their first appearance.

The deposition continued on the very shallow part of the carbonate platform, which was connected to the open sea. Red algae settled in the micritic mud on shoals, in between algal-coral agglomerations, in well aerated areas.

The K/T boundary

In the eastern part of the Dolenja Vas section, the contact between the rudist and the Paleocene micritic limestone is marked by a hardground, in the western part by 10 - 30 cm thick breccias (debris flow, Pl. 1: Fig. 1). The Cretaceous surface is incrustated by

Paronipora sp., the borings are filled with dark matrix containing abundant pyrite and goethite sphaerules from 20 to 70 μm . Their origin is supposed to be related to the concentration of organic matter in the shallow littoral shelf zone.

In the western part of the section in the interval from Dv 5a to Dv 5j the concentration of 14 trace elements has been established. Maximum of contents of some elements is about 60 cm below the K/T boundary. Two to three times increase of concentration with the respect to underlying and overlying beds can be noticed for Co (5 - 35 ppm), Ga (50 - 450 ppb), Ni (3 - 12 ppm), Sm (8 - 25 ppb) and Zr (12 - 45 ppm), while V (10 - 85 ppm) is almost ten times higher. According to latest data of HANSEN *et al.* (1995) the Iridium content from 1 to 5.8 ppb has been measured in the same K/T interval. The highest concentration is connected with the dark matrix in debris flow. This zone can be correlated with negative values of $\delta^{13}\text{C}$. The obvious abiotic changes in the sediments appear before the biotic crisis at the K/T boundary (DOLENEC *et al.*, 1995).

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Riassunto

Vengono descritte le successioni stratigrafiche dal Maastrichtiano al Thanetiano affioranti a Dolenja Vas Est ed Ovest. In base ai dati relativi alla paleontologia (alghe, foraminiferi, molluschi e coralli), petrografia, geochimica degli isotopi e al paleomagnetismo viene riconosciuta un'evoluzione da ambienti lagunari, con episodiche connessioni con il mare aperto (Maastrichtiano sup. - Daniano inf.) ad altri di laguna meno protetta con biocostruzioni (Daniano sup. - Thanetiano). Particolare riguardo viene riservato al passaggio Cretacico-Terziario, individuato in corrispondenza di una breccia (debris flow) dove si riscontrano anomalie di iridio e valori negativi di $\delta^{13}\text{C}$.

Plate 1 - Figs *1. Breccia as debris flow, clasts with *Rh. liburnica* and Algae surrounded by *Paronipora elegans* (GLÜCK) (ex *Microcodium*) Dv West, K/T x10; *2. *Fleuryana adriatica* DE CASTRO, DROBNE, GUŠIĆ, Dv-46/5074, x80; *3. *F. adriatica*, Dv-47b/5079, x30; *4. *Rhapydionina liburnica* (STACHE) fA, fB, Dv-9/10997m, x10. **R u d i s t s** : polished and eroded surface, all samples from Dolenja Vas, natural size: *Bournonia* sp., *5,*9,*11,*13; *B. aff. quadripinnae* PEJOVIĆ *6; *B. problematica* PLENIČAR & STOLFA ZUCCHI *7; *B. excavata* (D'ORB.) *8; *B. triangulata* PLENIČAR & STOLFA ZUCCHI *10; *Biradiolites rotundatus* PLENIČAR *12,*14. (See opposite page)

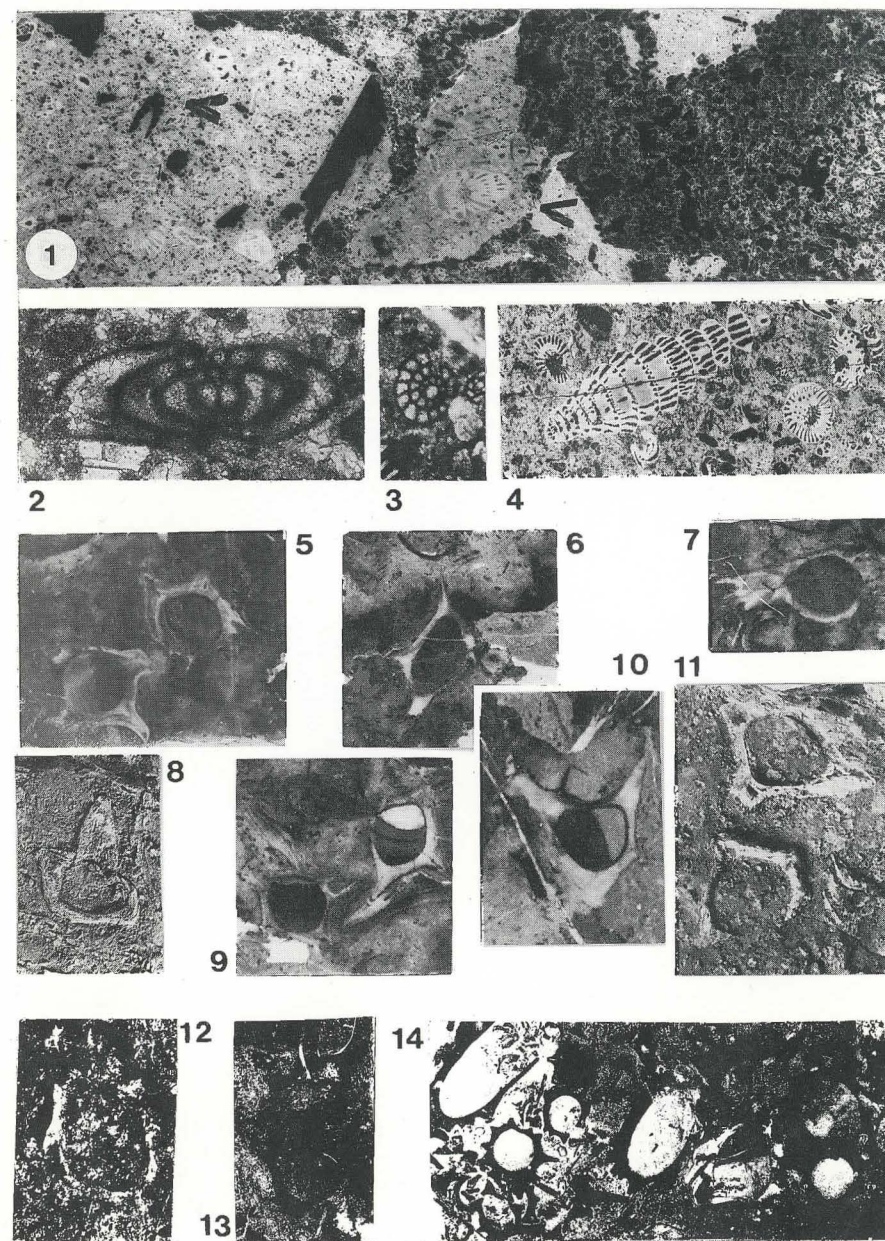


Plate 2 - **Corals**: *1. *Litharaeopsis subepithecata* (OPPENHEIM), Dv-24/ 928c, x6; *2. *Actinacis cognata* OPPENHEIM, Dv-23/4684, x8; *3. *Dendrophyllia dendrophyllodes* M.EDW. & HAIME, Dv-7/978b, x4. **Foraminifera**: *4. cf. *Protelphidium* sp., Dv-44/4/6564, x60; *5. "*Scandonea*" sp. Dv-38/5044, x30; *6. *Miscellanea juliettae villattea* LEPPIG, Dv-30/4702, x30; *7. *Coskinon rajkae* HOTTINGER & DROBNE, Dv-30/4701, x30; *8a,b. *Cymopolia* ssp., Dv-33/5013, x10. (See opposite page)

