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EXCURSION A

NEOGENE DEPOSITS OF LISBOA AND SETÚBAL PENINSULA

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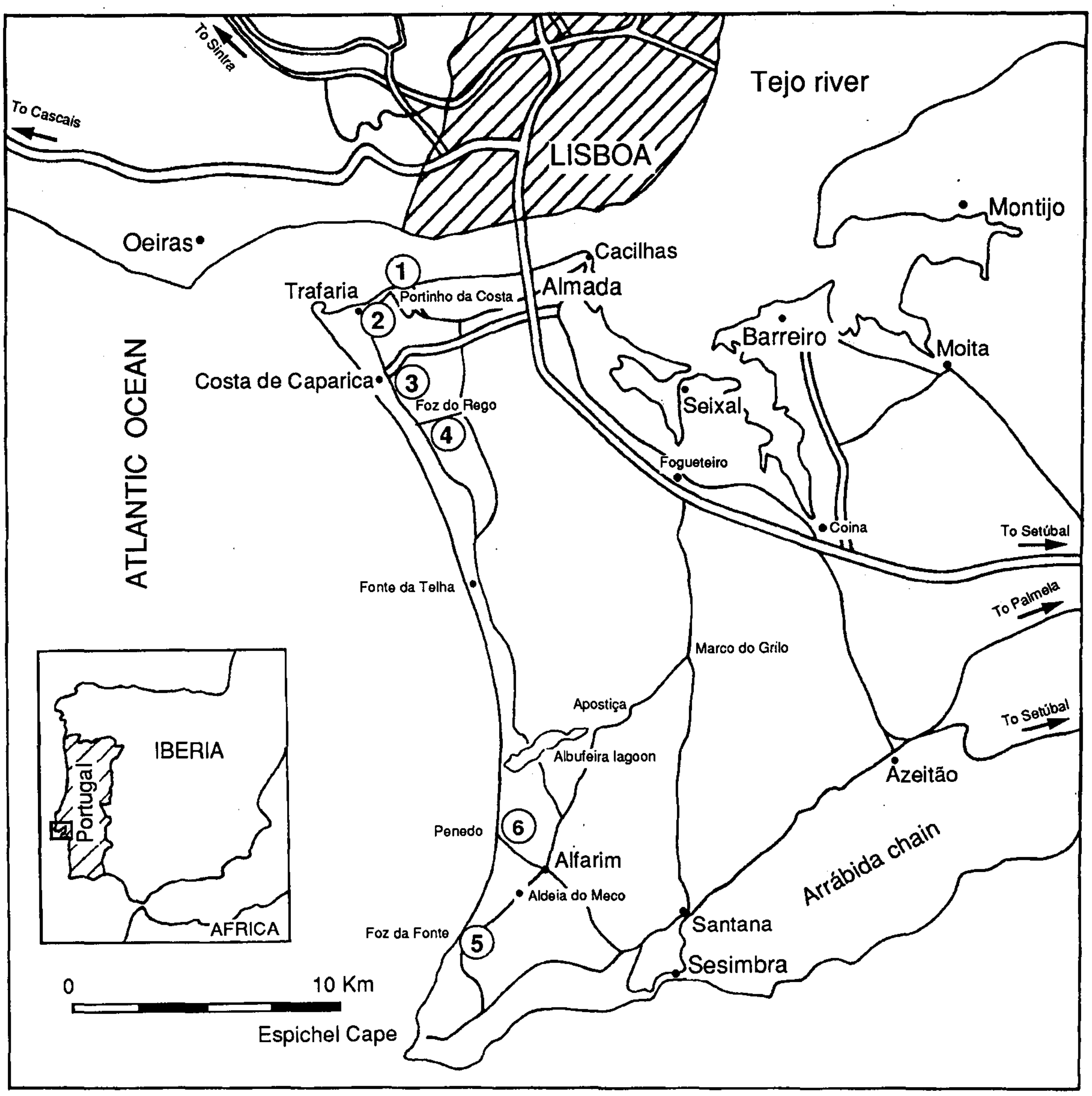

Fig. 1 - Itinerary and geographical situation of localities to be visited.

FOREWORD

The main goal of this excursion is to show the Miocene series of the Lower Tagus basin in Lisbon region. It comprises a very complete sucession of mostly marine and some continental beds since lowermost Miocene (Aquitanian) to Upper Miocene (Tortonian), corresponding to seven cycles characterized by a marine transgression and the next regression. Most of these beds are rich in fossils. Hence it was possible to obtain a fairly accurate local time-scale based on both marine and continental fossils, K-Ar glauconite ages and paleomagnetism. Conditions are particularly suited for marine-continental correlation.

As many of the classical sections are now under buildings in Lisbon, the best exposures are those at Setúbal Peninsula, just South of Lisbon. Except for Aquitanian, all later levels are well exposed here.

1st STOP

PORTINHO DA COSTA

The first stop will be at Tagus cliffs (left bank) at Portinho da Costa.

Both the Upper part of unit ("Division") II (COTTER, 1956) and unit III are shown. They are separated by an erosion surface related to the beginning of the Burdigalian transgressive cycle.

Unit II corresponds to a regression, and includes sands and sandstones with oysters and pectinids. The lower part of this unit yielded some continental fauna (mainly mammals) in Lisboa (at Universidade Católica and Av. do Uruguay), from the mammal unit MN3a. Higher beds contain planktic foraminifera from Blow's N5 zone.

Two boreholes near the bridge yielded dinoflagellates (*Homotryblium pallidum*, *Operculodinium centrocarpum*, *Spiniferites ramosus*, *Systematophora placacantha*), spores (Bryophyta, *Polypodiaceae*), pollens (*Pinus*, *Engelhardtia*, *Platycarya*) and some plant macroremains (*Gleditschia oehningense*, *Carpinus orientalis*, *Populus*, *Salix*, *Ulmus*).

Ostracod fauna of unit II includes *Hemicyprideis helvetica*, *Pokorniella lusitanica* and *Cyamocytheridea carbonneli*, among other species.

Unit III is represented by a fossil rich (mollusks, algal balls, etc.) biocalcarenite. These rather coarse beds evolve vertically into finer grained bluish or greyish pyritic siltstones with some calcareous intercalations, to be shown at the next stop.

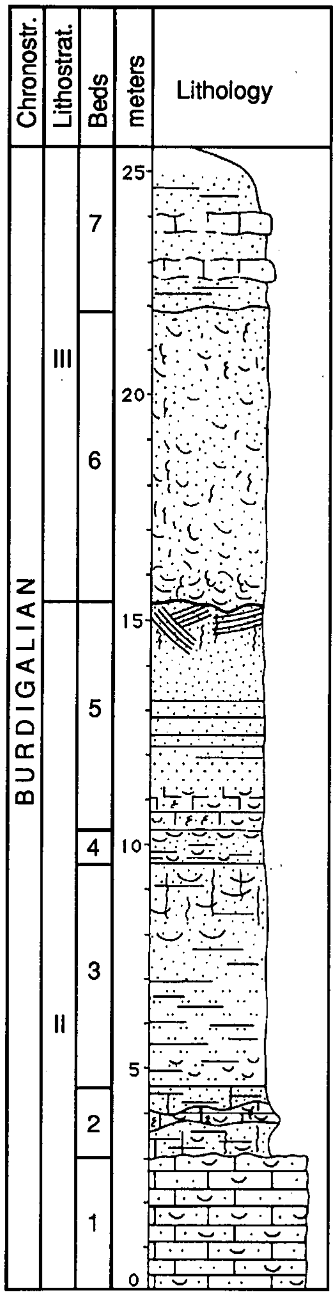

Fig. 2 - Portinho da Costa section.

Ostracod fauna comprises *Loxoconcha* (*S.*) *bonaducea*, *Aurila* (*A.*) *larieyensis*, *Cnestocythere truncata*, *Pokorniella minor*, etc.

Unit III yielded dinoflagellates (*Cordosphaeridium solaster*, *Spiniferites ramosus*, *Hystrichokolpoma rigaudae*), spores (Bryophyta, Polypodiaceae) and pollens (*Pinus*, *Cathaya*, *Alnus*, *Quercus*, *Myrica*, *Bombax*, Sapotaceae; *Bombax* and *Myrica* as well as *Quercus* and *Alnus* became more frequent); climate seems to have been somewhat warmer and moister than during units II's times. This beginning of warming proceeded during middle Burdigalian (unit IV-a).

2nd STOP

TRAFARIA

At Trafaria, units IV-a and IV-b are well exposed. The lower part of the section (about 10m) shows the IV-a silststones, rich in Foraminifera and Ostracoda. The IV-a unit, which represents the maximum of the Burdigalian transgression, is overlain by regressive deposits of the IV-b unit. This unit is rich in fossils; it is particularly noteworthy the presence of well preserved ones as the very fine shells of the Gasteropod *Pereiraia gervaisi*. Nannofossils point out to Martini's NN4 zone.

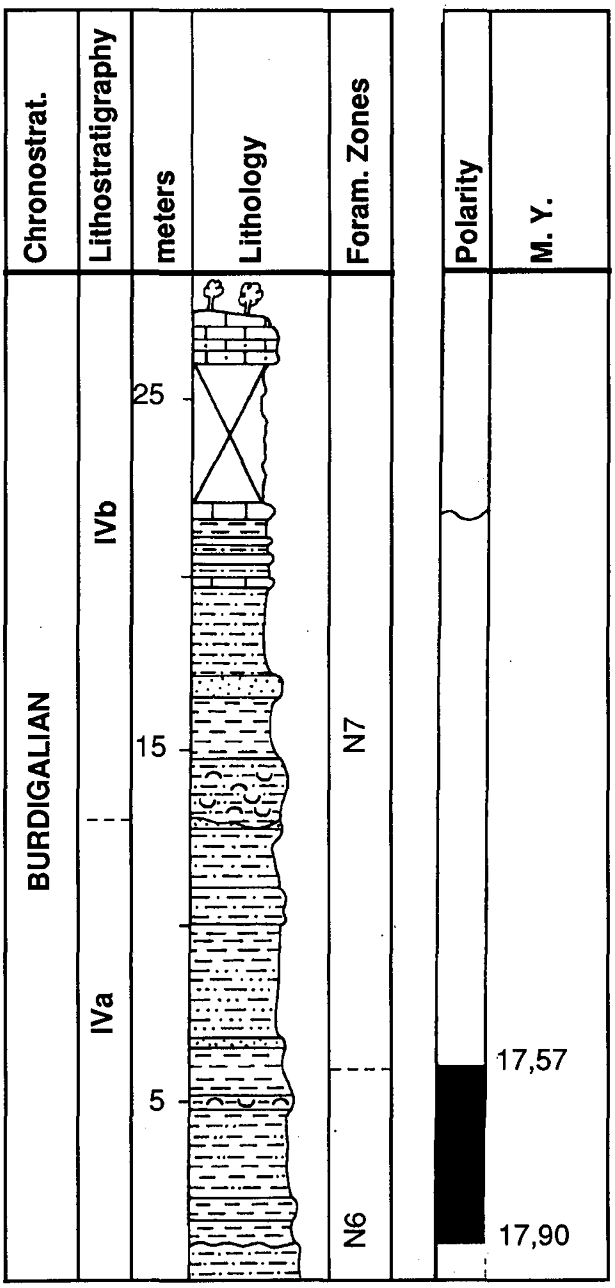

Fig. 3 - Trafaria section (SEN *et al.*, 1992).

Planktic Foraminifera (*Globigerinoides altiaperturus*, *G. bisphericus*, *G. trilobus*, *G. obliquus*, *Globorotalia obesa*, *Globoquadrina* sp.) indicate N6(?) (lower part) and N7 zones.

In Lisbon, IV-a bluish silstones grade into lower salinity, silty clays with oysters and *Cerithium*, and these into plant fossil rich clays and fluviatile feldspathic sands (IV-b) with land mammal fauna including the first mastodonts and the last anthracotheres (MN4a mammal unit).

The IV-a Ostracoda fauna comprises *Aurila* (*A.*) *larieyensis*, *Cnestocythere truncata*, *Cytherella* (*C.*) *antunesi*, *Cytheretta* (*C.*) *ferreirae*, *C.* (*P.*) *schoelleri*, *Neonesidea corpulenta*, *N. rochae*, *Pokornyella minor*, *Ruggieria* (*R.*) *micheliniana*, *Loxoconcha grateloupiana* and *Miocyprideis fortisensis*.

Spores are very common (Bryophyta, Polypodiaceae, Pteridaceae, Gleicheniaceae, Schizeaceae). Gymnosperms are scarcer than in early Burdigalian. Otherwise, Angiosperms are exceedingly common; apogee is attained both for *Bombax* and Sapotaceae. *Engelhardtia*, *Myrica*, Araliaceae, *Diospyros*, *Alnus*, *Corylus* and *Castanea*/*Castanopsis* are well represented.

Climate seems to have been warm and humid, maybe tropical.

At Trafaria, marine influences prevail. The first level of IV-b unit is a biocalcarenite very rich in Heterosteginids, rhodolits and mollusks.

Among the IV-b Ostracod fauna there are *Cytherella* (*C.*) *jonesiana*, *Loxoconcha* (*L.*) *tagana*, *L.* (*L.*) *hastata*, *L.* (*S.*) *grateloupiana*, *Miocyprideis fortisensis*, *Neocyprideis aquitanica and Costa* (*C.*) *batei*.

During Upper Burdigalian (div. IV-b) vegetation is particularly rich in subtropical and temperate forms (*Populus*, *Salix*, *Quercus*, *Ulmus*, *Zelkova*, *Acer*, *Sapindus*, *Magnolia*). Sapotaceae and Lauraceae are very scarce.

By the end of the Burdigalian, vegetation changed into a warmer and moister association with *Engelhardtia* and Sapotaceae. *Castanea*/*Castanopsis* and *Quercus* were common.

Paleomagnetic determinations allowed us to recognize three zones, a reverse one at the base, followed by a normal one (lower part) and by a reverse one for the remaining part of this sucession. They can be ascribed to the zones C5D and to the lower reverse polarity interval of C5C.

3rd STOP

COSTA DE CAPARICA

In this region, Langhian is poorly exposed. At Costa de Caparica, Serravallian and

Tortonian can be observed in detail. A sucession of bluish or greyish pyritic silty clays ("schlier facies"), that make up the VI-a unit, corresponds to the Serravallian. This is a succession of decreasing upwards granulometry sequences, separated by minor erosion surfaces; macrofauna is particularly well represented the base of each sequence

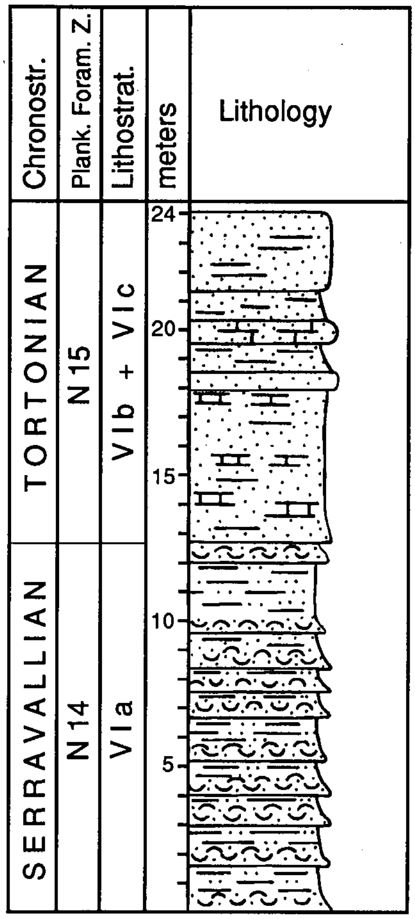

Fig. 4 - Costa de Caparica section.

(*Corbula*, Venerids, Ostreids, Naticids, other Gasteropoda, *Schizaster*, otoliths and other fish remnants). Some of the pelecypods, namely *Pelecyora*, occur in life position. Planktic Foraminifera include *Globorotalia* aff. *praemenardii*, *Gl.* gr. *scitula*, *G. mayeri* (sinist.), *G. lenguanensis* and *Neogloboquadrina* aff. *acostaensis* that indicate for the upper part of the unit N14 Blow's zone, Upper Serravallian.

Ostracods are common (*Plicatella variopunctata*, *Costa batei*, *Cyamocytheridea strigulosa*, *Olinfalunia plicatula*, *Aurila oblonga*, *Nonurocythereis seminulum*).

During Serravallian times (VI-a unit.), tropical humid plants are common (*Toddalia*, *Spirematospermum*, Sapotaceae) in association with aquatic ones or plants living on the banks (*Taxodium*, *Nuphar*, *Sparganium*, *Stratiotes*, *Alnus*, *Myrica*). Climate was distinctly less warm and much more humid than before.

Above VI-a unit there is a sucession of fine white or yellowish sands and sandstones representing VI-b and VI-c units. Fauna comprises large vertebrates (cetaceans, a turtle), many fishes, mollusks, bryozoans, echinoderms, crustaceans, etc. Sediments show much bioturbation. As far as Foraminifera are concerned, *Globorotalia mayeri* nearly disappears and *Neogloboquadrina* aff. *acostaensis* (dext.) becomes common, as well as *Globorotalia praemenardii*; *Globoquadrina* being scarce. This association indicates N15 (Blow) Lower Tortonian. Hence the Serravallian-Tortonian boundary can be rather accurately situated at the top of the VI-a unit.

4th STOP

FOZ DO REGO

During Tortonian times (VII-a and VII-b units), marine sedimentation proceeded with no major changes. The whole series includes large-scale lenticular bodies of yellowish fine sands and silts.

At Foz do Rego, the section shows some of the last marine Miocene beds of the lower Tagus basin (Lisbon area). Still at Foz do Rego, two different sedimentary bodies can be recognized; to the North, there are yellow sands including some levels extremely rich in *Chlamys macrotis* and some *Modiolus*. Southwards there is a clayey sedimentary body very rich in well preserved mollusks (62% Bivalves; 38% Gasteropods — *Turritella subarchimedis*, *Neverita josephinia*, *Sphaeronassa mutabilis*, *Panopaea*, *Pelecyora*, *Corbula gibba*, *Spisula subtruncata*, *Tellina distorta*, *Nuculana fragilis*, etc.), probably related to storm activity. Burrowing and boring activities by clionids, annelids and predators are significant. Remains of Cetaceans, Fishes, Cirripeds, Echinoids, Bryozoans and Crustaceans have been collected.

As for palynological contents Foz do Rego (VII-b) yielded many Dinoflagellates, most common being several *Spiniferites* species (*ramosus*, *pseudoramosus* and *pseudofurcatus*), along with some *Achomosphaera grallaeformis*, *Cordosphaeridium* sp. and *Implectosphaeridium* sp. This association bears evidence to neritic and rather warm waters.

Liverworts and ferns (Pteridaceae, Polypodiaceae) are quite common, pines being most common. Other Gymnosperms are

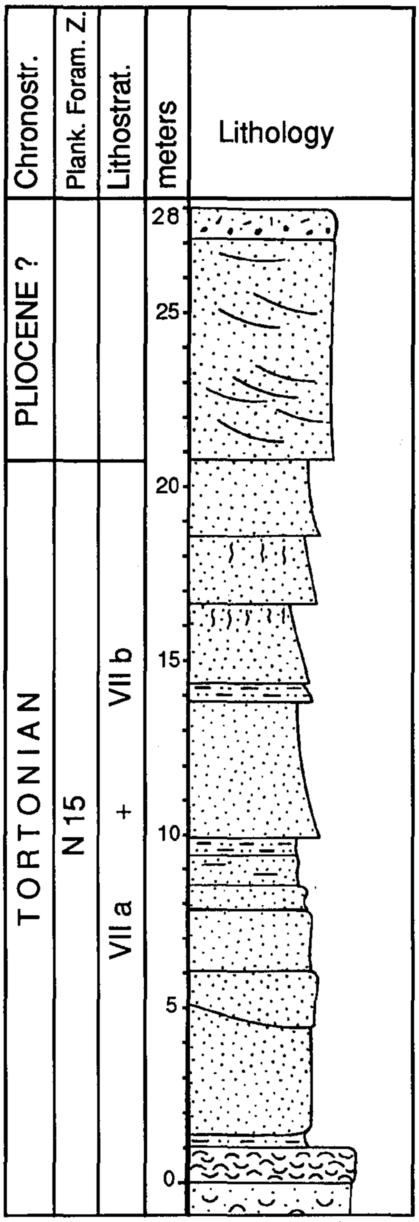

Fig- 5 - Northern part of Foz do Rego section.

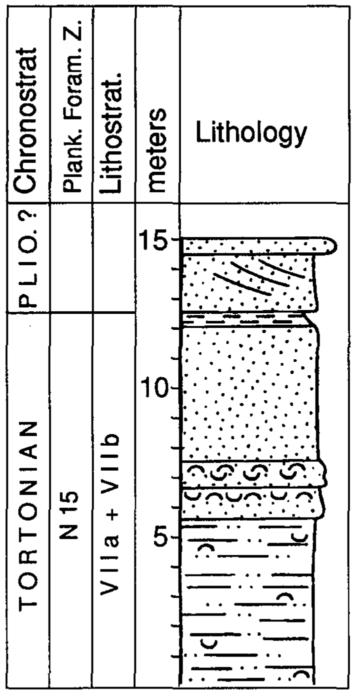

Fig. 6 - Southern part of Foz do Rego section.

present (*Abies, Cathaya,* Taxodiaceae). As for the Angiosperms, *Quercus, Myrica* and Oleaceae are the most common trees; *Engelhardtia, Castanea, Alnus,* Sapotaceae and Palmae are also represented. Among shrubs and herbs, Amaranthaceae-Chenopodiaceae, Compositae, Graminae and *Armeria* are well represented. Plant fossils point out to a mixed mesophytic forest, clearly develloped under marine influence. Climate was rather dry with contrasting seasons. However the association found in the uppermost bed seems to correspond to a slight increase in humidity (scarce mediterranean forms and some increase of humid ones).

Ostracod associations comprise *Cytheretta (C.) orthezensis, Loxoconcha (Sagmatocythere)* aff. *grateloupiana, Loxoconcha (L.) ducasseae, Olimfalunia costata, Cyamocytheridea strigulosa* and *Aurila* sp., which correspond to marine upper infralittoral conditions.

The higher part of this unit is more compact and shows much bioturbation.

Fauna as a whole indicates warm waters, normal salinity and infralittoral environments.

Among Foraminifera there are *Globigerina bulloides, G. apertura, Neogloboquadrina* aff. *praehumerosa* (dext.), *N. continuosa* (dext.); they still correspond to Blow's N15 zone. This age correlates well with the 3.1 cycle of relative change of coastal onlap of HAQ *et al.* (1987), and with the sequence A of SIERRO *et al.* (1990) for the Guadalquivir basin.

5th STOP

FOZ DA FONTE

In its southern part, the Lower Tagus basin is limited by the "Serra da Arrábida", a small E-W alpine chain mainly composed of folded Jurassic and Cretaceous, and some Tertiary deposits.

At "Serra da Arrábida", early Miocene beds overlie Paleogene units. However, on the coast and somewhat farther away from the "Serra", at Foz da Fonte, Lower Miocene directly overlies middle Cretaceous (Cenomanian) limestones .

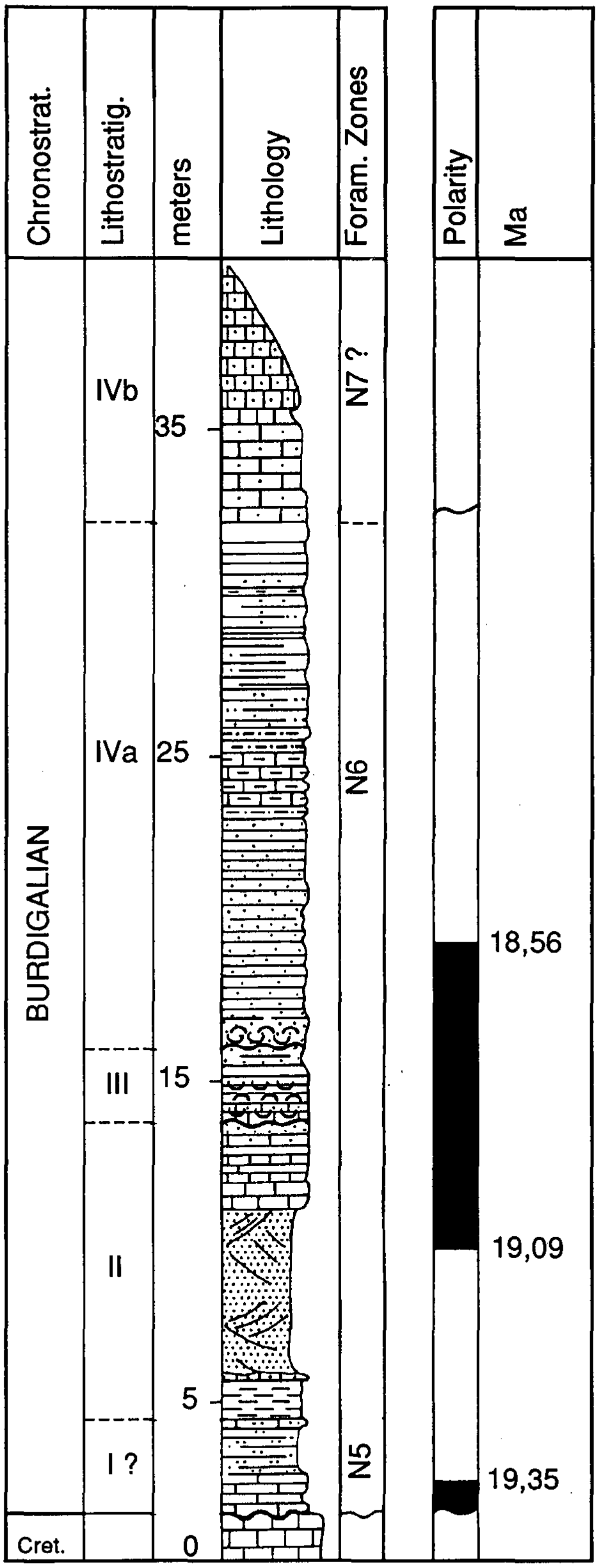

Fig. 7 - Foz da Fonte section (NASCIMENTO, 1988, modified).

Planktic Foraminifera from the lowermost levels point out to a N5 Blow zone age. *Globigerinoides altiaperturus* first appearance (regarded by many authors as a marker for the Aquitanian - Burdigalian boundary) occurs about 2,5 meters above the base of the Miocene succession. *Praeorbulina glomerosa s.l.* has not been found. At this point, the remaining part of the section may be ascribed to N6 zone (Blow), and perhaps to N7 zone at the top.

Under a paleomagnetic viewpoint, the same section corresponds to the normal period of C6 anomaly, to the C5E anomaly and to the reverse period of the C5D anomaly.

This section shows a succession of more or less littoral facies very rich in fossils. Lowermost beds include cobbles and pebbles from Cretaceous rocks (mainly volcanites and limestones). They yielded Myogipsinids and other Foraminifera, corals and mollusks, among other fossils.

Higher up, sand beds with disperse *Gryphaea griphoides* valves correspond to a regression event probably the same as for the unit. II in Lisbon. These sands grade into calcareous sandstones. An erosion surface seems to indicate the beginning of the unit. III.

Lying on the erosion surface there is a conglomerate mainly composed of oyster valves, on which there is an accumulation level of *Turritella* shells. These detrital, shallow facies mark the beginning of the Burdigalian transgression.

6th STOP

PENEDO

The cliffs at Penedo beach, about 1 Km North from the 5th Stop, show some higher levels than at Foz da Fonte.

Biocalcarenites are exposed at the bottom of the cliff. Above them there are sands, sandstones and, again, some biocalcarenites rich in macrofauna. The sands from level 2 contain some benthic foraminifera.

Over level 7 there are silty-clayey levels, in positive sequences (thicking upwards) not so rich in macrofauna as the lower ones but with plentiful microfauna (Foraminifera, Ostracoda). In lower part of bed 8, *Orbulina suturalis* and *O. universa* occur, indicating the Serravallian. These species have been found till the top of the section. *Clavatorella sturanii* is present at bed 10 (N8-N12, according to the authors); *Globigerinoides subquadratus* is always present. The Foraminifera point out to a Lower to Middle Serravallian (N9/10 - N13) age for this part of the section.

Part of the succession is masked by Plio-Quaternary sands. At the northern end of the beach, compact greyish to green clays are exposed. These are overlain by two conglomerate levels, very rich in fossils — cetacean bones, shark's teeth, mollusks, echinoids, etc. Rounded pebbles show a strongly dark patina. These beds are Serravallian in age, and may correspond to condensed levels.

Level 9 comprises green glauconite - rich sands with mollusks and planktic foraminifera including *Globorotalia* (between *G. praemenardi* and *G. miotumida*), scarce *Turborotalia* cf. *humerosa praehumerosa* and *Neoglo-boquadrina* cf. *acostaensis*. These association seems indicate earliest Tortonian.

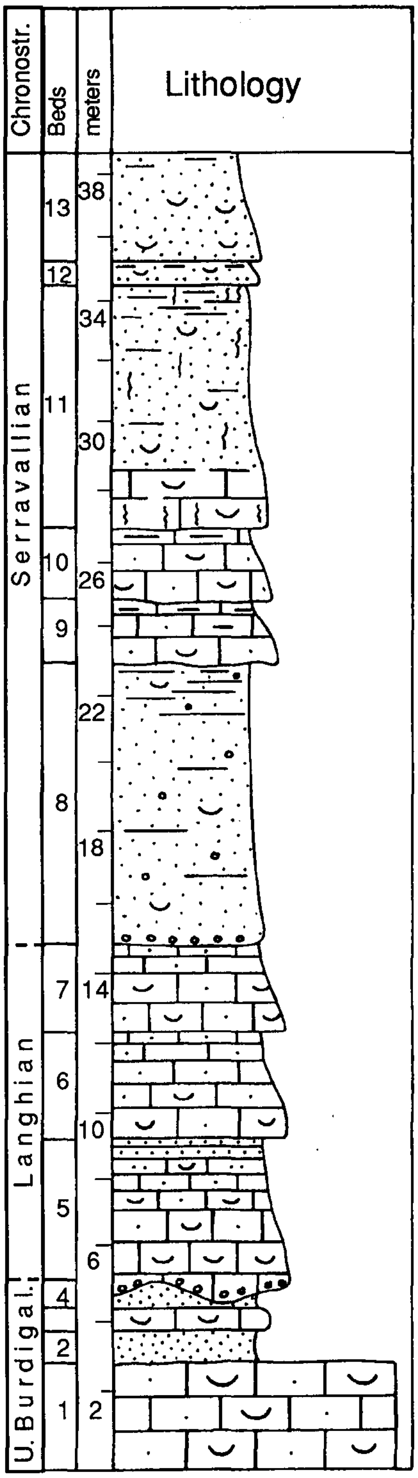

Fig. 8 - Southern part of Penedo section.

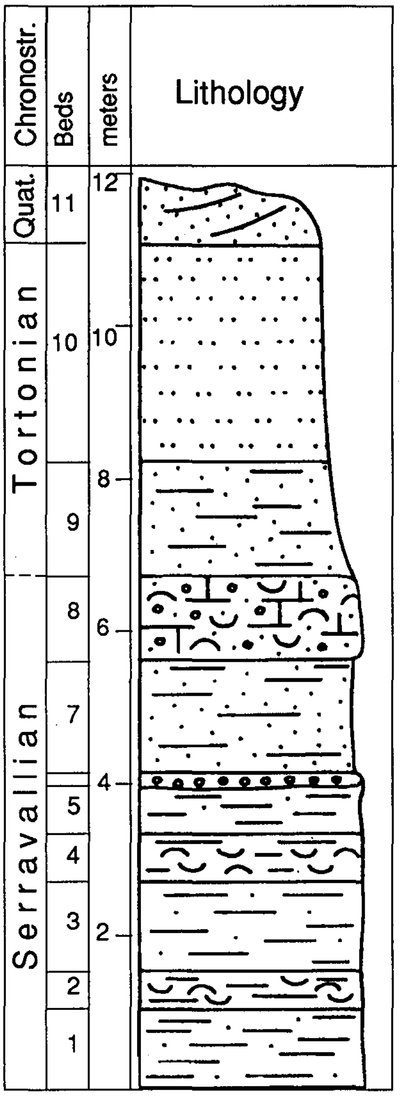

Fig. 9 - Northern part of Penedo section.

K-Ar glauconite age from the upper part of this bed is 10.97±0.25 My (early Tortonian).

Sedimentation changed upwards to yellowish siltstones poor both in micro and macrofauna. These are the last Miocene marine levels so far recognized in this region.

The whole Miocene series is covered by Plio-Quaternary sands.

REFERENCES

See page 67.