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**MICROPALÉONTOLOGY OF PALEOGENE
DEEP WATER SEDIMENTS, HAUTE-SAVOIE, FRANCE**

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Thèse de *Monsieur Bernhardt Franz UJETZ*

intitulée :

"MICROPALÉONTOLOGY OF PALEOGENE DEEP WATER SEDIMENTS, HAUTE-SAVOIE, FRANCE."

La Faculté des Sciences, sur le préavis de Messieurs R. WERNLI, professeur titulaire et directeur de thèse (Département de géologie et paléontologie), J. CHAROLLAIS, professeur ordinaire et codirecteur de thèse (Département de géologie et paléontologie), P. KINDLER, docteur (Département de géologie et paléontologie), H. LUTERBACHER, professeur (Université de Tübingen), R. PLANCHEREL, docteur (Université de Fribourg) et F. RÖGL, docteur (Naturhistorisches Museum Wien, Geologisch-paläontologische abteilung), autorise l'impression de la présente thèse, sans exprimer d'opinion sur les propositions qui y sont énoncées.

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ABSTRACT

Twenty two outcrop sections were sampled in order to present the benthic and planktonic foraminiferal species from Paleogene, deep water deposits. The sections studied were derived from the Voirons massif, Subalpine chains, Chablais Prealpine front and Thônes syncline in the Haute-Savoie of France. Two supplementary sections were studied in the Romand Prealpine front for comparative faunal analyses.

An outline of the paleoecological parameters interpreted, including dissolved oxygen levels, salinity levels, carbonate and silica availability, temperature and energy, substrate and bathymetry, is presented, illustrating the use of both planktonic and benthic foraminifers in obtaining the paleoenvironmental conditions on Paleogene deep water deposits.

The paleoecology and biostratigraphy of the studied sections were interpreted using modern foraminiferal taxonomic and biostratigraphic concepts. Outer neritic to abyssal depth associations were observed. Nannofossils and Palynomorphs were also analysed for complementary and comparative biostratigraphic assessment and provided varying results. A model involving the development of surface water sedimentary plumes is given to explain the occurrence of mixed microfossil assemblages, along with other possible problems associated with biostratigraphical and paleoecological interpretation.

The major foraminiferal paleoecological and biostratigraphical trends within the studied region, were assessed for the early-middle Paleocene, late Paleocene, middle Eocene, late Eocene and early Oligocene and compared with faunas from southern, subtropical, paratethyan and northern provinces.

Calcareous dominated assemblages represent the early-middle Paleocene and are similar to Atlantic-Tethyan faunas. The late Paleocene is typified by deepest water DWAF (Deep water agglutinated faunas) of typical orogenic origin. The middle Eocene consists of both well oxygenated shelf and dysaerobic, bathyal faunas comparative to both northern and southern palaeogeographic domains. The late Eocene is represented by highly diverse faunas observed throughout the studied areas. However, some more restricted, dysaerobic bathyal faunas were also recorded from the Voirons massif. The early Oligocene is marked by the widespread occurrence of dysaerobic, bathyal cool-water faunas such as the *Chilostomella-Praeglobobulimina-Bulimina* association. Foraminiferal results were assessed with the aim of providing the key trends for future palaeogeographic reconstruction. Some palaeogeographic implications and problems are raised in the light of new biostratigraphical and paleoecological results.

Approximately 90 planktonic foraminiferal species and 170 benthic species, belonging to the Astrorhizida, Lituolida, Miliolida, Nodosariida, Robertinida, Buliminida, Rotaliida and Globigerinida, were recorded, and noted with remarks on morphological features, stratigraphic and geographic distributions within the studied area and from neighbouring sedimentary basins.

RESUME

1.1. Buts

Malgré quelques travaux ponctuels (Charollais et al. 1975, 1981, Rosset et al. 1976, Kindler et al. 1995) la datation et les milieux de dépôts des flyschs paléogènes NW alpins restent encore très lacunaires. Après les publications récentes et synthétiques en taxinomie (Loeblich & Tappan 1988) et en biostratigraphie (Toumarkine & Luterbacher 1985, Bolli & Saunders 1985), une révision de la micropaléontologie de ces séries devenait nécessaire. En effet, aucunes corrélations précises ni hypothèses paléogéographiques raisonnables ne pouvaient être formulées sans cela. Le but de cette recherche est donc: 1) Etablir le bilan des foraminifères planctoniques et benthiques sur la base de concepts taxinomiques modernes, pour ce front NW des Alpes, 2) Définir la biostratigraphie et la paléoécologie de ces dépôts, 3) Comparer les associations de foraminifères avec celles des provinces paléogéographiques voisines, 4) Poser les bases d'un cadre paléogéographique pour les dépôts de flyschs et de molasses dans cette aire.

1.2 Matériel et méthodes

Environ 400 échantillons de marnes et autres roches lavables ont été prélevés sur le terrain et analysés au laboratoire. La plus grande partie provient des collectes de l'auteur, d'autres appartenant à des chercheurs travaillant à l'établissement de la feuille géologique Annemasse à 1/50 000.

Les recherches portent sur le massif des Voirons, le front des Préalpes du Chablais, les chaînes subalpines et le synclinal de Thônes en Haute-Savoie. Quelques coupes ont été levées dans le front des Préalpes romandes pour comparaisons.

L'étude au laboratoire concerne principalement les formes dégagées, mais quelques lames minces ont été exécutées dans les calcaires gréseux pour contrôles. Seuls les résidus supérieurs à 125 microns ont été analysés et un comptage d'au moins 200 foraminifères a servi à établir le rapport plancto-benthique et la diversité spécifique (index α de Fisher).

Environ 260 espèces planctonique et benthiques sont décrites et commentées au sujet du statut taxinomique, de la valeur stratigraphique et de la signification paléoécologique. Une abondante iconographie au MEB complète le travail et servira de référence pour les recherches futures.

Si les foraminifères restent le but essentiel de ce travail, de nombreuses analyses palynologiques, de nannoflores et d'ostracodes ont permis de contrôler les datations et de préciser les paléomilieux. L'examen des palynomorphes est du au Dr. S. Wood (Univ. de Genève) et Dr. R. Jan du Chêne (Univ. de Genève), celui des nannoflores au Dr. J. Krohovsky (Académie des sciences, Prague), les ostracodes étant contrôlés par le Dr. H. Oertli (Pau, France).

1.3 Situation géographique

Le champ d'étude comprend essentiellement les secteurs suivants:

1. Massif des Voirons: Suivant les études régionales de Lombard (1940), on distingue 1) la molasse autochtone (non étudiée ici), 2) la molasse (charriée) subalpine, 3) les mélanges préalpins ou wildflyschs et 4) la nappe du Gurnigel d'origine pennique.

2. Chaînes subalpines: Dans cette unité, les Marnes à foraminifères et les Schistes à *Meletta* en partie déjà explorés par Charollais et al. (1980) ont été révisés.

3. Front des Préalpes romandes: Dans cette aire ce sont surtout les flyschs du Gurnigel qui sont analysés.

4. Front des Préalpes du Chablais: À l'exclusion de celles des Voirons, on a regroupé ici les séries de la Dranse et de St Gingolph.

5. klippe de Sulens (Synclinal de Thônes): Des prélèvements ont été effectués dans l'unité de Nantbellet à l'W de la klippe, alors que la formation "gréso-glauconieuse" soit-disant albo-aptienne, mais en réalité éocène, a été analysée dans le torrent des Marais. Dans la même région est incluse la coupe des Combes.

1.4. Travaux antérieurs.

Dans le secteur concerné peu de travaux ont été entrepris à cause des sédiments trop pauvres en faune, de la mauvaise préservation des fossiles, des remaniements intenses, ou encore des conditions paléoécologiques défavorables (milieux restreints peu profonds, ou au contraire profond mais anaérobiques).

Pour le Paléocène, les études sont dispersées à cause de la faible représentation des ces terrains. On peut citer les travaux de Kindler (1990), pour l'Ultra-helvétique, et ceux de Brouwer (1965), Van Stuijvenberg (1981), Winkler (1985), et Kuhn (1992), pour le Gurnigel et le Schlieren-flysch.

Pour l'Eocène moyen et supérieur ce sont essentiellement les publications de Rosset et al. (1976), Charollais et al. (1975, 1981) et Kindler et al. (1995) qui servent de base. L'Oligocène, représenté par les Marnes à foraminifères et les Schistes à *Meletta* est mieux connus par les travaux de Charollais et al. (1980).

Des comparaisons avec les provinces adjacentes peuvent être faites en Suisse centrale et dans le sud du fossé rhénan. Plus loin les recherches portant sur la Paratéthys (Rögl 1994, Cicha et al. 1996) et la molasse bavaroise (Wenger 1987, Reiser 1987, Dohmann 1991) nous ont servis de base. Enfin des comparaisons à plus longues distances ont été faites avec l'Europe du Nord, les Carpathes, le Sud de la France, le Nord de l'Italie et l'Espagne.

1.5. Cadre biostratigraphique

Biozonation: Pour le front Nord des Alpes aucun schéma biozonal n'a été proposé dans la littérature. Il faut aller jusqu'en Paratéthys (Rögl 1985) pour trouver des bases solides, et plus loin

dans le Caucase, les travaux de Subbotina (1947, 1950, 1953) et Krashennikov (1969) font autorité.

Si la biozotation par foraminifères planctoniques est maintenant bien assise pour les régions de basses latitudes et tropicales (synthèse in Toumarkine & Luterbacher 1985, et in Bolli & Saunders 1985), il n'en est pas de même pour les zones tempérées-boréales. Ceci est dû à la rareté des espèces-index et à la dominance d'autres espèces à valeur stratigraphique incertaine. Un des buts principaux du présent travail est donc de proposer une biozotation fiable pour cette aire qui servira de référence pour l'interprétation future des séries flysch.

Chronostratigraphie: L'échelle chronostratigraphique basée sur la radiométrie et la magnétostratigraphie est tirée des travaux de Cande & Kent (1992, 1995) et la délimitation des époques et des étages suit ceux de Jenkins & Luterbacher (1994). Ces résultats ont été corrélés pour les dépôts molassiques suisses par Berggren et al. (1995) et adoptés dans le présent travail.

2. Paramètres paléocéologiques

Les paramètres environnementaux utilisés dans cette étude sont: 1) le niveau d'oxygène dissout, 2) la salinité, 3) le taux de carbonate de calcium et de silice disponible, 4) la température, 5) l'énergie hydraulique, 6) le type de substrat et 7) la bathymétrie. L'interprétation de ces paramètres est basée essentiellement sur la distribution spatiale des foraminifères mais également sur des critères de morphologie fonctionnelle.

Avec l'apparition de nombreux nouveaux genres au Paléogène, les foraminifères peuvent être assez bien comparés aux formes modernes. Ainsi la distribution actuelle des espèces compilées dans les travaux de Murray (1973, 1991) peut servir de modèle, avec la prudence requise, pour les terrains étudiés. Dans les assemblages, deux bons paramètres sont représentés par la proportion des ordres et genres de foraminifères et la diversité spécifique mesurée par l'index α de Fisher.

2.1. Oxygène dissout

Un indice α de Fisher >5 , indique un niveau d'oxygène dissout normal à haut. Ces milieux bien oxygénés contiennent des espèces calcaires avec des tests grands, solides et ornementés. La présence d'endofaune comme *Lenticulina* et *Vaginulinopsis* va également dans ce sens, alors que les faibles diversités, ne contenant que peu d'espèces opportunistes, et l'absence d'endofaune suggèrent des conditions dysaérobiques. Certains genres de Buliminacea, ainsi qu'*Haplophragmoides*, *Nonionella* et *Bathysiphon*, survivent avec peu d'oxygène et sont de bons indicateurs dans ce sens. Il en est de même pour des petites espèces, allongées, aplaties, unisériées ou trisériées comme *Bulimina*, *Brizalina*, *Bolivina*, *Cassidulina*, *Eponides* et *Fursenkoina*. Les tests lisses, non ornementés, souvent avec tube entosolénien indiquent la même tendance.

2.2. Salinité

Un indice α Fisher >5 est caractéristique de salinité normale. Ce paramètre peut également être contrôlé par un diagramme triangulaire formé par les tests calcaires hyalins, les porcelanés et les

agglutinés. Une salinité normale tend vers les calcaires hyalins, alors que les conditions hyposalines dérivent vers le pôle des agglutinés.

2.3. Carbonate de calcium et silice.

Les assemblages à haute diversité d'espèces calcaires et solides sont typiques d'un taux de carbonate de calcium dissout élevé. En dessous de la CCD dominant les espèces non calcaires. L'abondance de silice dissoute est marquée par les radiolaires, les foraminifères agglutinés, les espèces calcaires à test fragile et les spicules d'éponges.

2.4. Température et énergie de l'eau.

Chez plusieurs espèces de foraminifères planctoniques la température peut être estimée en fonction de la prédominance dextre ou senestre de l'enroulement. Mais ceci est également vrai chez certains benthiques comme *Bulimina*. Une diversité spécifique faible et la présence de grands espèces agglutinées marquent des eaux stagnantes, alors que les grands foraminifères calcaires complexes tels que *Discocyclina* et *Operculina* signalent des milieux peu profonds et bien éclairés.

2.5. Substrat

Le type de substrat peut être déterminé par la présence de formes fixées, la granulométrie et la nature de l'agglutinat, ainsi que par la porosité des parois. Beaucoup d'espèces vivent sur des algues (non fossilisables), et *Cibicides*, *Quinqueloculina* ou *Discorbis* par exemple, reflètent des milieux peu profonds envahis par la végétation.

2.6. Bathymétrie.

Ce paramètre est des plus intéressants pour les reconstructions paléogéographiques. Il est basé sur nombre d'espèces marqueurs, la diversité spécifique, le rapport plancto-benthique et la taille de certains espèces planctoniques. Par exemple pour le Paléogène, *Cibicidoides dutemplei* marque une bathymétrie de 100-600m, *Hanzawaia ammophila* 100-400m, *Aragonia velascoensis* 200-2000m, *Nuttalides truempyi* 500-4000m, etc.

3. Analyse des coupes de terrain

Les 24 coupes de terrain sont représentées, dans le manuscrit, sous forme de logs détaillés avec la distribution verticale des espèces de foraminifères, les indices P-B et α Fisher ainsi que des critères sédimentologiques. Voici, résumé, les résultats les plus importants pour chacune d'entre elles:

Massif des Voirons

*Bellevue: âge P18-P20, bathyal sup., salinité et oxyg. normal à la base, moins au sommet.

*Bons: P11-P12, bathyal, ouvert, bien oxyg.

*Chauffemérande: P15, bathyal moy.-sup., dysaérobique.

- *Fillings: P14-P17, bathyal, profond, mal oxyg.
- *Fiol: P16, bathyal inf., bien oxyg.
- *Juffly: Paléocène, profond, dysaérobique probable.
- *Montauban: Oligocène inf. à la base, néritique, restreint, sous influence contin.,
- *Saxel: P15-P16, mal à bien oxyg., bathyal inf.
- *Signal des Voirons A: Paléocène, abyssal. prob., dysaérobique.
- *Signal des Voirons B: P1-P2, bathyal moy., bien oxyg.
- *Supersaxel: P13-P16, bathyal sup., oxyg. variable.

Chaînes subalpines septentrionales

- *Brison: Paléoc. sup.-Eoc. inf.?, turbidites.
- *Dessy: P18-P20, néritique externe -bathyal sup., partiellement dysaérobique.
- *Sage: P18-P19 (P20-21?), néritique externe-bathyal sup.
- *Vacherie: P18-P19, néritique externe-bathyal sup.
- *Venay: P18-P20, néritique externe.

Préalpes romandes

- *Cucloz: stérile.
- *Fayaux A: Paléocène, profond, dysaérobique.
- *Fayaux B: Paléocène.

Préalpes du Chablais

- *Dranses: P13-P15 à la base, dysaérob. et P16 au sommet, néritique externe, bien oxyg.
- *St Gingolph: âge indéterminé, sous la CCD?

Synclinal de Thônes

- *Les Combes: P15-P16, partiel. néritique externe, bien oxyg.
- *Marais: P12-P14, restreint, dysaérobique, bathyal.
- *Nantbellet: P12, néritique externe à bathyal sup., bien oxyg.

4. Problèmes posés par les sédiments profonds du Paléogène en biostratigraphie et paléoécologie

De par leur nature même, ces sédiments éminemment détritiques terrigènes comportent une importante fraction de faunes et de flores remaniées ce qui rend la datation et l'étude paléoécologique délicate. L'analyse, très soignée, devra discriminer l'homogénéité des assemblages (sur le plan stratigraphique et paléoécologique), l'état de conservation des tests, leur taille et bien sûr le contexte sédimentologique. Les palynomorphes et la nannoflore calcaire n'échappent pas à ce travers, mais il est remarquable de constater que, selon nos travaux, les foraminifères offrent un meilleur outil d'analyse, plus fiable, dans ce type de sédiment, que ces deux derniers groupes de microfossiles.

Dans certains cas, et particulièrement dans l'Oligocène, la divergence des résultats obtenus par les palynomorphes et la nannoflore par rapport à ceux fournis par les foraminifères, pourrait s'expliquer hydrologiquement par un phénomène de plume turbide d'eau douce de surface. Celle-ci inhiberait le développement de la microflore mais permettrait celui des foraminifères planctoniques plus tolérants et plus profonds.

5. Evolution des foraminifères: une base pour les reconstructions paléogéographiques

5.1. Paléocène inférieur et moyen

Le massif des Voirons exhibe des faunes benthiques et planctoniques assez riches mais relativement peu diverses, comparables à celles des régions sud-alpines. Le milieu, bathyal, est plus ou moins dysaérobique, mais surmonté par une colonne d'eau bien oxygénée. Par contre, aux Fayaux, les associations sont typiquement alpines, de type "faune à *Rhabdammina*", moins profondes, mais froides, stagnantes et mal oxygénées.

5.2. Eocène moyen

La présence de faunes bathyales, bien oxygénées, à la coupe de Bons (attribuée jusqu'ici aux Flysch des Voirons), nettement différentes des celles des flysch du Gurnigel, implique que ces sédiments: 1) appartiennent bien aux Flysch des Voirons mais ont une origine paléogéographique différente, 2) représentent une écaïlle tectonique d'origine ultra-helvétique.

5.3. Eocène supérieur

Les Marnes de Boège ont également une origine paléogéographique différentes de celles des Flyschs du Gurnigel. Quant aux turbidites de Fillings, elles font probablement partie d'un bloc charrié le long du chevauchement basal de la nappe du Gurnigel.

5.4 Oligocène inférieur

Les bonnes corrélations entre les associations des bassins péri-alpins avec le Nord de l'Europe et les Carpathes suggèrent un "couloir polonais" entre la Téthys et la Mer du Nord à cette époque. À Bellevue, l'apparition de faunes froides est conforme à "l'évènement oligocène". Mais la baisse du niveau océanique général n'est pas enregistrée sur notre terrain, à Bellevue par exemple, qui montre plutôt une augmentation de la bathymétrie.

6. Paléontologie systématique

Ce chapitre important donne les références principales pour environ 260 espèces de foraminifères planctoniques et benthiques, à l'usage du déterminateur. Il est abondamment illustré par 440 vues au microscope électronique à balayage, présentées sur 11 planches photographiques. La classification suit celle de Haynes (1981) pour les ordres, et celle de Loeblich & Tappan (1988) pour les super-familles, les familles et les genres. Pour chaque taxa, la synonymie, qui ne se veut pas

exhaustive, est limitée au type et à quelques références prises dans la littérature la plus récente. Les "remarques" relèvent les rapports et différences, les occurrences stratigraphiques locales et générales, ainsi que la signification paléocéologique.

7. Conclusions

Les conclusions sont posées en 9 points principaux:

- 1) Au Paléocène inférieur et moyen, la présence de riches faunes à dominance calcaire-hyaline dans le massif des Voirons, montre des relations avec les provinces atlantiques et téthysiennes.
- 2) Le Paléocène supérieur est représenté par des assemblages cosmopolites, bathyaux et abyssaux (foraminifères agglutinés profonds), surtout dans le flysch du Gurnigel des Préalpes romandes, mais aussi dans les Voirons et au front des Préalpes du Chablais. Ils se raccordent aux faunes de la Mer du Nord.
- 3) A l'Eocène moyen, les faunes sont dysaérobique, bathyales, au front des Préalpes du Chablais et ressemblent à celles du Caucase. Dans le synclinal de Thônes et les Voirons, elles sont plus diverses, aérobiques, généralement néritiques externes, et similaires aux assemblages méditerranéens subtropicaux.
- 4) A l'Eocène supérieur, on trouve des faunes diverses, aérobiques, néritiques externes, dans le synclinal de Thônes, les Voirons et le front des Préalpes du Chablais. Elles montrent des affinités avec les provinces du Sud. Mais aux Voirons on note également des assemblages bathyaux avec des fluctuations dysaérobiques-aérobiques.
- 5) A l'Oligocène inférieur on observe des faunes dysaérobiques bathyales à aérobiques néritiques externes dans les Voirons et les Chaînes subalpines. Elles impliquent des connections probables avec les bassins du Nord de l'Europe et de la Paratéthys.
- 6) La biozotation "standard" tropicale-subtropicale, par foraminifères planctoniques, est applicable pour le Paléogène du Nord-ouest des Alpes. On note cependant à l'Eocène supérieur et à l'Oligocène inférieur la rareté de quelques espèces planctoniques index et la faible abondance des individus dans certains secteurs. Dans ce cas, les espèces benthiques peuvent offrir un outil complémentaire utile pour la biostratigraphie.
- 7) A l'Eocène supérieur et à l'Oligocène inférieur, les fréquents remaniements de microfossiles divers (foraminifères, nannofossiles calcaires et palynomorphes) peuvent être expliqués par un phénomène de plume sédimentaire d'eau douce.
- 8) Les sédiments profonds du Paléogène de Haute-Savoie ont été souvent mal interprétés à cause de la rareté des études micropaléontologiques. Pour ce faire, une analyse biostratigraphique multidisciplinaire employant différents groupes de microfossiles est essentielle. Toute future reconstruction paléogéographique restera illusoire sans une révision systématique de ces sédiments de type flysch.
- 9) Dans l'étude des faciès profonds, les foraminifères apparaissent comme l'outil le plus performant pour la biostratigraphie. Ils offrent également des marqueurs intéressants pour la paléocéologie, particulièrement pour la bathymétrie et l'oxygène dissout des environnements de dépôts.

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1. INTRODUCTION

1.1 Aims

With recent advances in Paleogene foraminiferal taxonomy (Loeblich & Tappan 1988), biostratigraphy (e.g. Toumarkine & Luterbacher 1985, Bolli & Saunders 1985, Berggren & Miller 1988, Berggren et al. 1995, Rögl 1994, Cicha et al. 1996) and paleoecology (e.g. Murray 1991), a re-examination of the faunal elements present in deep-water Paleogene deposits from the north-western Alps is necessary. Accurate definition of the age of previously, often poorly defined, Paleogene sequences and their depositional environments is required so that refined palaeogeographic reconstruction of the alpine front can be presented in the future.

The aims of this study are to (1) document the foraminiferal species, using modern taxonomic concepts, of several Paleogene sequences from the north-western Alps, (2) define the biostratigraphy and paleoecology of these deposits, (3) compare these foraminiferal faunas with nearby palaeogeographic provinces and assess their utility for biostratigraphy and paleoecology, and (4) to propose a basis for palaeogeographic reconstruction of deep water Paleogene sediments in the region.

1.2 Materials and methods

1.2.1 Material studied

X Samples studied were derived entirely from outcrop sections and those prefixed by a "U" were taken by the author of this study. Samples prefixed by KS and An3s were derived from the work of Kindler et al. (1995) and the field work of Yves Kerrien for the "Annemasse Feuille géologique à 1: 50 000" (1996, in press). The material studied was collected from the Voirons massif and Prealpine front of the Chablais Prealps, Subalpine chains and Thônes syncline in the Haute-Savoie, France and also from the Prealpine front of the Romand Prealps, Switzerland for comparative purposes (Fig. 1).

1.2.2 Field sampling

Sampling was aimed principally at the shaly intervals within alternating sandstone/shale turbidite successions. Where Bouma sequences occurred, the uppermost hemipelagic Te interval was sampled. Sampling was concentrated at the bottom and top of thickening-up and thinning-up parasequences where present. Some sandstone samples were also taken for complementary microfossil and petrographic thin section analysis.

1.2.3 Sample preparation

Samples were crushed and placed in boiling water for about 20 minutes. A small amount of Calgon™ (a mud dispersant) and detergent were added to cause further disaggregation. After boiling, samples were wet sieved through 1mm, 125µm and 63µm sieves. The 63-125µm and >125µm-1mm size fractions were retained for sediment and microfossil examination.

1.2.4 Microfossil analyses

The >125µm-1mm residues were placed on counting trays and at least 200 foraminifers were systematically picked from each sample residue to provide planktonic/benthonic test ratios and species diversities. Foraminiferal counts less than 200 represent exhaustive picks due to the scarcity of foraminifers. In this study, the foraminiferal species diversities were measured by the Fisher α index which takes into account the number of both planktonic and benthonic species present among a certain number of individuals (Figure 3). This statistically valid count enables an accurate analysis of the foraminiferal assemblage (Murray 1973). Distribution charts of foraminiferal species and other microfossils for each sample were constructed from systematic picks and the selective picking of rarer species from both the 63-125µm and >125µm-1mm sediment fractions.

Foraminifers were identified to species level to determine assemblage characteristics, age zonation, correlation of sections and an interpretation of their depositional environments. Stratigraphic distributions of foraminifers within the sections were determined by noting the presence or absence of each taxon within the samples.

Secondary electron images of selected specimens were obtained using a JEOL 6400 Scanning Electron Microscope at 15-30 kV accelerating voltage and 20-50 nm spot size. These were prepared by mounting specimens on SEM aluminium stubs with double-sided sticky tape and coating the stubs with carbon and gold in a vacuum evaporator.

Palynomorphs were prepared by Michel Floquet (University of Geneva) and were identified by Dr. Susan Wood (University of Geneva) and Dr. Roger Jan du Chêne (University of Geneva and Consultant, Bordeaux). Nannofossils were examined by Dr. Jan Krhovský (Academy of Sciences, Prague) and ostracods by Dr. Henri Oertli (University of Geneva and Bizanos, France).

1.3 Geographical and geological setting

The field work area is concentrated in several parts of the north-western Alps, principally in Haute-Savoie, France. Most of the studied sections are located in the Voirons massif of the Chablais Prealps, Haute-Savoie, France. Other sections were located in the Subalpine chains, Front of the Chablais and Romand Prealps, and southern part of the Thônes syncline (Fig. 1).

1.3.1 Voirons massif

The Voirons massif, according to previous regional studies (e.g. Lombard 1940), is composed of four vertically stacked tectonic units: (1) autochthonous molasse, (2) subalpine (thrust) molasse, (3) prealpine melange (Plancherel 1979) or wildflysch (4) the Gurnigel nappe of south-Penninic origin (Caron 1976, Caron et al. 1980, Van Stuijvenberg 1979). Outcrops from the latter 3 units were studied here.

The autochthonous molasse is generally attributed to late Oligocene-Miocene continental regime, based on mammal dates and was not studied here. The subalpine molasse, which consists of alternating shales and sandstones, is thought to be of early Oligocene (Rupelian) age due to its petrographic similarity with the Vaulruz sandstones, the age of which was based on bivalves and fish scales (Lombard 1940, Mornod 1949).

The wildflysch zone or Prealpine mélange in the Voirons massif is situated between the subalpine molasse and Gurnigel nappe. It consists of slices of Cretaceous and Jurassic limestones from the Ultrahelvetian realm, late Eocene microbreccias rich in *Lithothamnium* and foraminifers and Val d'Illiez Formation. The Val d'Illiez Formation includes a succession of turbiditic sediments, consisting of marls, shales, sandstones and conglomerates (abundant in volcanic elements), and is thought to represent an early-middle Oligocene filling phase of the North Alpine foreland or Molasse basin (Homewood *et al.* 1986). This unit has been given numerous names attached to flysch e.g. Flysch subalpin (Mornod 1949), Flysch Parautochtone (Badoux 1972), North Helvetic Flysch (Trümpy 1980). In the Voirons region, Van Stuijvenberg and Jan du Chêne (1981) designated a late Eocene age for the North Helvetic Flysch based on calcareous nannofossil and palynological assemblages. It is also considered as the lowermost facies of the Lower Marine Molasse (Diem 1986, Homewood *et al.* 1986, Lateltin 1988). Lateltin (1988) interpreted the Val d'Illiez Formation as turbidites which were deposited below wave-base at depths between 200 and 400m. These deposits have been incorporated into the Alpine orogenic belt and are now found within the Helvetic nappes and as tectonic slices below the frontal thrust plane of the Prealps.

The Voirons flysch was attributed to the external Ultrahelvetian Prealps (Lugeon, 1896, Lombard 1940, Jan du Chêne *et al.* 1975), derived from a paleogeographic basin located directly to the south of the Helvetic shelf. However, the resemblance of these deposits to coeval units from the Upper Prealpine nappes led Caron (1976) and Caron *et al.* (1980) to reject these assumptions and to create a new tectonic unit, the Gurnigel nappe, of south-Penninic origin. In the Voirons massif, the Gurnigel nappe consists of three distinctive tectonic units; the Branta, Saxel and Tête du Char slices (Van Stuijvenberg, 1980). These units are subdivided into three lithostratigraphic units; the Voirons sandstones (Grès des Voirons), the Vouan conglomerates (Conglomérats du Vouan) and the Saxel or Boège marls (Marnes de Saxel ou de Boège) (Van Stuijvenberg & Jan du Chêne, 1981). After studying several sections in the Voirons region, they suggested that the Voirons sandstones were deposited between the early Thanetian and the Lutetian based on palynomorphs and nannofossils. An earlier Paleocene age (Danian) for some other sections consisting of Voirons sandstones was later determined also using nannofossils and dinocysts (Van Stuijvenberg & Jan du Chêne 1981). Lombard (1940) and Rigassi (1958) suggested that the Voirons sandstones were restricted to the middle Eocene on the basis of larger foraminifers from sandstone beds and smaller planktonic foraminifers from two shaly horizons respectively. Ivaldi (1989) demonstrated that these sandstones are petrographically different from the Val d'Illiez formation. The Boège marls, the uppermost unit of the Gurnigel nappe in the Voirons massif, were attributed to the middle Eocene (Bartonian).

1.3.2 Subalpine chains

The "Massif des Bornes" (Bornes massif) is a para-autochthonous tectonic unit located between the Arve valley and the lake of Annecy in the northeastern part of the Subalpine chains. It is composed of a series of faulted anticlines and synclines formed of late Jurassic to Tertiary formations, disrupted by fractures and thrusts formed during the Oligocene-early Miocene and

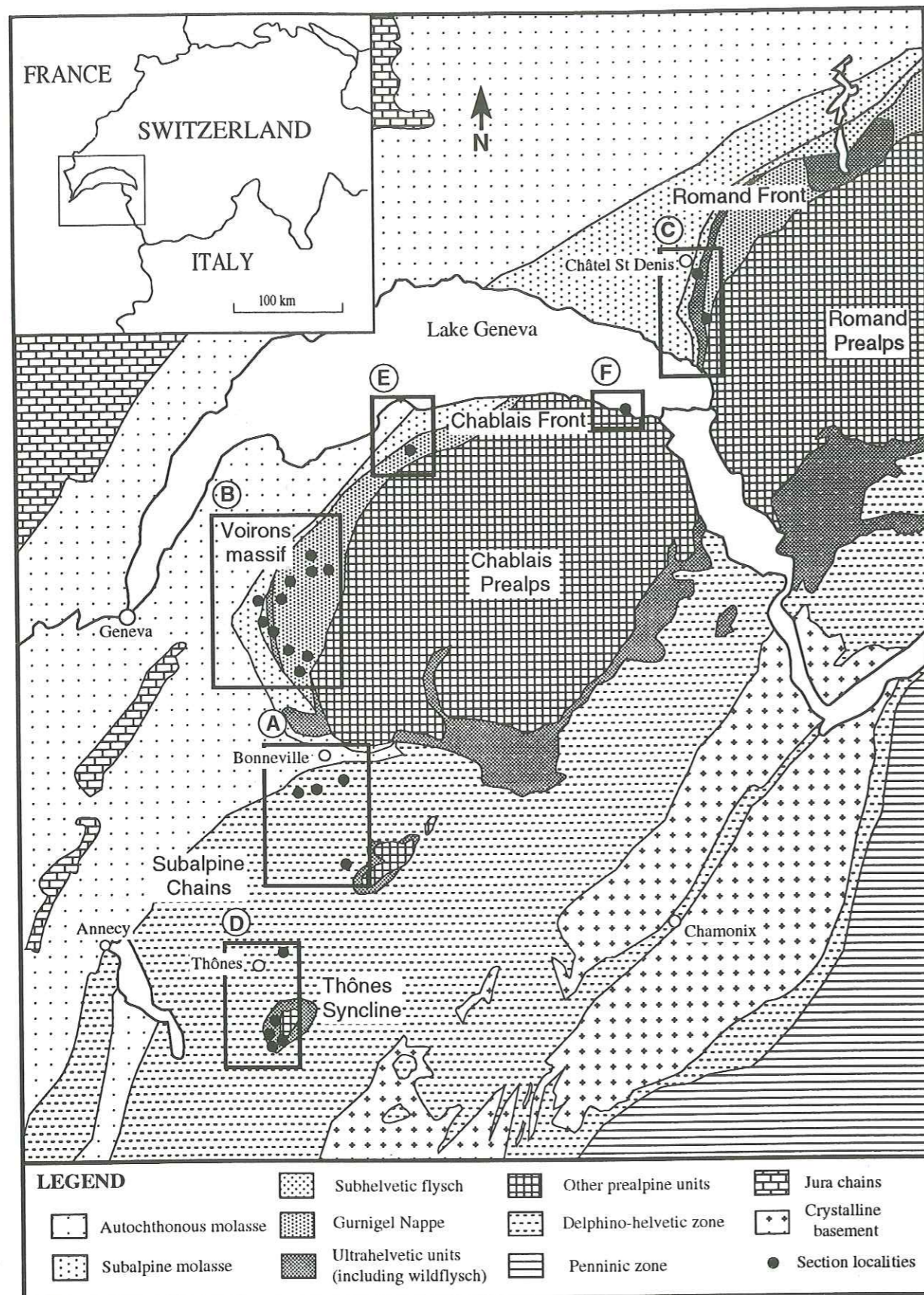
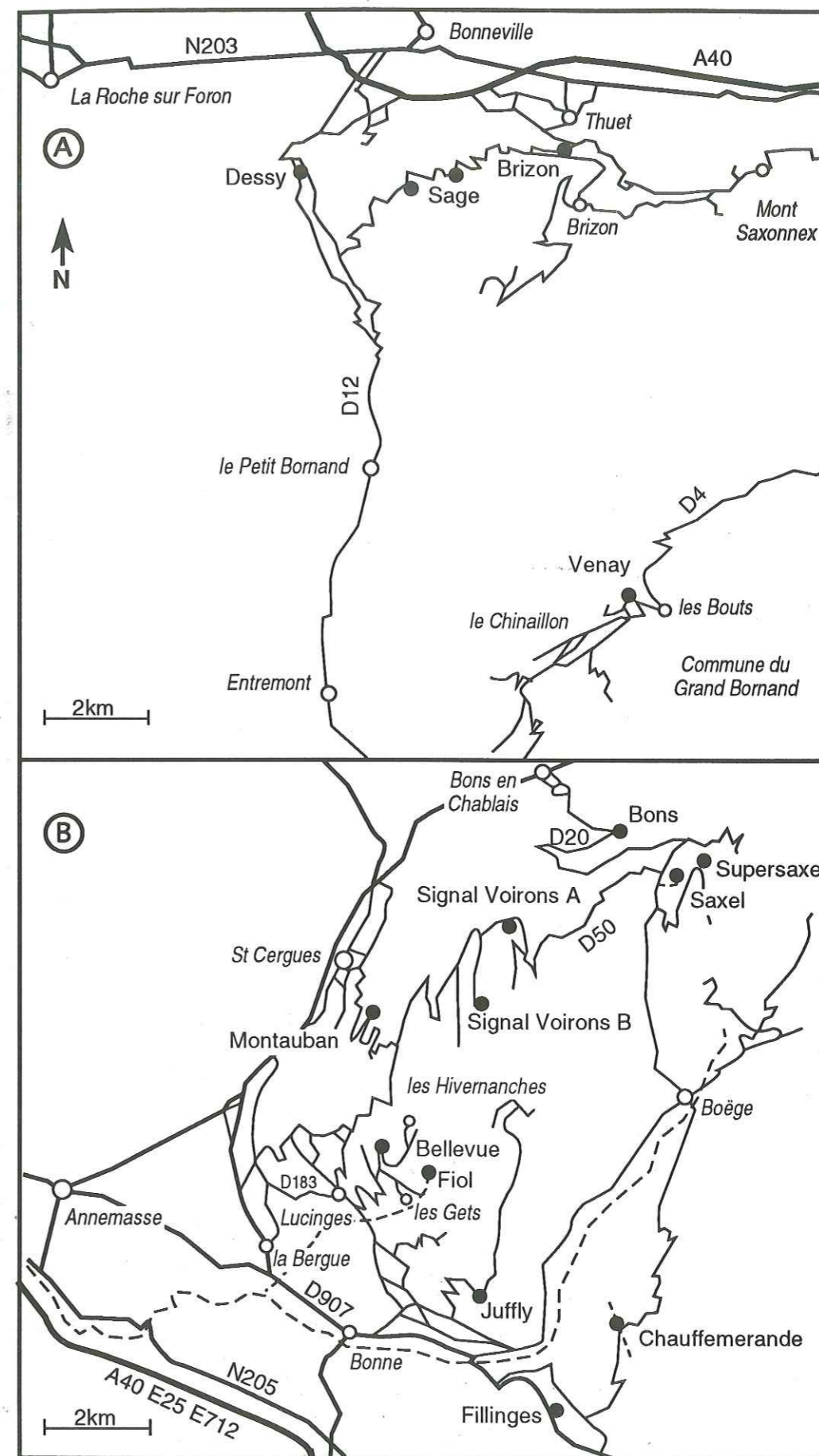
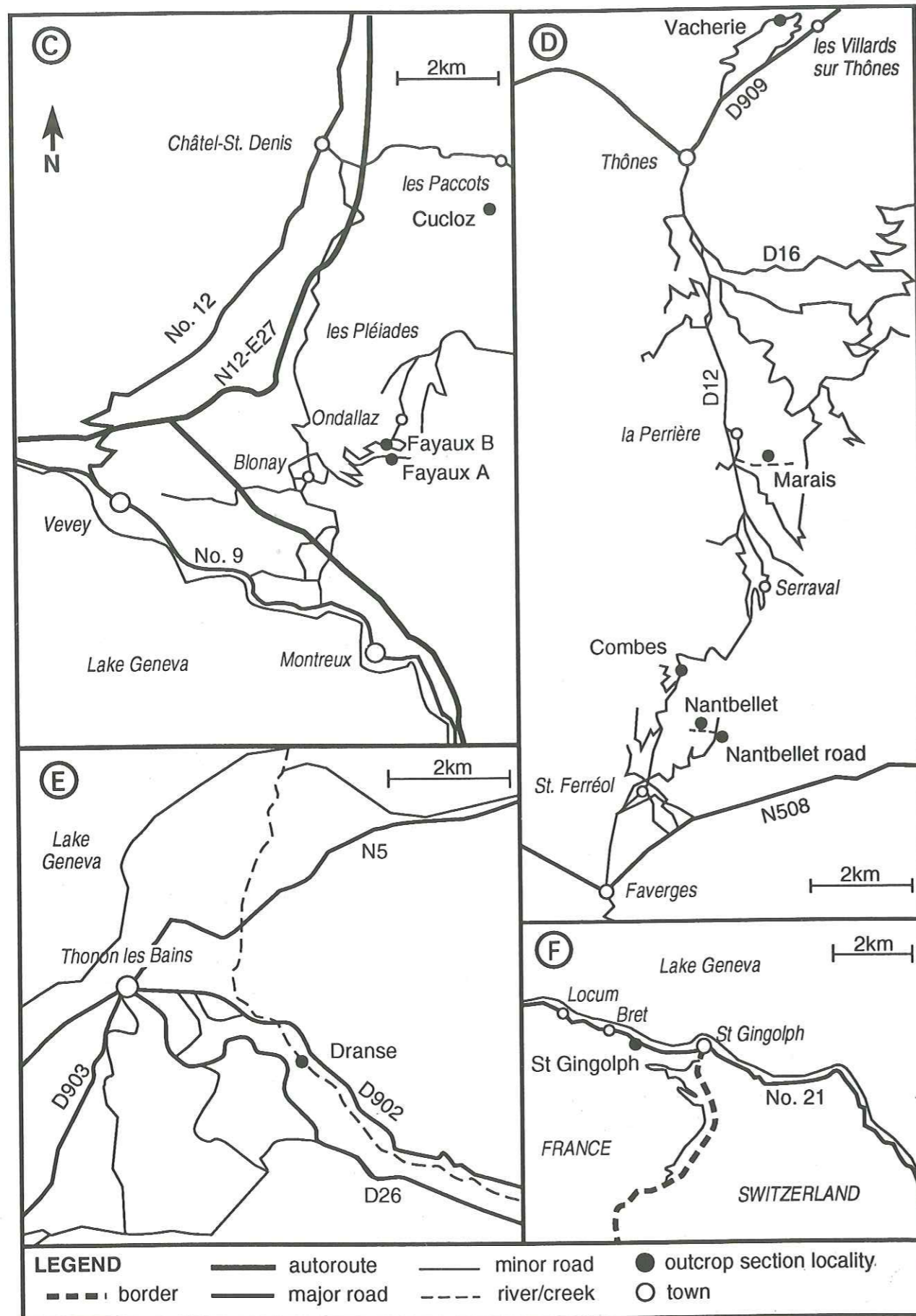


Figure 1: Geographic and tectonic setting of study area featuring positions of studied sections





Miocene-Pliocene alpine orogenic phases (Charollais et al. 1988, Huggenberger & Wildi 1991). The subalpine chains were probably overridden, prior to their formation, by Ultrahelvetic and Penninic nappes. These nappes are represented by the Sulens and Anne Klippen (Rosset et al. 1976). Deep water sedimentation in the Subalpine chains did not occur until the late Eocene to early Oligocene with the "Marnes à Foraminifères" (Foraminiferal marls) and "Schistes à Meletta" (Meletta shales) and volcanoclastic turbidites of the Val d'Illiez formation which also include the "Marno-micacé" (Micaceous marls), (Charollais et al. 1988).

The foraminiferal marls grade into the Meletta shales and are of latest most Eocene to early Oligocene age (P17-P19 planktonic foraminiferal zones) based on dinocysts, spores and pollen, planktonic and benthic foraminifers, nannofossils and ostracods. In the central Alps, globigerinid-rich shales apparently already occur in the middle Eocene (Pfiffner 1986) and late Eocene (Eckert 1963). On the basis of planktonic to benthic foraminiferal ratios, Charollais & Wellhäuser (1962) concluded that the lower part of this formation was deposited in a marine basin of less than 100m and the upper part, rich in globigerinids, in around 1000m water depth. On the basis of ostracods, a 400-800m water depth was estimated. The Meletta shales, rich in organic matter and fish debris (*Clupea* sp.), were recognized as early-middle Oligocene in age (P19-P20 planktonic foraminiferal zones) on the basis of dinocysts, spores and pollen, planktonic and benthic foraminifers and nannofossils (Charollais 1963, Charollais & Wellhäuser 1962, Charollais et al. 1975, 1980, 1988). Furthermore, the presence of *Palliolum* (*Pappiolum*) sp. and *Acmaea* sp. (bivalves and gastropods) suggest a 600-1000m water depth depositional environment. Gaudant et al. (1994) suggested that the Meletta shales in the eastern part of the Bornes massif were at least partly deposited in shallower water.

The micaceous marls member of the Val d'Illiez formation correspond to distal turbidites, overly the Meletta shales, and are attributed by superposition to the middle Oligocene (Charollais et al. 1988). These sediments are thought to be of deeper water origin in the more internal part of the Subalpine chains (Thônes syncline) in comparison to the external part. On the basis of ostracods, a lagoonal environment was determined in the Dessy syncline (Charollais et al. 1988). Charollais et al. (1988) also suggested a middle Oligocene age for the overlying Val d'Illiez sandstones. Martini (1968) indicated a shallow water environment for the uppermost part of the Val d'Illiez sandstones on the basis of shallow water ostracods.

1.3.3 Romand Prealpine front

In the Châtel St Denis area, the Prealpine front of the Romand Prealps exhibits a similar tectonic setting in comparison to the Voirons massif of the Chablais Prealps (Weidmann et al. 1982). An early Oligocene age, based on palynomorphs, was suggested for the Cucloz formation, an equivalent of the Val d'Illiez Formation (Weidmann et al. 1982). These authors also reviewed one sample from the work of Corminboeuf (1959) which hosted a planktonic foraminiferal assemblage attributed to the P18-P20 planktonic foraminiferal zones. Furthermore, they suggested that this formation was deposited in an environment below wave base, between tens and hundreds of metres water depth.

A number of studies have been conducted on the Gurnigel flysch in the Romand Prealps and have focused on nannofossil, dinocyst and trace fossil assemblages (Van Stuijvenberg et al. 1976, Van Stuijvenberg 1979, Crimes et al. 1981). Furthermore, the presence of abundant deep water agglutinated foraminiferal (DWAF) or "*Rhabdammina* type" faunas have been recorded (Brouwer 1965, Van Stuijvenberg et al. 1976, Van Stuijvenberg 1979, Winkler 1983). Kapellos (1973) examined the *Nummulites-Assilina* larger Foraminifera associations within sandstone beds and nannofossil assemblages from shaly intervals. In a review, Caron et al. (1989) indicated that the Gurnigel flysch ranges from the late Cretaceous (Maastrichtian) to the middle Eocene and was deposited in several deep-sea fans below the CCD.

1.3.4 Prealpine front in the eastern Chablais

Sediments located along the Dranse river and at St Gingolph, located in the external part of the Chablais Prealps, are excluded from the Voirons massif. These deposits were previously considered as late Eocene Ultrahelvetetic flysch (Badoux 1965, Jan du Chêne et al. 1975).

1.3.5 Southern part of the Thônes syncline

Located in the southern part of the Thônes syncline, the Nantbellet unit, which represents the lower nappe of the Sulens klippe, (Rosset et al. 1976) shows a continuous stratigraphic succession from the late Jurassic to late Eocene that is similar to the series exposed in other regions of the Ultrahelvetetic Prealps (Anatra et al. 1980, Kindler 1988, Charollais et al. 1993). Early Eocene dinocyst and foraminiferal assemblages were retrieved from the "calcaires plaquetés" Formation belonging to the Nantbellet unit (Charollais et al. 1981). This formation along with the underlying, previously designated Aptian-Albian, "Gréso-glaucouneux" Formation, were recently defined as middle Eocene deposits (Kindler et al. 1995).

The Combes unit is represented by two lobes situated in the western flank of the Thônes syncline. It is composed of flysch (Moret 1934), probably of ultrahelvetetic origin, and is of late Eocene age defined by a rich planktonic foraminiferal assemblage (Rosset et al. 1976).

1.4 Previous work on foraminiferal Paleogene biostratigraphy and paleoecology

Due to sampling difficulties (e.g. preservation of foraminifers, reworking etc.) and the occurrence of unfavourable paleoecological conditions (e.g. restricted shallow water, anaerobic conditions), smaller benthic and planktonic foraminiferal studies on Paleogene alpine deposits are scarce (see Chapter 6?). Paleocene smaller foraminiferal assemblages are very rare from the Helvetic and Ultrahelvetetic basins due to the absence of sedimentation during this period. However, rare Paleocene smaller foraminifers were identified in thin sections derived from Ultrahelvetetic realm sediments (Kindler 1990). The Paleocene in the Gurnigel and Schlieren flysch (Penninic) realm was restricted to deep-water agglutinated benthic assemblages (e.g. Brouwer 1965, Van Stuijvenberg 1981, Winkler 1983, Kuhn 1992). Middle to late Eocene foraminiferal species were recorded from Ultrahelvetetic flysch in the Haute-Savoie, France (Rosset et al. 1976, Charollais et al. 1975, 1978, 1981, Kindler et al. 1995). Most alpine foraminiferal studies from the Subalpine chains

were derived from late Eocene and Oligocene sediments. Rigassi (1958) illustrated a foraminiferal fauna near Naves, Haute-Savoie, France from the foraminiferal marls and suggested a Sannoisian (early Oligocene) age by comparison with other European faunas. A number of more detailed studies followed from the Subalpine chains on the Foraminiferal marls and Meletta shales including Charollais & Wellhäuser (1962) and Charollais et al. (1980). Lateltin & Müller (1987) and Lateltin (1988) also listed foraminiferal species from the Foraminiferal marls recovered from the Aravis chains.

Further north in central Switzerland, illustrated biostratigraphic studies from foraminiferal marls of late Eocene age were provided by Eckert (1963) and Kuhn (1972). Corminboeuf (1959) detailed an Oligocene fauna from the Cucloz formation which at the time he thought was Paleocene based on the abundance of reworked forms. This assemblage was later highlighted by Weidmann et al. (1982). Other studies from the Oligocene in the Gurnigel region (Blau 1966) and from near the Thouens lake (Scherer 1966) have also been illustrated. Foraminiferal faunas were also documented from the Jura near Basel and the southern part of the Rhine Graben, including Tschopp (1960), Schneider (1960), Diebold (1960) and Fisher (1965). Doebli et al. (1976) listed the foraminiferal species and further interpreted the paleoecology of the Rupelian foraminiferal marls and fish shales from the Rhine graben. Recently, Huber (1994) also illustrated a predominantly shallow-water Rupelian foraminiferal fauna from the Rhine graben.

Important biostratigraphic studies are illustrated in Rögl (1994), Cicha et al. (1986, 1996) from the central Paratethys, Wenger (1987), Reiser (1987) and Dohmann (1991) from the Bavarian Molasse, Batjes (1958) from Belgium and Sztrakos (1979, 1982, 1987) from the Eocene-Oligocene of Hungary. Many studies concerning the biostratigraphy of agglutinated foraminifers from principally the North Sea and the Carpathians are comparable with some assemblages from the alpine region (e.g. Gradstein & Berggren 1981, Gradstein et al. 1988, Geroch & Nowak 1983, Charnock & Jones 1990, Kaminski et al. 1988, 1990). In more southerly regions a number of Eocene-Oligocene foraminiferal studies derived from southern France, northern Italy and Spain have been well documented (e.g. Colom 1943, Le Calvez 1966, Butt 1966, Baumann & Roth 1969, Toumarkine & Bolli 1970, 1975, Campredon & Toumarkine 1972, Luterbacher 1975, Braga et al. 1975, Hillebrandt 1976, Jutson 1979, Grünig & Herb 1984, Grünig 1985, Coccioni 1988, Parisi & Coccioni 1987, Molina et al. 1988, Bellagamba & Coccioni 1990, Barbin & Grünig 1991, Mathelin & Sztrakos 1993). Detailed benthic foraminiferal studies including extinction ranges from the Atlantic Paleocene-Eocene include; Berggren (1974), Berggren & Aubert (1975, 1976), Aubert & Berggren (1976), Tjalsma & Lohmann (1983), Miller & Katz (1987) and for the Oligocene, Berggren & Aubert (1976) and Müller-Merz & Oberhänsli (1991). Important cosmopolitan studies on benthic foraminifers include Beckmann et al. (1981), Morkhoven et al. (1986) and Bolli et al. (1994).

1.5. Biostratigraphic framework

1.5.1 Biozonations

Well developed Paleogene biozonations for benthic foraminifers are rare due to their paleoecological limitations. However useful zonations by Gramann & von Daniels (1988) and von Daniels & Gramann (1988) were constructed for the northwestern region of Europe. Beckmann et al. (1981) suggested a benthic zonation based on material from the Caribbean and Atlantic. A Cainozoic benthic zonation for bathyal and abyssal forms derived from DSDP wells was also documented by Berggren & Miller (1989).

Planktonic foraminiferal zonations have never been constructed for the alpine region. Therefore, biostratigraphic studies are dependant on zonations defined from other regions. Rögl (1985) and Spiegler et al. (1988) proposed zonations for the Paratethys and northwestern part of Europe respectively. Valuable biozonations were developed in the Soviet Union, predominantly from Subbotina (1947, 1950, 1953) and Krasheninnikov (1969) derived from the Caucasus mountains. However, the standard planktonic foraminiferal zonations are generally derived from low latitude, subtropical regions e.g. Bolli (1957), Blow (1969, 1979), Berggren 1969, Postuma (1971), Premoli Silva & Bolli (1973), Stainforth et. al. (1975) etc. Correlation of these works was synthesised in Toumarkine & Luterbacher (1985) and Bolli & Saunders (1985) and, together with supplementary species ranges in Berggren (1977) and the recent biozonations of Berggren & Miller (1988) and Berggren et al. (1995), were used extensively in this study (Fig. 2). Jenkins (1985) also established a valid biozonation for southern mid-latitude planktonic foraminifers.

Unfortunately, foraminiferal zones are not always observed from alpine deposits due to the rarity of index species. It is well known that the same species may occur for different periods of time in different geographic areas depending on environmental conditions. Therefore, a careful use of extinction ranges of planktonic species, from the above mentioned biozonations and other biostratigraphic studies (see chapter 1), was needed in in order to define a correct biostratigraphy for this study.

1.5.2 Chronostratigraphy

Paleogene time scales have been proposed based on radiometric dates on magnetic polarity chrons (Cande & Kent 1992, 1995). The standard names for series and stages of the Paleogene follow Jenkins & Luterbacher (1994). The chronostratigraphic position of the Eocene-Oligocene boundary corresponding to 34 Ma (planktonic foraminiferal boundary of zones P17 and P18) has recently been defined by Premoli Silva & Jenkins (1993). Correlations of biostratigraphic datum events to magnetic polarity stratigraphy improves correlation of the standard magnetostratigraphic, biostratigraphic and chronostratigraphic boundaries. The time scale by Berggren et al. (1995). was adapted in this study (Fig. 2). Berger (1992, 1996) has correlated the recent Cande & Kent (1992, 1995) magnetostratigraphy and biostratigraphy to Swiss Molasse depositional events.

TIME (Ma)	POLARITY	EPOCH	AGE	PLANKTONIC FORAMINIFERA			Bolli 1957, 1966, Prem. & B. 1973	Stainforth et al. 1975	T. & L., B. & S. 1985	CALC. NANNO. Martini 1971
				B. & M. 1988	Berggren et al. 1995	Blow 1979				
24		OLIGOCENE	LATE CHATTIAN	P22	<i>Gl. ciperoensis</i>	N4		<i>G. kugleri</i>		
25							P22		<i>G. ciperoensis</i>	NP25
26										
27										
28				EARLY RUPELIAN	P21	<i>Gl. angulisuturalis-Pg. opima s.s.</i>	P21		<i>P. opima opima</i>	NP24
29						<i>Gl. angulisuturalis/Ch. cubensis</i>				
30					P20	<i>Gl. sellii</i>	P19/P20			NP23
31					P19	<i>T. ampliapertura</i>			<i>G. ampliapertura</i>	
32										
33					P18	<i>Ch. cubensis-Pseudohastigerina spp.</i>	P18		<i>C. chipolensis/P. micra</i>	NP22
34									NP21	
35			LATE PRIABON	P16	<i>T. curialensis/Cr. inflata T. cerroazulensis</i>	P16		<i>T. cerroazulensis</i>	NP19/20	
36										
37				P15	<i>Po. semiinvoluta</i>	P15		<i>P. semiinvoluta</i>	NP18	
38										
39			MIDDLE BARTONIAN	P14	<i>Tr. rohri-M. spinulosa</i>	P14		<i>T. rohri</i>	NP17	
40					P13	<i>Gb. beckmanni</i>	P13		<i>Gb. beckmanni</i>	
41										
42				P12	<i>M. lehneri</i>	P12		<i>M. lehneri</i>	NP16	
43										
44		EOCENE	LUTETIAN	P11	<i>Gb. kugleri/M. aragonensis</i>	P11		<i>G. subconglobata</i>	NP15	
45										c
46										b
47					P10	<i>H. nuttalli</i>	P10		<i>H. aragonensis</i> <i>H. nuttalli</i>	a
48									NP14	
49			EARLY YPRESIAN	P9	<i>Pt. palmerae-H. nuttalli</i>	P9	<i>P. palmerae</i>	<i>A. pentacamerata</i>		
50					P8		<i>M. aragonensis</i>	<i>M. arago</i>	<i>M. aragonensis</i>	NP13
51					P7	<i>M. aragonensis/M. formosa</i>	P8b		<i>M. formosa</i>	NP12
52										
53				P6	<i>M. formosa/M. lensiformis-M. aragonensis</i>	P8a		<i>M. subbotinae</i>	NP11	
54										
55				P6	<i>M. velascoensis-M. formosa/M. lensiformis</i>	P7			NP10	
56										
57				P5	<i>M. velascoensis</i>	P6		<i>M. velascoensis</i>	NP9	
58			LATE SELAND. THAN.	P4	<i>A. soldadoensis-Gl. pseudomenardii</i>	P4		<i>P. pseudomenardii</i>	NP8	
59										
60				P4	<i>Gl. pseudomenardii-A. subsphaerica</i>				NP6 NP7	
61										
62				P3	<i>Ig. albeari-Gl. pseudomenardii</i>	P3		<i>M. pusilla pusilla</i>	NP5	
63										
64			EARLY DANIAN	P3	<i>M. angulata-Ig. albeari</i>	P3		<i>M. angulata</i>	NP4	
65										
66				P2	<i>Pr. uncalata-M. angulata</i>	P2		<i>M. uncalata</i>		
67										
68				P1	<i>Gl. compressa-Pr. inconstans</i>	P1b		<i>S. trinidadensis</i>		
69										
70				P1	<i>S. triloculoides-Gl. compressa</i>	P1a		<i>S. pseudobulloides</i>	NP3	
71										
72					<i>P. rugubina-S. triloculoides</i>				NP2	
73									NP1	

Figure 2: Chronostratigraphic correlation of several foraminiferal biozonations (Modified after Berggren & Miller 1988, Berggren et al. 1995)

2. PALEOECOLOGICAL PARAMETERS

The environmental parameters that are interpreted here are principally (1) dissolved oxygen levels and (2) bathymetry. However, (3) salinity levels, (4) calcium carbonate and silica availability, (5) water temperature, (6) water energy and (7) substrate conditions are also regarded. Analysis of the environmental parameters is based mainly on the distribution patterns and functional morphology of benthonic and planktonic foraminifers at species, generic and order levels.

With the appearance of many new genera during the Paleogene, foraminifers from Alpine flysch deposits have a closer approximation to modern species and genera in comparison to those from older sedimentary deposits. Therefore, the distributions of modern benthonic foraminifers may provide analogues which may be used to reconstruct the depositional conditions of these Cainozoic sediments (Murray 1983). Ecological data on recent foraminifers may be interpreted for fossil forms. These interpretations will be more precise if analogies are made between forms at the lower taxonomic levels. However, it is often difficult to find fossil species which are the same as recent ones as faunas change with time. In cases where there are not even genera in common between fossil and recent faunas, the entire assemblage can be used as a comparison. The proportion of foraminiferal orders in an assemblage may also be of significant value and will be assessed in this study. In this study, the diversity of foraminiferal assemblages is measured by the Fisher α index, taking into account the number of species present among a certain number of individuals (Murray 1973, 1991) (Figure 3).

As stated by Boltovskoy et al. (1991), morphological trends have been studied more intensely relating to depth and, in decreasing order of frequency, salinity and temperature. However, changes in depth are inevitably accompanied by changes in several other intercalated parameters such as temperature, pressure, dissolved oxygen etc. and depth itself may be of little consequence. Therefore whilst using morphological traits it is important to remain prudent. It is the combination of morphological trends, analogies with modern forms, order proportions, planktonic-benthonic ratios, Fisher index values and general assemblage characteristics that allow an interpretation of the depositional environments. Calculations were made only where at least 100 specimens were picked.

2.1 Dissolved Oxygen Levels

Foraminiferal species diversities greater than α 5 are indicative of normal to high dissolved oxygen levels (Murray 1973). Well oxygenated environments contain diverse calcareous faunas which are characterised by large, thick shelled and ornamented foraminiferal species (Murray 1973, 1991, Boltovskoy & Wright 1976, Pflum & Frerichs 1976). The presence of infaunal, benthonic foraminiferal genera, such as *Lenticulina* and *Vaginulinopsis* may also indicate that levels of dissolved oxygen were normal to high. These forms are characterised by compressed, angulate tests which are adapted to 'slice' through well aerated sediment. The occurrence of a sparsely diverse foraminiferal assemblage, containing a few opportunistic species, is suggestive of a low oxygenated depositional environment. The absence of infaunal and the predominance of epifaunal foraminifers

may also indicate anaerobic (oxygen concentrations $<0.1\text{ml/L}$) conditions. A feature of modern oceans is the existence of an oxygen minimum zone (OMZ) at depths between 500-2000m as a result of biological processes of oxygen consumption (Southam et al. 1982). Basin-wide dysaerobic episodes occur as an expansion of the oxygen minimum layer which is particularly attractive for explaining mid-depth deposition of organic-rich sediments. Dynamics of anoxia are controlled by the interaction of oceanic circulation, biological activity and nutrient distribution. The level at which the oxygen minimum occurs is remarkably consistent, exceptions occurring where it is higher under regions of very high productivity such as the equator.

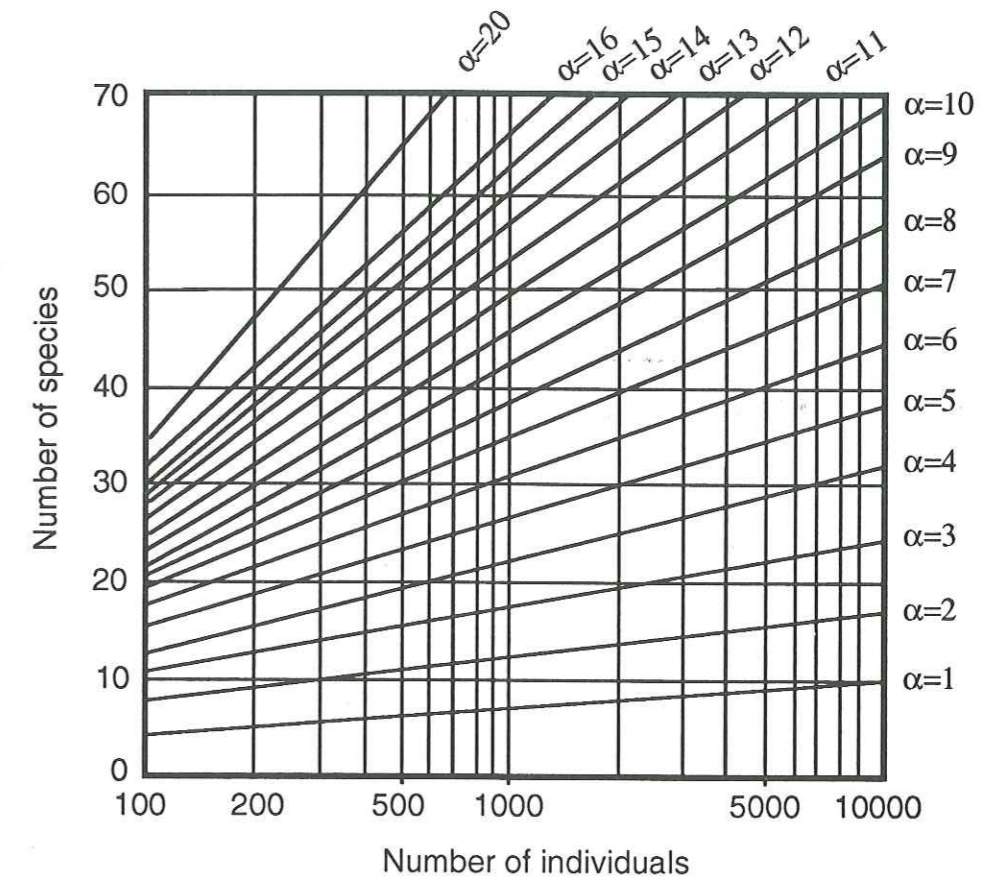


Figure 3: Graph illustrating the calculation of the Fisher index (α), taking into account no. of species and no. of specimens in a given assemblage (Murray 1973, 1991)

The levels of dissolved oxygen may also be deduced by the presence of certain foraminiferal genera. *Bulimina*, *Bolivina*, *Brizalina*, *Cyclammina*, *Haplophragmoides*, *Nonionella* and *Bathysiphon* are benthonic foraminifers which require little oxygen to survive (Boltovskoy & Wright 1976). Therefore, assemblages which consist predominantly of these genera may indicate low levels of dissolved oxygen.

Low foraminiferal species diversities could indicate a depositional environment restricted by stagnation of bottom waters or with shallowing (Haynes 1981). However, assemblages dominated by small (high surface to volume ratios), elongate, flattened uniserial to triserial benthonic foraminifers (i.e. *Bulimina*, *Bolivina*, *Brizalina*, *Cassidulina*, *Eponides* and *Fursenkoina*) most likely results from low oxygen conditions rather than shallowing (Bernhard 1986, Kaiho 1991, Sen Gupta

& Machain-Castillo 1993). OMZ faunas at around 1000m water depth consist mainly of elongate-conical species belonging to *Bulimina* (Ingle & Keller 1980).

Smooth-walled and non-ornamented (e.g. *Bulimina*, *Globobulimina* and *Chilostomella*) specimens require low amounts of oxygen. It has been commonly recognized that pores in the test wall of calcareous foraminifers act as conduits for gas exchange. It follows that foraminifers with large and numerous pores are strategically adapted for low oxygen environments (Perez-Cruz & Machain-Castillo 1990). However, Verhallen (1991) suggested that a porous internal passage or "central canal", like an entosolenian tube, helps gas exchange in anaerobic-tolerant, non-costate, smooth-walled species of *Bulimina* from Mediterranean Neogene sediments. *Uvigerina* despite its relatively thick-walled test also seems to prefer low oxygen (Boltovskoy et al. 1991).

Sediments in oxygen minimum zones support a low-diversity, high dominance foraminiferal fauna, typically with 2 to 3 species forming up to 80% of the foraminiferal assemblage. Generally a relatively small number of opportunistic species become conspicuously dominant in bathyal oxygen minimum zones. These species can utilize the trophic resource of increased organic loads generally associated with dysoxia (Sen Gupta & Machain-Castillo 1993). As most species are unable to tolerate low oxygen environments, the reduced competition allows a few adapted species to colonize this type of environment. Thus, high dominances of a few small, hyaline, thin-walled, unornamented species are typical of bathyal oxygen minimum zones (Sen Gupta & Machain-Castillo 1993).

Luterbacher (1984) studied Paleogene sediments from the southern Pyrenees and showed that large numbers of *Bulimina* were found only in turbidite facies where they occur mainly in the proximal facies at bathyal depths. Müller-Merz & Oberhänsli (1991) also recognized Eocene bathyal faunas containing high percentages of buliminids from the South Atlantic ocean. Quintero and Gardner (1987) also studied upper middle bathyal assemblages (500-1300m) from northern California, with well developed oxygen minima (<0.5 ml/L dissolved oxygen), which were characterised by high abundances of *Bolivina*, *Bulimina*, *Buliminella* and *Uvigerina*.

2.2 Salinity Levels

Foraminiferal species diversities greater than $\alpha 5$ are indicative of normal marine salinities (Murray 1973, 1991). The occurrence of a thick walled, calcareous fauna also suggests normal salinities (32-40 parts per thousand). The majority of foraminifers are adapted to normal marine salinities (about 35 ppt.) and it is in such conditions that the highest diversity assemblages are found (Brasier 1980). Tri-plots of the three types of foraminiferal test composition (calcareous hyaline, calcareous porcellaneous and agglutinated) provide information on salinity levels. Normal marine foraminiferal assemblages usually plot towards the calcareous hyaline corner (Murray 1973, 1991). Hyposaline (<32 parts per thousand) foraminiferal assemblages usually plot towards the agglutinated test corner (Murray 1973, 1991). The organic cement in the agglutinating foraminifers and their ability to build tests of siliceous grains means that they can live under hyposaline conditions in shallow water, estuarine environments (Haynes 1981). Hypersaline (>40 parts per thousand) assemblages are dominated by porcellaneous foraminifers (Murray 1973, 1991). Hypersaline and hyposaline conditions are characterised by low foraminiferal species diversities (Murray 1973, 1991).

However, the method can give misleading results when there has been selective post-mortem reworking, solution or disaggregation of tests (see Chapter 4).

Radiolarians and planktonic foraminifers occur, mostly in the upper few hundred metres of the water column, in all oceans of normal marine salinity (Boltovskoy & Wright 1976, Sanfilippo & Riedel 1985). Therefore, faunas which contain large numbers of radiolarians and planktonic foraminifers are also suggestive of normal marine salinities.

The foraminiferal genera occurring in this study which support normal salinity conditions are *Alabamina*, *Anomalinoidea*, *Bathysiphon*, *Bolivina*, *Cassidulina*, *Chilostomella*, *Cibicides*, *Cibicidoides*, *Cyclammina*, *Discorbis*, *Eponides*, *Fissurina*, *Fursenkoina*, *Gaudryina*, *Globobulimina*, *Globocassidulina*, *Haplophragmoides*, *Heterolepa*, *Hoeglundina*, *Lagena*, *Lenticulina*, *Melonis*, *Nonion*, *Nonionella*, *Nummulites*, *Pararotalia*, *Patellina*, *Planulina*, *Pullenia*, *Quinqueloculina*, *Recurvoides*, *Reophax*, *Saccamina*, *Textularia*, *Trifarina*, *Triloculina*, *Trochammina* and *Uvigerina* (Murray 1973, 1991, Boltovskoy & Wright 1976, Murray et al. 1989). *Bolivina*, *Bulimina*, *Cibicides*, *Globobulimina*, *Nonion* and *Quinqueloculina* can tolerate slight brackish environments (Murray et al. 1989).

Le Calvez & Le Calvez (1951) discovered that at lowered salinity various Nonionidae species show reduced test size. Many foraminiferal species become smaller, thin-walled and lose their ornamentation (Boltovskoy et al. 1991). However, small specimens may also be attributed to low oxygen levels. Some *Quinqueloculina* and *Triloculina* lose their pseudopodial activity when salinity is reduced to 30 parts per thousand or less. This would prevent these forms from colonizing hyposaline environments (Murray 1973).

2.3 Calcium carbonate and Silica Availability

Greiner (1974) showed that colder, less saline areas are characterized mostly by agglutinated faunas whereas temperate areas contain regular calcareous hyaline forms and low to high salinity tropical areas contain abundant miliolids. In recent seas, microfaunas dominantly composed of agglutinated species are characteristic both of marginal marine conditions and of deep-sea bottoms undersaturated in calcium carbonate (Haynes 1981). Few calcareous organisms occur at depths greater than 3000m. For this reason, agglutinated foraminifers dominate populations at abyssal depths. The presence of a highly diverse, thick walled calcareous foraminiferal assemblage indicates high levels of dissolved calcium carbonate. The occurrence of siliceous radiolarians, agglutinated foraminifers, sponge spicules and thin-walled calcareous species suggest that dissolved silica was readily available within the water column. Corliss (1979) whilst studying *Globocassidulina subglobosa* suggested that the high solubility of calcium carbonate at great depths is probably one of the factors responsible for the presence of only uniformly small-sized specimens.

2.4 Water Temperature and Water Energy

Temperature is one of the principal factors controlling depth zonation of foraminiferal species. However, it cannot be solely responsible for the depth zonation of foraminiferal species as the

individuals of certain species may live in waters of greatly differing temperature at the same depth (Boltovskoy & Wright 1976).

Planktonic foraminifers are also adapted to different oceanic layers of particular temperatures and densities (Frerichs et al. 1972). Forms adapted to cooler, denser water have fewer buoyancy problems and therefore lower test porosity than those from warmer or shallower waters. The latter improve their buoyancy with a high test porosity and prominent spines. In several planktonic species, warm and cool populations can be distinguished by a predominance of right-hand (dextral) or left-hand sinistral coiling (Bé 1977). Collins (1989) observed among *Bulimina* species that dextrally coiled specimens are strongly associated with warm temperatures but cold temperatures do not necessarily produce dominantly sinistral specimens. It appears that intra-specific morphological variability increases with increasing temperature (Boltovskoy et al. 1991).

Marine organisms living in zones of high, constant temperature are characterized by high species diversity (Boggs 1987). The quantity of available calcium carbonate is reduced in cool waters, prohibiting the construction of thick walled calcareous forms (Boltovskoy & Wright 1976). Therefore, the occurrence of siliceous radiolarians, sponge spicules and agglutinated foraminiferal species may suggest low water temperatures. A summary of foraminiferal genera, identified in this study, and their distribution related to temperature defined from modern studies by Murray (1973, 1991), Murray and Wright (1974), Boltovskoy & Wright (1976) and Haynes (1981) are illustrated in figure 4

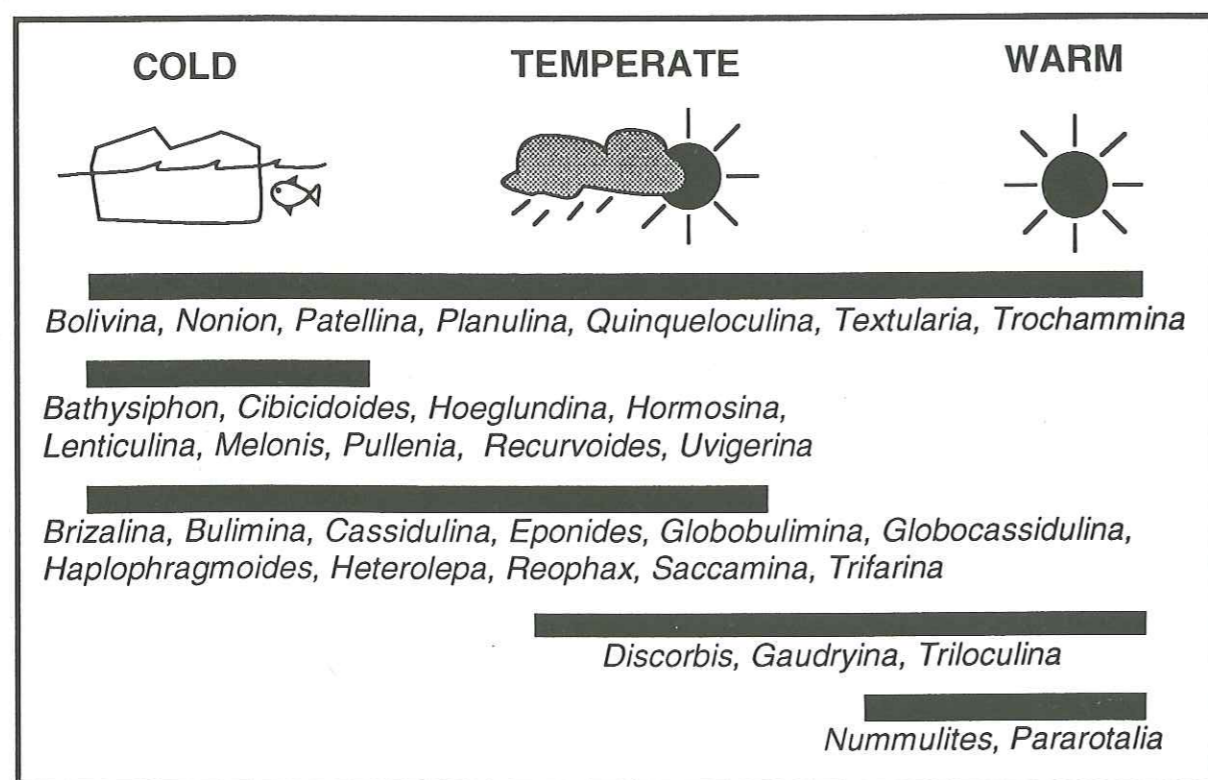


Figure 4: Distribution of modern foraminiferal genera according to temperature (Modified after Murray 1973, 1991, Boltovskoy & Wright 1976, Haynes 1981)

The presence of large agglutinated foraminifers and low species diversity indicates stagnant water conditions (Haynes 1981). The occurrence of sponge, bryozoan and echinoid material may also be suggestive of quiet and clear waters as sediment which is agitated by waves or currents can clog up the pores of these organisms (Boggs 1987). Larger (complex) foraminifers such as *Nummulites*, *Discocyclina* and *Operculina* are present in shallow water environments where light is readily available (Haynes 1981). Therefore, the absence of larger foraminifers at shallow water depths may indicate unclear waters, as sediment held in suspension greatly reduces light penetration.

Glaucinite formation occurs, by the precipitation of materials such as microfossils, in open marine environments at the sediment/water interface in clear and unturbulent waters (Odin & Matter 1981). When sediment rates are other than slow, sediment would be removed far too quickly to allow significant glauconitization (Ireland et al. 1983). Therefore, the high abundance of authigenic glauconite grains would suggest a low energy depositional environment.

2.5 Substrate conditions

The presence of silt, fine sand and glauconite indicate soft substrate conditions. The wall composition of agglutinated foraminifers may indicate the type of substrate conditions in the depositional environment. Finely agglutinated foraminifers indicate fine grained substrates. The abundance of infaunal lenticular or compressed shaped benthonic foraminifers also indicate a soft sediment substrate as these forms are required to 'slice' through sediment to obtain nutrients. Silty and muddy substrates are often rich in organic debris and the small pore spaces contain bacterial blooms. Such substrates are therefore attractive to foraminifers and support large populations. Many of these species are thin-shelled, delicate and elongate forms (Brasier 1980). The larger pore spaces and gravels contain few nutrients and therefore support sparser populations. Foraminifers from these substrates may be thicker-shelled and heavily ornamented.

Many modern examples of *Discorbis*, *Cibicides* and various Miliolidae (e.g. *Quinqueloculina* and *Triloculina*) live in association with seaweed, seagrass and calcareous algae (Murray and Wright 1974, Boltovskoy and Wright 1976). Some *Quinqueloculina*, *Patellina* and *Pararotalia* apparently graze on the unicellular algae and bacteria on seaweed and seagrass (Haynes 1981, Murray 1991). Seaweed and seagrass provide a habitat and a means of dispersal for these epibiotic foraminifers and can occur to depths of 150m (base of the photic zone) but are more common in the upper-most 50m of the water column. Therefore, the occurrence of *Cibicides*, *Quinqueloculina* and *Discorbis* may reflect a shallow water, vegetated substrate.

Planulina, *Patellina*, *Cibicidoides*, *Eponides*, *Gaudryina*, *Heterolepa*, *Textularia* and *Pararotalia* are epifaunal clinging forms and abundant on hard substrates (Murray 1991). The influence of substrate on the morphology of the test is particularly important in agglutinated and sedentary forms.

2.6 Bathymetry

Bathymetric models for Paleogene sediments are based on the comparison of upper and lower tolerance depth limits of recent foraminifers at order, genus and species level, analogous to Paleogene

forms. The value of these limits increases as the systematic hierarchy decreases. However, even at the order level, useful trends may be deciphered (Figure 5). This involves the analysis of foraminiferal distribution patterns, recurrent species associations and known bathymetric tolerances of living species. Bathymetric zonation terminology follows the model outlined by Ingle (1980) (Figure 5).

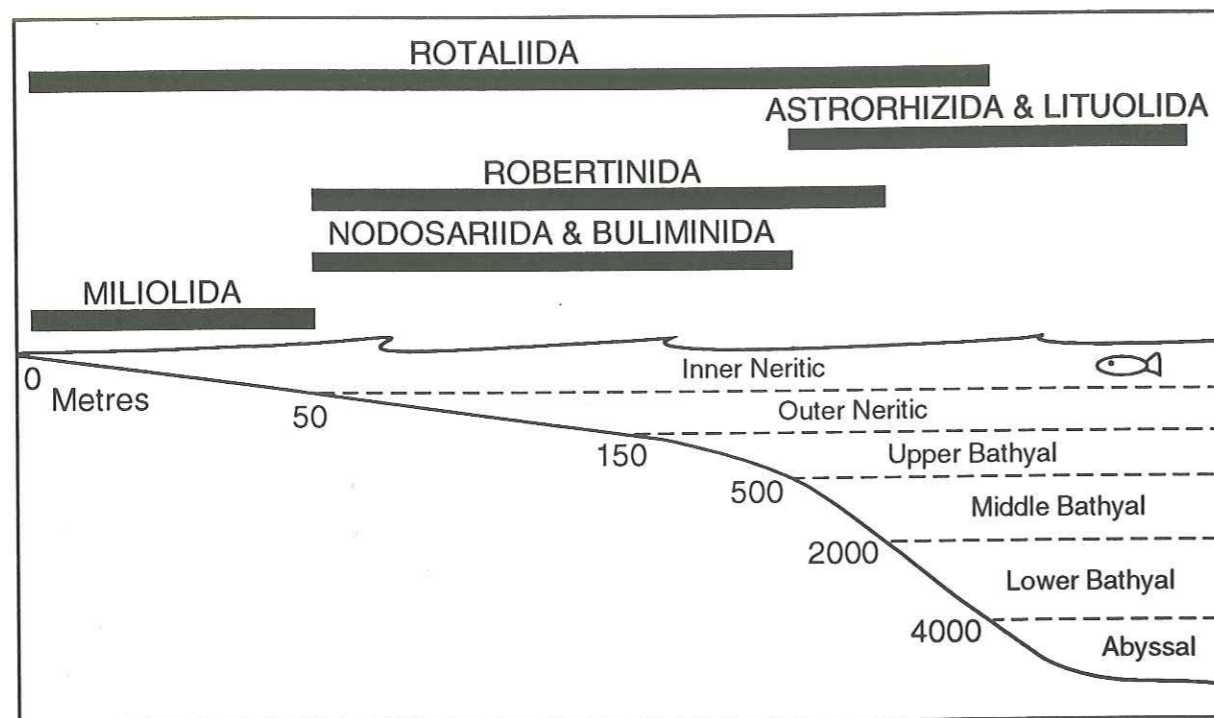


Figure 5: Broad modern bathymetric trends of benthic foraminifers at the order level, and bathymetric zonation (Modified after Boltovskoy & Wright 1976, Ingle 1980)

Foraminiferal number and diversity varies as a function of rate of reproduction and rate of sedimentation, with highest abundances generally associated with the neritic to bathyal transition where low rates of sedimentation, upwelling and high productivity combine to form an unusually rich benthonic habitat (Ingle 1980). It is assumed that diversity is highest in open marine conditions and decreases in environments restricted by stagnation of bottom waters or proximity to land, with shallowing (Haynes 1981) (Figure 6).

Numbers of radiolarians and planktonic foraminifers decline markedly in near-shore waters (Sanfilippo & Riedel 1985, Murray 1976). Murray (1976) concluded that assemblages in the inner shelf consist almost exclusively of juveniles, low species diversity, and <20% planktonics in the foraminiferal assemblage. In the middle shelf there is a high proportion of juveniles with only few species represented by adults, low diversity and a 10-60% planktonics in the foraminiferal assemblage. In outer shelf depths there is a wide range of sizes with juveniles and adults of some species, juveniles only of others, lower diversity than on the slope, and 40-70% planktonics in the foraminiferal assemblage. On the upper part of the continental slope, a wide range of sizes with juveniles and adults, maximum diversity and >70% planktonics in the foraminiferal assemblage (Figure 6). A maximum planktonic foraminiferal shell size that is less than 0.5mm usually indicates

water depths less than 50m. At depths greater than 100m, the maximum planktonic foraminiferal test size usually exceeds 1mm (Murray 1976) (Figure 6).

A slow increase in the percentage of planktonic foraminifers with increasing depth is found in inner shelves and coastal areas where slightly lowered salinity and increasing turbidity are present in the water mass. A very rapid increase in the percentage of planktonic foraminifers with increasing depth occurs in outer shelf areas as more open ocean water mass conditions begin to dominate. Downslope movement of sediments in areas of high energy water movements may result in significant low planktonic foraminiferal percentages. In areas of restricted open circulation, the planktonic foraminiferal percentages are considerably lower than those found in similar depths in open oceanic areas (Gibson 1989). Gibson (1988) also noted that whereas the percentage of planktonic foraminiferal tests generally shows a progressive increase across the shelf and down the slope, the number of species of benthic foraminifers may level off on the outer shelf and fluctuate on the slope.

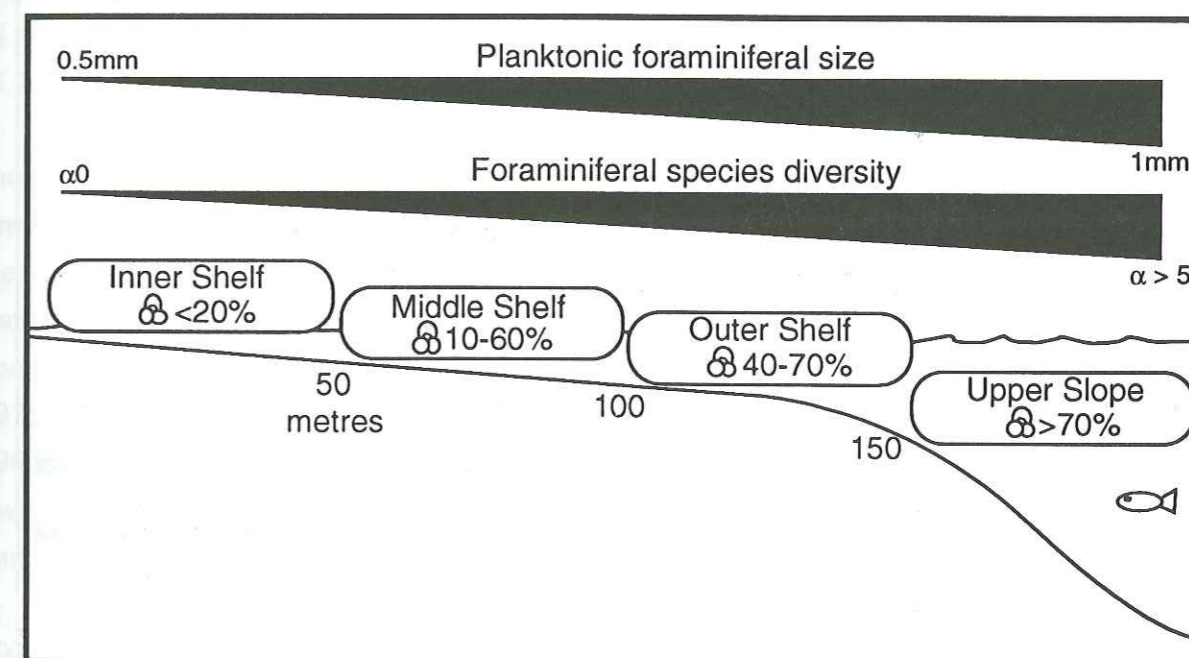


Figure 6: Bathymetric trends related to size and percentage of planktonic foraminifers and species diversity (Modified after Murray 1976).

Miliolids are exceptionally dominant in the inner neritic zone. *Quinqueloculina* forms are euryhaline (tolerate a large range of salinities), and are therefore dominant in shallow water estuaries, channels and bays. *Quinqueloculina* are much less common in outer neritic environments (Bandy 1960). Although *Triloculina* commonly occupy inner shelves, some bathyal cold species also occur. The presence of *Fissurina*, *Patellina* and *Lagena*, may suggest outer neritic depths (Murray 1973). The occurrence of *Discorbis* suggests depths less than 50m (Murray 1973). Rapid dissolution of aragonite occurs at depths greater than 200m (Boltovskoy and Wright 1976, Haynes 1981). Therefore the occurrence of well preserved *Hoeglundina* specimens would suggest outer neritic depths.

Pleurostomella occupies middle bathyal to abyssal depths (Figure 7). Grünig & Herb (1984) defined a *Pleurostomella*-dominated fauna to have occupied upper bathyal depths within Eocene sediments near Biaritz. *Gyroidinoides soldanii* is found below the shelf. Species of *Melonis* are restricted mainly to mid neritic and deeper zones. The upper and lower depth limits of several Paleogene benthic foraminiferal species, including *Heterolepa dutemplei* (100-600m), *Hanzawaia ammophila* (100-4000m), *Aragonia velascoensis* (200-2000m), *Hoeglundina elegans* (200-4000m), *Rzehakina epigona* (200-4000m), *Bulimina trinitatensis* (500-4000m), *Nuttallides truempyi* (500-4000m) and *Bulimina jarvisi* (1000-4000m) were described by van Morkhoven et al. (1986) and are used in this study.

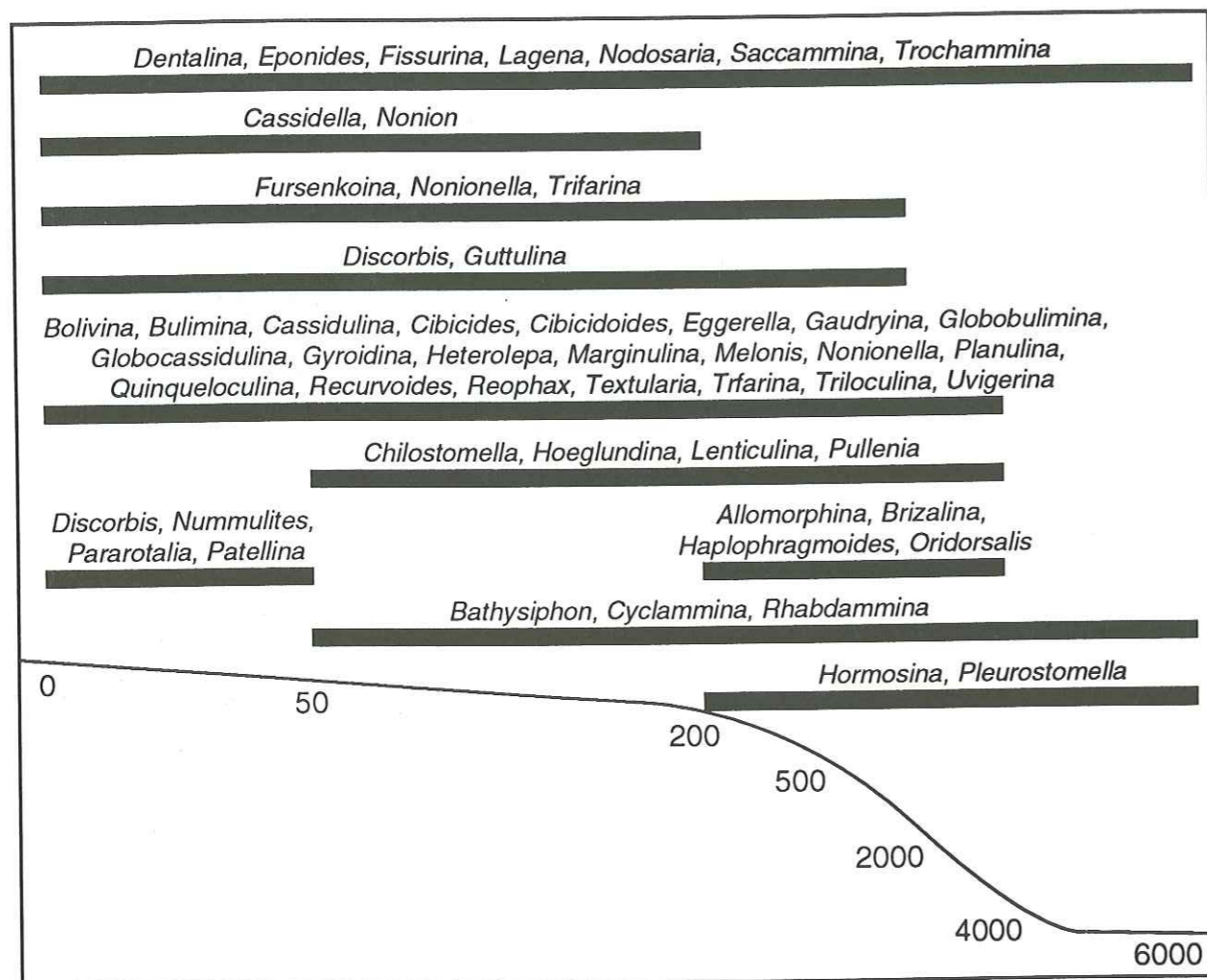


Figure 7: Bathymetric distribution of modern foraminiferal genera (Modified after Boltovskoy & Wright, Murray 1973, 1991).

Dominant genera in the upper bathyal zone are *Bolivina*, *Uvigerina*, *Cassidulina*, *Pleurostomella*, *Gyroidina*, *Chilostomella*, *Allomorphina*, *Pullenia*, *Bulimina*, several *Cibicides* and *Nonion* (Figure 7). Among the porcellaneous forms, *Pyrgo* is dominant and is represented by very large specimens. Agglutinated foraminifera form around 5% of the assemblage. The lower bathyal zone consists of *Bolivina*, *Uvigerina*, *Glomospira*, *Gyroidina*, *Pullenia*, *Trochammina*, *Planulina*,

some *Cibicides*, *Nonion*, numerous *Fissurina* and *Lagena*. Principal traits of the benthonic assemblages of abyssal zone deeper than 3000-3500m are that the specimens are large but not abundant and are characterised by simply constructed forms including *Rhabdammina*, *Bathysiphon*, *Reophax*, *Hormosina*, *Haplophragmoides* and *Cyclammina* (Boltovskoy & Wright 1976). (Figure 7). Agglutinated foraminifera dominate the benthonic population in the bathyal zone (150-4000m) as other organisms are unable to secrete calcite (Boltovskoy & Wright 1976). Assemblages derived from flysch sediments that are composed entirely of agglutinated foraminifera are often referred to as "*Rhabdammina* type" faunas which are thought to indicate below CCD deposition (Brower 1965). However, Moorkens (1975) suggested that the amount of decaying organic matter, pH values and Eh values of the sediment also play an important role in determining the composition of the agglutinated assemblages (see Chapter 5 for further discussion). *Cyclammina* is identified with the bathyal zone throughout modern oceans (Bandy 1960). However, McNeil (1988) recognized a species of *Cyclammina* in lower to outer neritic (50 m-150m) environments from an Eocene Formation in Arctic Canada. He recorded that the complexity of the test of this species increased from the base to the top of the outer neritic zone. Boltovskoy & Wright (1976) and Murray (1973) suggest upper depth limits of 70m for *Cyclammina* and *Bathysiphon* and 50m for *Gaudryina* (Figure 7).

Pullenia quinqueloba, *Hoeglundina*, *Melonis*, *Gyroidinoides*, *Alabamina* and *Buliminids* show morphological trends when traced from neritic to bathyal waters (Bandy 1960, Plum & Frerichs 1976, Haynes 1981). The degree of inflation and size of the test varies according to depth. Generally, the size and degree of inflation of the test, increases with depth for these foraminifera. Large, inflated specimens of *Pullenia quinqueloba* are found in the bathyal zone and small, compressed forms are usually located in the outer neritic zone (Bandy 1960, Plum and Frerichs 1976). *Cibicides* develops deflected sutures and *Eponides* decreases in size with deepening (Bandy 1960). *Bolivina* specimens lose prominent ornamentation with increases in depth. *Chilostomella ovoidea* increase in size with an increase in depth (Bandy 1963). *Uvigerina eocaena* decrease their number of costae or their height with an increase in depth (Grünig 1984).

Glaucinite accumulates in modern seas between 75 and 500m, and mostly between 100 and 200m (Odin & Stephan 1982). Optimum glaucinitization conditions occur in open marine, outer neritic environments beyond the zone of fluvial influence where sedimentation rates are slow (Odin & Matter 1981).

3. RESULTS FROM STUDIED SECTIONS

Each section is described in the following order; locality, previous studies, lithostratigraphy, biostratigraphy (distribution of microfossils and foraminifers) and paleoecology. Figures for sections indicate lithologies, sample positions and sedimentary features, and chart the distribution of foraminiferal species and microfossil elements. The previous studies cited, concern only studies related to the described section. Studies on correlated sediments are outlined in chapter 1. Biostratigraphic and paleoecologic interpretations were defined using the criteria assessed in chapters 1.5 and 2.

VOIRONS MASSIF

3.1 Bellevue

Locality

This section is situated 20km southeast of Geneva in the Voirons massif along the D183 road from la Bergue to les Hivernanches, Haute-Savoie, France (coord: 908, 100-140, 950, alt. 980m).

Previous studies

The Bellevue exposure was first studied by Lombard (1937) who focused on the petrography of the sandstones and conglomerates and suggested a Priabonian age from the occurrence of *Nummulites fabiani* in thin section. Vuagnat (1943) recognized volcanic fragments which are attributed to the Val d'Ille Formation. Lombard & Vernet (1964) suggested that the Bellevue section represents a tectonic slice. Carletti (1987) found foraminifers (det. R. Wernli) from one washed sample which was dominated by *G. officinalis*, indicative of a middle Eocene to early Oligocene age. Wernli (in Kerrien et al. 1996) for the explication note of the French regional 1:50000 Annemasse map, observed an early-middle Oligocene foraminiferal assemblage, consisting of *G. gr. praebulloides*, *G. ciproensis ciproensis*, *G. officinalis*, *G. ouachitaensis gnaucki* and *G. ampliapertura*. Carletti (1987), like Weidmann et al. (1982) and Lateltin (1988), also suggested that the Val d'Ille Formation was deposited below the wave-base but further recognized deltaic sedimentation.

Lithostratigraphy

Lateltin (1988) subdivided the Val d'Ille Formation into three members: (1) the "Marnes laminées" which consist of grey shales with rare silt or sandstone laminae of millimetric to centimetric scale, (2) the "Schistes marno-micacés" which are composed of intercalations of centimetric and decimetric-scale fine sandstones and silty marls, and (3) the Val d'Ille Sandstones which include decimetric to plurimetric-scale beds of sandstones and conglomerates. Fine grained sandstones are often laminated and possess a large proportion of calcitic matrix in comparison to the percentage of quartz and feldspar grains. They seem to be poor in volcanic material. In contrast,

the coarser grained sandstones and conglomerates possess a relatively small proportion of matrix and contain characteristic radiolarite, limestone, andesite and ophiolite fragments whose origin remains controversial (Homewood & Caron 1982, Vuagnat 1983, Lateltin 1988, Caron *et al.* 1989). Thermoluminescence analysis of quartz grains suggests that the terrigenous components of the Val d'Ille sandstones have been altered by alpine metamorphism (Ivaldi 1989). Sediment residues from shaly samples contain abundant mica and calcite fragments, frequent skeletal material, and rare quartz grains.

Biostratigraphy

Distribution of microfossils

Foraminifers are abundant throughout the section. Planktonic foraminifers form between 46-97% of the foraminiferal assemblages within the lower shaly interval (Figure 8). From the uppermost part of the section, in sample UB50, planktonic foraminifers form 14% of the foraminiferal assemblage (Figure 9). Pteropods pertaining to the genus *Limacina*, were found rarely to commonly throughout these sediments. Rare occurrences of echinoid debris, probably reworked, were also observed throughout. Rare to frequent, sporadic occurrences of ostracods, sponge spicules, gastropods, and bivalve, bryozoan and fish debris were retrieved within this section (Figures 8 & 9).

Nannofossil assemblages from sample UB15, containing *Criboecium reticulatum*, were attributed to the NP16-NP18 zones (corresponding to the P12-P15 planktonic foraminiferal zones). Sample UB50 also was attributed to the NP18 zone on the presence of *Chiasmolithus oamaruensis* and absence of *Isthmolithus recurvus* (equivalent to the P15 planktonic foraminiferal zone).

Dinocyst assemblages in sample UB1 consist of reworked Cretaceous forms (*Odontochitina* spp., *Diconodinium* spp., *Chatangiella* spp.), but predominantly of middle Eocene-early Oligocene forms (*Areosphaeridium pectiniforme*, *Phthanoperidinium comatum*, *Cordosphaeridium gracilis* and *Deflandrea phosphoritica*). The presence of *Slowakipollis hippophaeides* (Oligocene) remains dubious. Sample UB4 hosts middle Eocene forms including *P.comatum*, *C.gracilis*, *D.phosphoritica* and *A.diktyoplokus*. The latter species indicates the latest most Eocene. Sample UB8 contains Jurassic forms (*Ctenidodinium ornatum*). However, the presence of *Areoligera senonensis*, *A.pectiniforme*, *Dapsilidinium* sp. cf. *D.pastielsi*, *P.comatum*, *C.gracilis*, *D.phosphoritica* and *T.filosa* indicates a middle to late Eocene age. Sample UB14 is composed of reworked Cretaceous forms and an association which indicates the middle to late Eocene and perhaps early Oligocene, although no form limited to only the Oligocene was determined. Palynofacies counts from samples UB1, UB4, UB8 and UB14 indicate a distal, oxidising environment.

Distribution of foraminifers

Globigerinids are the most dominant group throughout the section. Rotaliids are also common whilst nodosariids, astrorhizids, lituolids, buliminids and robertinids are frequent to rare. Miliolids are common in UB11 and probably represent a turbiditic influx of reworked shelf

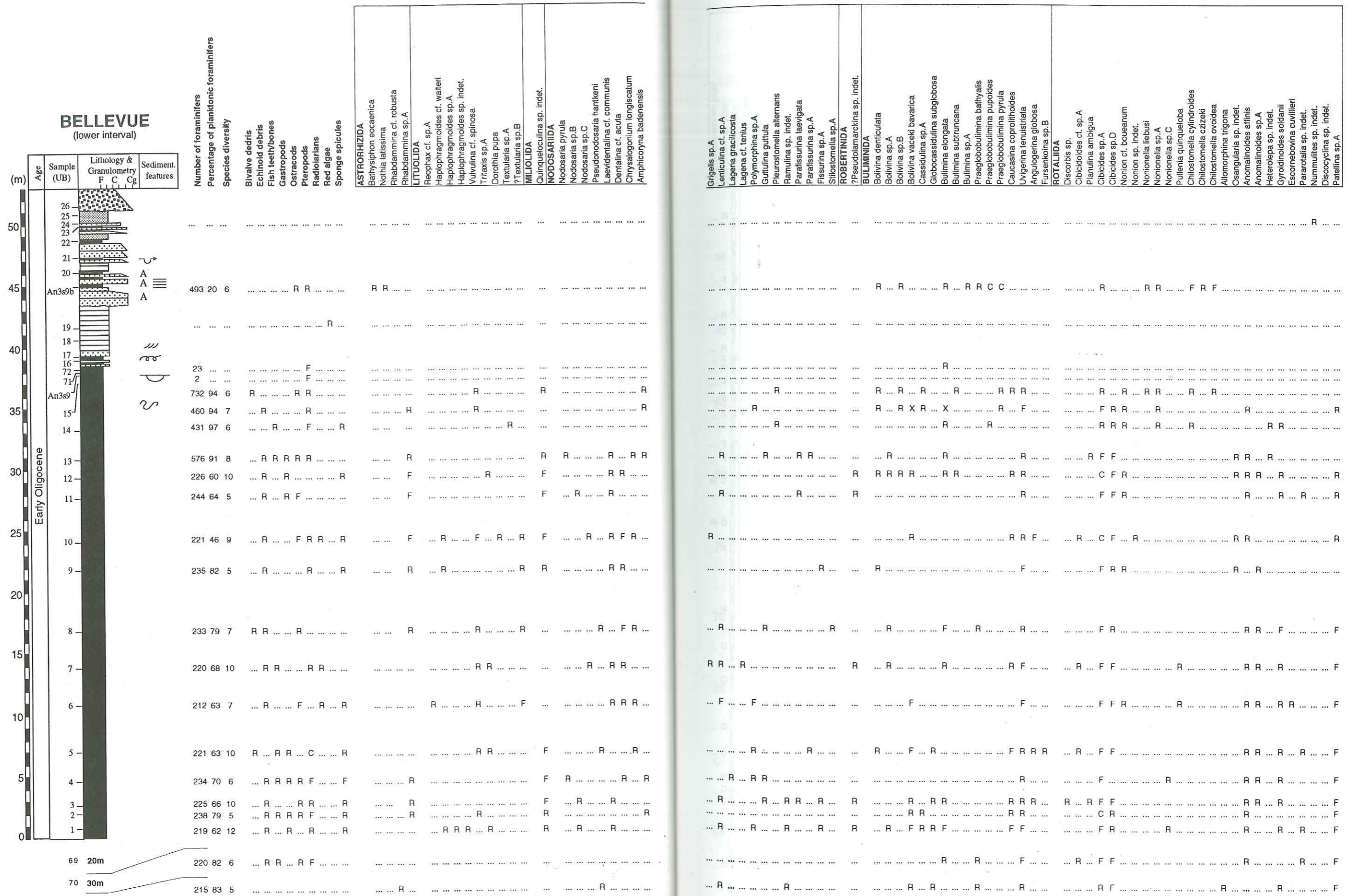


Figure 8: Lithological log of the lowermost part of the Bellevue section with foraminiferal species distributions

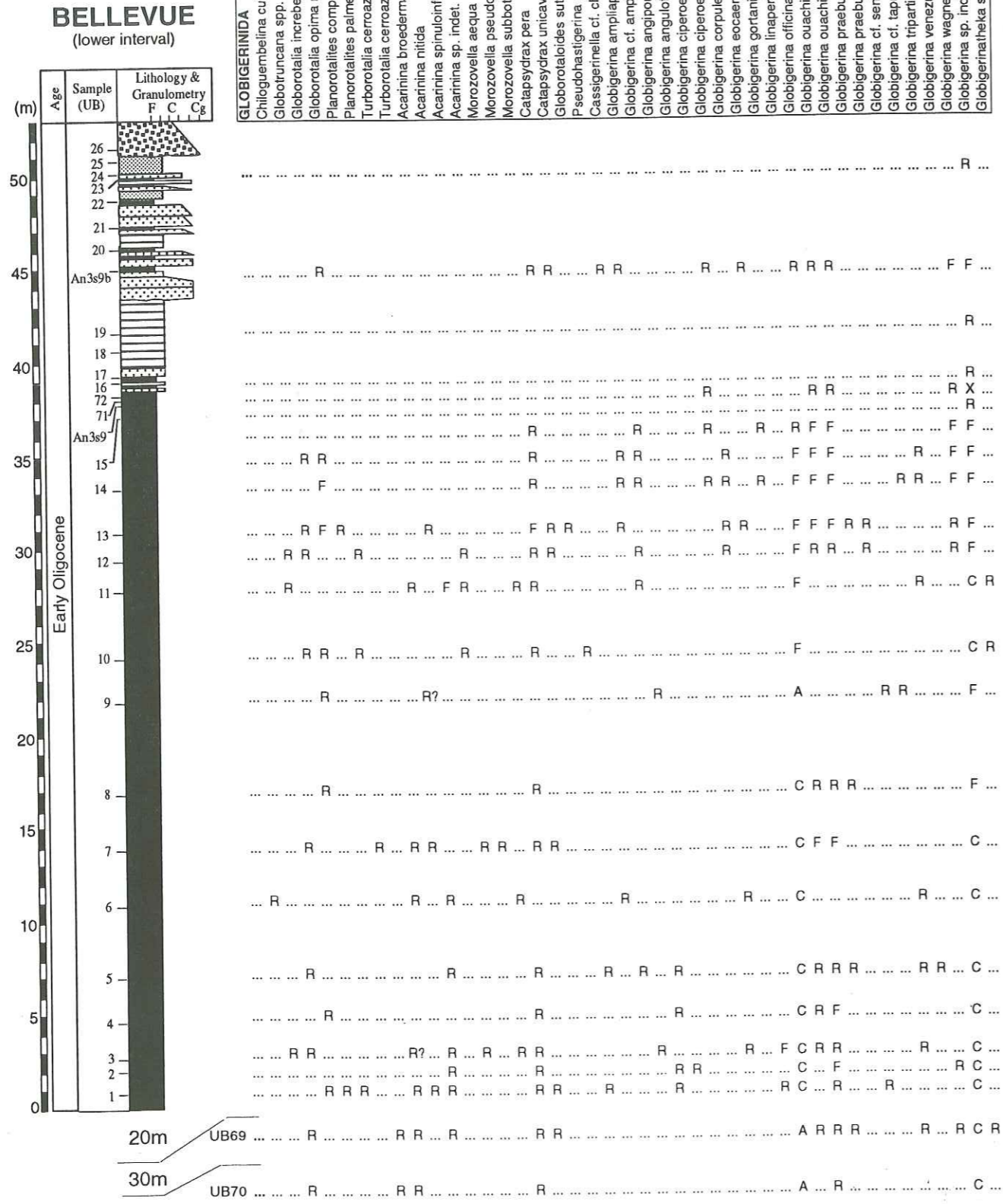


Figure 8 (Continued): Lithological log of the lowermost part of the Bellevue section with foraminiferal species distributions

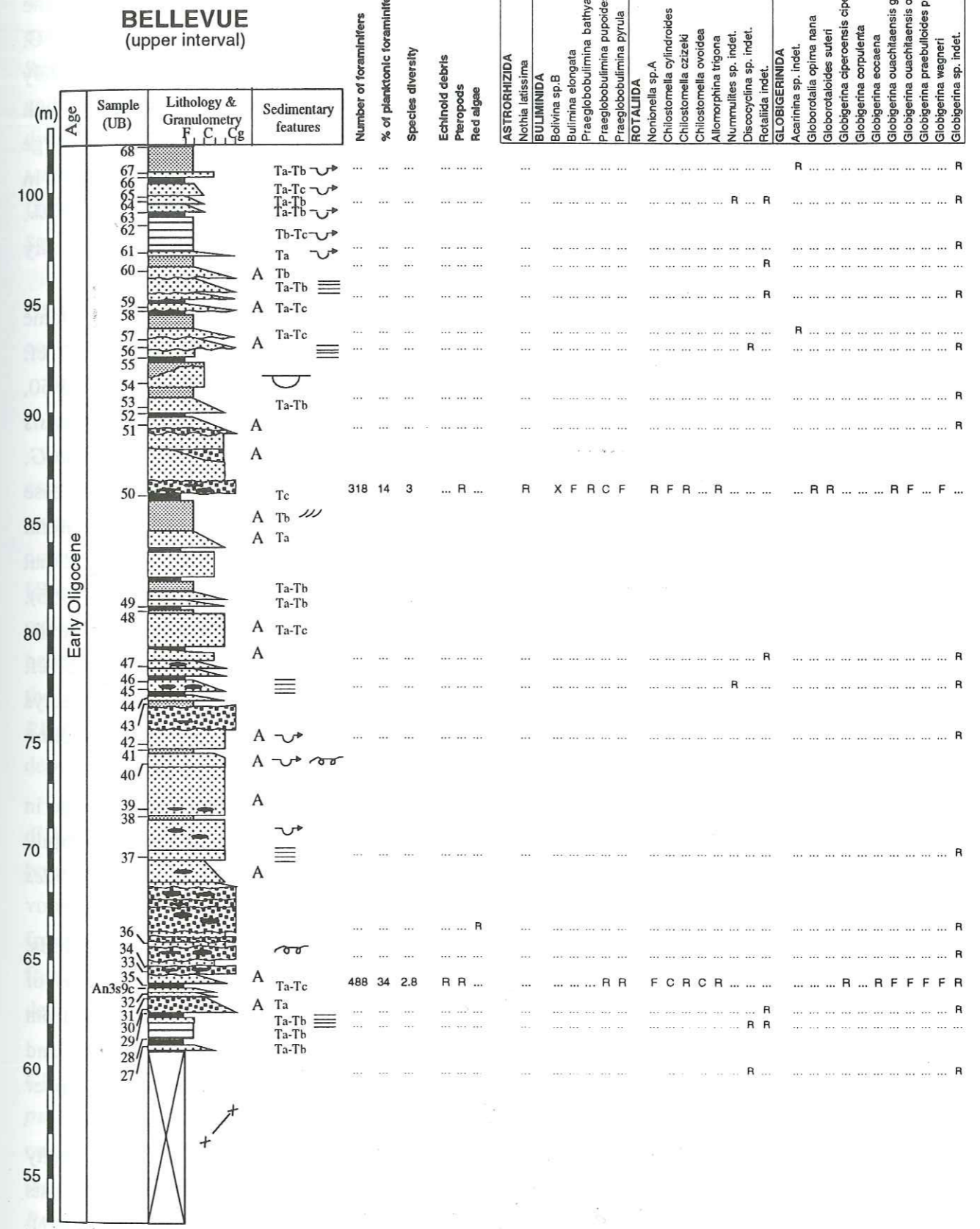


Figure 9: Lithological log of the uppermost part of the Bellevue section with foraminiferal species distributions

sediment. Buliminids are abundant in UB50 and An3s9b. Rotaliids are abundant in An3s9c. The foraminiferal assemblages from the Bellevue section are predominantly composed of small and stratigraphically long ranging Paleogene *Globigerina*, *Globorotalia* and *Catapsydrax* species. The frequent occurrence of long ranging species (*G. officinalis*, *G. eoacena*, *G. corpulenta*, *G. tripartita*, *G. gr. praebulloides*, *G. opima nana*, *C. pera*) emphasizes the difficulties in accurately dating Paleogene sediments. Some of these taxa exist throughout the Eocene and continue through to the end of the Oligocene. *G. officinalis* is the most common species which was found in large proportions in all samples throughout the Bellevue section. The percentage of planktonic forms in foraminiferal assemblages from samples UB13, UB14 and UB15 are high, exceeding 80%. Planktonic foraminifers from these samples are also distinctly larger in comparison to partially reworked assemblages in underlying horizons (UB1-UB12).

Sediments throughout the Bellevue section are attributed to the *G. ampliapertura* planktonic foraminiferal P18-P20 zones. This age is determined by the concurrent occurrence of *C. cf. chipolensis*, *G. wagneri*, *G. ouachitaensis gnaucki* and *G. ampliapertura* in sample UB50, positioned near the top of the section, within the Val d'Illez Sandstones. *G. ciproensis ciproensis*, *G. wagneri*, *G. ouachitaensis gnaucki*, *G. ouachitaensis ouachitaensis* and *G. ampliapertura* were also recovered from the uppermost part of the lower shaly interval at the base of the section confining these and overlying sediments to the P19-P20 planktonic foraminiferal zones (Figures 8 & 9). That is, the lowermost part of the middle Oligocene. It should be noted that this foraminiferal zone is considered as the base of the early Oligocene by Berggren et al. (1995). The basal part of the lower interval is also confined to the early Oligocene (P18-P19 planktonic foraminiferal zones) based on *G. wagneri*, *G. gr. ouachitaensis*, *G. angulofficinalis*, *C. cf. chipolensis*, *G. angiporoides* and *G. increbescens*. The frequent occurrence of Oligocene Paratethys benthic species including, *Angulogerina globosa*, *Caucasina coprolithoides*, *Bulimina elongata*, *Praeglobobulimina pyrula* and *Praeglobobulimina pupoides* also suggests an Oligocene age.

Benthic foraminifers represent a small percentage of the total foraminiferal assemblage in samples UB13, UB14 and UB15, which were taken from the uppermost 10 metres of the thinly bedded shales. *Uvigerina*, *Bolivina*, *Bulimina*, *Praeglobobulimina*, *Chilostomella* and *Cibicides* commonly occur in these samples.

In shaly horizons within the Val d'Illez Sandstones, rare and poorly preserved rotaliids, miliolids and textulariids were recovered. Poorly preserved, fragmented rare specimens of *Nummulites* (UB24, UB45, UB64) and *Discocyclina* (UB27, UB30, UB56) were identified from coarse sandstone and conglomerate beds thin sections. Small unidentifiable globigerinids and rotaliids were frequently observed within the sandstones and microconglomerates of the upper interval.

Sample UB50 and An3s9c contains a rich benthic foraminiferal assemblage of low diversity ($\alpha 3$). Specimens are pyritised and well preserved, suggesting the absence of reworking. Most tests have been partly removed probably as a result of post-depositional dissolution (see Chapter 7). Further, the absence of pre-Oligocene planktonic foraminifers in these samples suggests that the benthic foraminifers have not been reworked. *Bulimina elongata*, *Praeglobobulimina pupoides*,

Chilostomella cylindroides and *Nonionella* sp.A were retrieved from this residue. *Praeglobobulimina pupoides* specimens represent approximately 90% of the entire foraminiferal assemblage from UB50 (Figure 9). These specimens are small, smooth-walled and non-ornamented. The lowermost shales (UB69-70, UB1-UB12) contain rich benthic associations. Species diversity varies from $\alpha 5-12$. There is significant reworking present within these sediments and therefore it is difficult to assess the exact nature of the benthic assemblages in terms of diversity. *Rhabdammina* sp.A, *Vulvulina cf. spinosa*, *Bolivina vacekibavarica*, *Uvigerina tenuistriata*, *Cibicides* sp.A, *Cibicides* sp.D, *Anomalinoidea affinis*, *Patellina* sp.A and *Gyroidinoides soldanii* are rarely to frequently present throughout this part of the section (Figure 8).

Foraminiferal assemblages from the upper part of the thinly bedded shales (UB13, UB14, UB15, An3s9 and An3s9b) show relatively high foraminiferal species diversities ($\alpha 5.5-7.5$) in comparison to sample UB50 ($\alpha 3$) from the upper Val d'Illez Sandstones interval (Figures 8 & 9).

Paleoecology

The lowerpart of the section contains significant reworking, as identified in the planktonic assemblages, and therefore only the upper part of the lower shaly interval was used for paleoecological analysis (Ujetz et al. 1994). The high foraminiferal species diversities occurring in assemblages from the upper part of the lower shaly interval (samples UB13, UB14, An3s9 and UB15) are indicative of open marine conditions with normal levels of salinity (32-37‰) and oxygen (>1ml/l). Further, the high percentage (>80%) of large planktonic foraminifers in the thinly bedded shales interval supports open marine conditions with normal salinity and oxygen levels in the upper bathyal zone. The presence of *Uvigerina tenuistriata*, *Pleurostomella alternans*, *Rhabdammina cf. robusta*, *Chilostomella ovoidea* and *Chilostomella cylindroides* suggests that deposition most probably occurred in upper bathyal depths.

The low foraminiferal species diversity ($\alpha 3$) recorded from sample UB50 in the upper Val d'Illez Sandstones interval could indicate a depositional environment restricted by stagnation of bottom waters or with shallowing (Figure 9). However, the presence of small (high surface to volume ratios), elongate uniserial to triserial benthic foraminifers in this sample most likely results from low oxygen conditions rather than shallowing. Also the presence of large planktonic foraminifers, which occupied the water column overlying OMZ, further suggests the possibility of a deep marine environment.

The frequent occurrence of smooth-walled, non-ornamented specimens, including *Chilostomella cylindroides*, *Bulimina elongata*, *Praeglobobulimina pyrula* and *Praeglobobulimina pupoides*, from samples An3s9b, An3s9c and UB50 also demonstrates a low oxygenated environment. The low species diversity, high dominance foraminiferal fauna, forming up to 80% of the foraminiferal assemblage is typical of a modern bathyal, OMZ fauna. Rarer occurrences of *Bolivina*, *Uvigerina* and *Nonionella* further support middle bathyal, dysaerobic deposition. In addition, the presence of *Nonionella* indicates normal marine salinity. Palynofacies counts from samples UB1, UB4, UB8 and UB14, revealed distal water sedimentation.

Reduced bottom water supply has also been recorded in the North Atlantic during the middle Oligocene (Miller & Katz 1987). Low oxygen Paleogene events occurred coincidentally with episodes of oceanic warming and sluggish deep-sea circulation (Kaiho 1991). The presence of *G. ciproensis ciproensis* within the Bellevue section may indicate oceanic warming, or at least warm surface waters at the time of deposition (Spezzaferri & Premoli Silva 1991). Dohmann (1991) recorded a similar low oxygenated, middle bathyal, foraminiferal assemblage consisting of *Chilostomella*, *Bulimina* and *Praeglobobulimina* species in lower Oligocene sediments from the Bavarian region of the Molasse Basin. Rögl (*pers. comm.* 1993) has also recorded similar assemblages within thick dysaerobic shales from the Austrian Molasse Basin and western region of the Carpathian arc. These sediments may be correlated with the Val d'Iliez Formation at Bellevue, indicating that a low oxygenated deep sea also existed in the southwestern corner of the North Alpine foreland basin during the early-middle Oligocene.

3.2 Bons

Locality

Situated about 20km northeast of Geneva and 1.5km from Bons on the D20 road, in the Voirons massif, Chablais Prealps, Haute-Savoie, France (Figure 1).

Previous studies

Lombard (1940) observed specimens of *Nummulites*, *Discocyclina*, *Asterodiscus* and *Assilina* from 2 samples within the lower part of the section. He concluded that this section represents the middle and upper parts of the Voirons massif which were deposited in a shallow, littoral environment during the Thanetian to Lutetian and perhaps the base of the Priabonian. Frequent observations of current changes suggested that reworking of fossils could not be excluded. This section, attributed to the Voirons Sandstones, was determined as latest Paleocene-earliest Eocene based on a *Wetziella homomorpha* association which is equivalent to the P5-P6 planktonic foraminiferal zones (Jan du Chêne et al. 1975).

Lithostratigraphy

The lower part of the section is predominantly composed of coarse grained sandstones which display groove casts and trace fossils under their basal surfaces. These thick, quartz rich sandstone beds are up to 2m thick and are intercalated by very thin shaly intervals (Figure 10). The beds are often laminated, amalgamated and show thinning up and thickening up trends. The upper part of the section consists generally of thin sandstone beds of centimetric scale which form thickening up sequences. The thin sandstones are intercalated by thin shaly horizons. Shales are the dominant lithology in the upper part of the section.

Sediment residues consist predominantly of mica and calcite, rare quartz grains and rare skeletal material. Irregular shaped calcite fragments are frequent. Glauconite and wood fragments are also very rarely retrieved from the residues.

Biostratigraphy

Distribution of microfossils

Foraminifers are generally moderately well preserved and rare to frequent throughout the section except for samples UCB3 and UCB18 where they are abundant. Autochthonous foraminiferal tests are generally well preserved and ferruginised in contrast to reworked tests which are white and poorly preserved. Pyritised diatoms, fish teeth, radiolarians, echinoid debris and ostracods are rarely and sporadically distributed within the section.

Nannofossil assemblages from UCB3 and UCB23 contain *Lophodolichus nascens*, *Discoaster multiradiatus*, *D. barbadiensis*, *D. binodosus* and *Chiasmolithus bidens* and are attributed to the early Eocene NP10 zone, equivalent to the P6 planktonic foraminiferal zone. Dinocyst assemblages from UCB3 and UCB23 were attributed to the early Eocene based on the occurrences of *Apectodinium homomorphum*, *A. quinquelatum*, *Adnatosphaeridium membraniphorum*, *A. multispinosum*, *Deflandrea phosphoritica* and *Areoligera gr. sentosa*.

Distribution of foraminifers

Samples UCB3 and UCB18, containing rich foraminiferal assemblages, are predominantly composed of globigerinids. Sample UCB20 consists mainly of astrorrhizids. Globigerinids and rotaliids are frequent. Planktonic foraminifers for these samples form 73-86% of the foraminiferal assemblages (Figure 10). Astrorrhizids are the largest component, whilst lituolids, rotaliids, nodosariids are frequent within the benthic assemblage of sample UCB18. The benthic population within UCB3 consists predominantly of poorly preserved, probably reworked, rotaliid specimens pertaining to *?Osangularia* sp. indet. *Glomospira charoides*, *Cibicides* sp.A, and *Annomalinoidea affinis* are also rarely to commonly found more or less throughout the section. Frequent to common occurrences of *Ammodiscus cretacea* and *Haplophragmoides* sp.A were derived from the lower part of the section and *Rhabdammina* cf. *robusta*, *Laevidentalina* cf. *communis*, *Arenobulimina* sp.A, *Recurvoidea* sp.A, *Trochamminoides irregularis* and *Cibicoides* sp.A from the upper part of the section. Sandstone beds contain rare skeletal material, consisting of rare specimens of *Discocyclina*, *Nummulites*, small rotaliids, *M. subbotinae*, *G. velascoensis* and *G.* sp. indet (Figure 10).

Globigerina linaperta occurs rarely to commonly throughout the section whilst frequent occurrences of *M. subbotinae*, *G. velascoensis*, *G.* cf. *senni*, *G. hagni* and *G. venezuelana* were also observed. Although the assemblages are dominated by early Eocene foraminifers such as *M. subbotinae* and *G. velascoensis*, the occurrence of *G. venezuelana*, *C. dissimilis*, *G. hagni* and *C. pera*, *C. unicava primitiva*, *G.* cf. *pseudoampliapertura*, *A. pentacamerata*, *M. spinulosa*, *T. cerroazulensis frontosa*, *G.* cf. *mexicana mexicana* and *G.* gr. *subconglobata* suggest at least a middle Eocene age, equivalent to the P11-P12 planktonic foraminiferal zones (Figure 10).

Paleoecology

The high percentage of planktonic foraminifers, high foraminiferal species diversity ($\alpha 5.75$), occurrence of *Bathysiphon eocaenica*, *Pleurostomella* sp.A and *Praeglobobulimina ?bathyalis* suggests an open marine, well oxygenated, bathyal environment (Figure 10).

Furthermore, the presence of *Nuttallides truempyi* indicates lower bathyal depths. The presence of *Pararotalia* sp. indet. from one sample demonstrates shelf to slope reworking.

3.3 Chauffemerande

Locality

The studied outcrop lies within a stream, frequently covered by vegetation, off the D220a road between Sardagne and Boège (coord: 912, 300-137, 500) near Chauffemerande in the Voirons massif, Haute-Savoie, France (Figure 1).

Previous studies

These sediments were defined as belonging to the Boège marls based on lithology and biostratigraphy (Van Stuijvenberg & Jan du Chêne 1981). These authors observed a *Rhombodinium perforatum* dinocyst association and nannofossil assemblages attributed to the NP18 zone. This corresponds to the P15 planktonic foraminiferal zone at the base of the late Eocene.

Lithostratigraphy

The outcrop lithology is similar to that at Saxel. Samples were derived from a thick sequence of Boège marls which outcrops for several 10's of metres and predominantly consists of shales intercalated by occasional thin beds of sandstone and overlies the Vouan Conglomerates (Figure 11). Residues consist of mica, calcite rich lithoclasts. Grains of quartz, pyrite and glauconite were rarely to frequently observed from the washed sediment fractions. Skeletal material is rare.

Biostratigraphy

Distribution of microfossils

Assemblages within the lowermost and uppermost parts of the section, are rich in foraminifers. Planktonic to benthonic ratios are high, ranging between 50-90%. In the two uppermost samples, rare sponge spicules, diatoms, radiolarians and echinoid debris were observed. The nannofossil assemblage, from sample UCH6, defined by the presence of *Criboecentrum reticulatum* and *Chiasmolithus oamaruensis*, was attributed to zone NP18 of late Eocene age. Dinocysts from UCH1 include reworked Jurassic, Cretaceous and early Paleocene forms with autochthonous, long ranging Eocene to early Oligocene specimens. Sample UCH6 contains *Rhombodinium draco* and *Rottmestia borussica* suggesting a late middle Eocene age corresponding to zones D10-D11.

Distribution of foraminifers

Assemblages consist predominantly of globigerinids. Rotaliids commonly occur in sample UCH6 at the base of the marls, whilst nodosariids and buliminids are rare. Frequent occurrences of rotaliids, nodosariids and astrorhizids occur within the upper part of the section. *Cibicides* sp.A occurs rarely to commonly throughout the section. *C. pera* also appears rarely to frequently throughout the section. Sporadic occurrences of *G. increbescens*, *T. cerroazulensis cerroazulensis*,

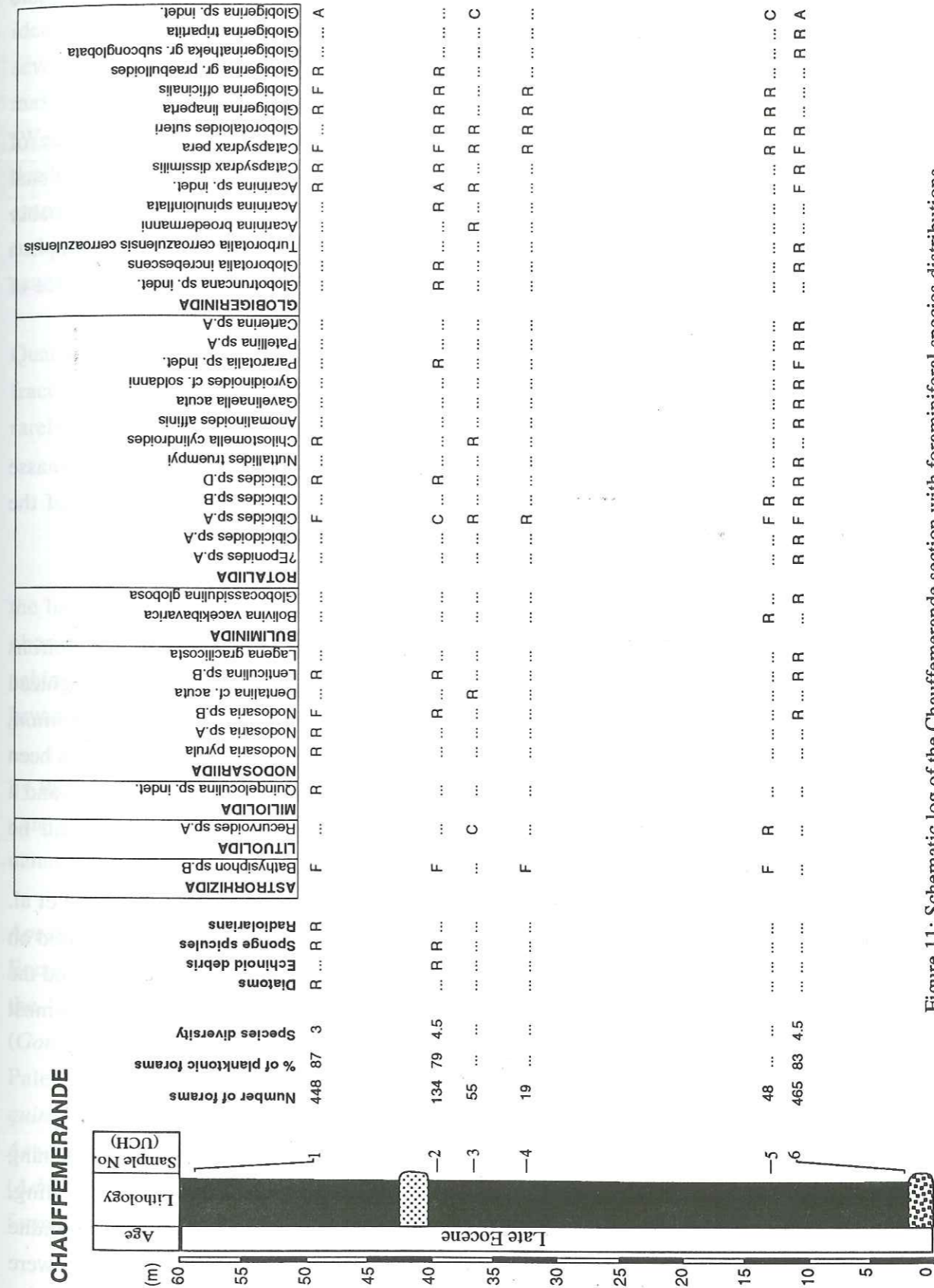


Figure 11: Schematic log of the Chauffemerande section with foraminiferal species distributions

G. tripartita, *G. suteri*, *G. gr. praebulloides* and the *Catapsydrax* group suggest a late Eocene age. *Acarinina* and *Morozovella* forms indicate reworking of early to middle Eocene sediments (Figure 11).

Paleoecology

The high percentage of planktonic foraminifers and species diversity, occurrence of *Nuttallides truempyi*, *Carterina sp.A*, diverse Rotaliids and Nodosariids suggest that the depositional environment was well oxygenated and of outer neritic to upper bathyal depth which probably increased to perhaps middle bathyal, more dysaerobic depths with the appearance of *Bathysiphon* and *Chilostomella* species and a lower foraminiferal species diversity. The frequent occurrence of *Pararotalia* at the base of the section probably indicates continental shelf to slope reworking.

3.4 Fillinges

Locality

This section is situated 20km southeast of Geneva along the D907 road between Annemasse and Samoëns (coord: 136, 00-911, 00, alt. 560m). It is located in the southwestern part of the Voirons massif in the Chablais Prealps of the Haute-Savoie, France (Figure 1).

Previous studies

Lombard (1940) described the Fillinges section as one of the best exposures in the Voirons massif and made it the type section of the Voirons sandstones. He, like Pilloud (1936), recognized that the sandstones were diverse, and usually contained fragments of Bryozoa, *Lithothamnium*, *Nummulites* and *Discocyclina*. Although he acknowledged that these foraminifers could have been reworked, Lombard (1940) interpreted a Thanetian to Lutetian (base of the Priabonian) age and a littoral depositional setting for the Voirons sandstones. Only later (Lombard 1963), did he recognize turbidites in the Fillinges section.

Based on the presence of dinocysts, scolecodonts, spores and pollen, Jan du Chêne et al. (1975) determined a late Paleocene (late Thanetian) age for the Fillinges section. This was based on the occurrence of a *Deflandrea speciosa* association corresponding to the NP7 nannofossil and the P4 foraminiferal zones. This section was attributed to the Saxel tectonic slice and exposes the most sandy facies of the Voirons Sandstones (interval 2 of Van Stuijvenberg 1980).

Lithostratigraphy

This section consists predominantly of thick sandstone beds of metric scale, and thickening up sandstone/shale sequences (Figure 12). Rare Ta-b Bouma sequences, graded bedding, amalgamated beds and sole marks clearly identify the alternating sandstones and shales as turbidite deposits. Within the thick sandstone beds at the base of the section, thin coal-rich layers were observed. Bioturbation is observed frequently on the basal surfaces of sandstone beds. The absence of storm or wave induced sedimentary structures further suggests that the Fillinges turbidites were deposited in deep-water, which is confirmed by foraminiferal analysis. As noted by Lombard

(1963), many sandstone beds display parallel and wavy laminae and sharp contacts, both of which could indicate reworking of the turbidites by bottom currents (Stanley 1993). Lombard (1963) identified five thinning-upward sequences in the 22m-thick succession. In contrast, we observed several thickening-upward sequences, where strata get progressively thicker upsection following a massive bed. This type of turbiditic succession is usually interpreted as submarine-fan progradation (Walker & James 1992). The Fillinges sandstones characteristically contain carbonate platform detritus (red algae and benthic foraminiferal debris) and mineral fragments derived from pink granites (Lombard 1963). Andesite or diabase debris, which are typical of several north Helvetic turbidites (e.g. Sawatzki 1975), have never been found in these sandstones. The Fillinges sandstones are also characterised by the presence of a coarse calcite cement.

Mica, calcite rich lithoclasts are the most abundant component in the washed residues. Quartz grains are generally common and calcite fragments are frequent throughout the sediment fractions. Pyrite frequently and sporadically occurs within the section. Coal fragments were also rarely retrieved from some samples.

Biostratigraphy

Distribution of microfossils

Foraminifers are generally rare throughout this section except for frequent occurrences at the base of the section (UFL8) and within sample UFL5. Pyritised radiolarians and diatoms were observed rarely and sporadically within the shaly horizons. Fish teeth, ostracods, sponge spicules, echinoid and poorly preserved and probably reworked coral debris, pteropods, microbivalves and bryozoan fragments occur rarely and sporadically within these sediments (Figure 12).

Nannofossil assemblages from sample UFL8a were attributed to NP16-NP19 zones defined by the presence of *Criboecium reticulatum*, corresponding to P12-P16 planktonic foraminiferal zones. However, these assemblages are dominated by the presence of forms attributed to NP9 nannofossil zone which correlates with the P5 planktonic foraminiferal zone of latest Paleocene.

The dinocyst assemblage from UFL5B is composed principally of *Deflandrea oebisfeldensis*, *Apectodinium hyperacanthum* and *Cerodinium dartmoorium* and indicates a late Paleocene to early Eocene age. However, one dubious specimen attributed to *Glaphyrocysta semitecta* characterises the late Eocene to early Oligocene. Assemblages in sample UFL8 include reworked Jurassic (*Gonyaulacysta jurassica*, *Callialasporites dampieri*), late Cretaceous (*Chatangiella* spp.), early Paleocene (*Palaeoperidinium pyrophorum*), late Paleocene-early Eocene (*Apectodinium quinquelatum*, *Apectodinium homomorphum*, *Deflandrea oebisfeldensis-dartmooria* type and *Areoligera senonensis*), late Paleocene-Eocene (*Diphyes colligerum*), early Eocene (*Adnatosphaeridium* sp. cf. *A. multispinosum*) and late Eocene (*Phthanoperidinium levimurum*) forms.

Distribution of foraminifers

Rotaliids are the most common foraminiferal element within the lowermost part of the section. Globigerinids, astrophidids, litiolids, nodosariids and buliminids are frequent. Astrophidids

and litiolids represent the most frequent foraminiferal order groups within the overlying shaly intervals. Globigerinids, rotaliids, buliminids and miliolids are very rare.

Bathysiphon sp.B, *Rhabdammina* cf. *robusta*, *Saccamina placenta*, *Ammodiscus cretaceus*, *Glomospira gordialis*, *Recurvoides* sp.A, *Dorothia retusa*, *Marsonella oxycona* and *Chilostomella cylindroides* were retrieved rarely to abundantly throughout the section. Rare to frequent occurrences of *Nonionella liebusi*, *Chilostomella ovoidea*, *Chilostomella chilostomelloides*, *Allomorphina trigona*, *Praeglobobulimina pupoides*, *Praeglobobulimina pyrula* and *Laevidentalina* cf. *communis* were observed within the lower part of the section. *Nummulites* and *Discocyclina* specimens were observed from UCB20. Small unidentifiable globigerinids and rotaliids were also observed within the sandstone beds (Figure 12).

The planktonic foraminifers retrieved are poorly to moderately well preserved. They are very rare, small, and generally preserved as pyritised, internal moulds. The occurrence of well preserved internal moulds of *G. gr. praebuloides*, *G. gr. ouachitaensis*, *G. cf. pseudoampliapertura* and *T. cerroazulensis cerroazulensis* suggests a late middle Eocene to late Eocene age, equivalent to the P14-P17 planktonic foraminiferal zones. Moderately well preserved tests of *G. opima nana*, *G. eocaena*, *C. globiformis*, *G. gr. mexicana* and *G. gr. index* further support this age (Figure 12). A few rare, reworked specimens of Cretaceous (*Globotruncana* sp. indet.) and early Eocene (*M. caucasica*, *M. lensiformis*) forms were also recognized. The composition and similarity of the *Chilostomella*-*Praeglobobulimina* benthic assemblages to those of Wenger (1987), Rieser (1987) and Dohmann (1991) from the molasse in Bavaria may also suggest Oligocene deposition. Furthermore, the frequent occurrence of agglutinated benthic assemblages, which are also a feature of Paleocene flysch deposits, does not rule out an Oligocene age. Assemblages containing *Ammodiscus*, *Haplophragmoides*, *Glomospira*, *Bathysiphon* and *Rhabdammina* are also well developed throughout the Paleogene-Neogene in the North sea and characterise Rupelian sediments from the Rhine graben (Gradstein & Berggren 1981, Gramman 1988, Charnock & Jones 1990, Kaminski et al. 1988).

Paleoecology

All of the foraminiferal assemblages are dominated by agglutinated and calcareous benthic foraminifers. Throughout the section, relatively well preserved assemblages consisting of *Praeglobobulimina* spp., *Chilostomella* spp., *Allomorphina trigona* and *Bathysiphon* spp. were recovered. *Chilostomella*, *Allomorphina* and *Praeglobobulimina* are among the dominant genera frequenting the bathyal zone in modern marine waters (Boltovskoy & Wright 1976). Furthermore, these are smooth-walled, non-ornamented, opportunistic, calcareous forms suggesting low oxygen conditions (Sen Gupta & Machain-Castillo 1993). Wenger (1987), Rieser (1987) and Dohmann (1991) have all recorded *Chilostomella*-*Bulimina* dominated assemblages from the Oligocene and Miocene molasse of Bavaria. They have attributed these faunas to middle and upper bathyal depositional environments. The low species diversity, low percentage of planktonic foraminifers and the dominance of *Chilostomella*, *Bulimina* and *Bathysiphon* suggests that deposition probably occurred in a dysaerobic, middle bathyal environment, possibly related to an OMZ. This benthic

assemblage resembles a foraminiferal fauna recovered from the Val d'Ille Formation of middle Oligocene age, also located in the Voirons massif (Ujetz et al. 1994).

Agglutinated benthic foraminifers (*Bathysiphon*, *Saccamina*, *Ammodiscus*, *Glomospira*, *Kalamopsis*, *Haplophragmoides*, *Trochamminoides*, *Cyclamina*, *Ataxophragmium*, *Dorothia*, *Marsonella*) are very common throughout the section and further reflect deep marine conditions (Figure 12). Several of these agglutinated species which form "Flysch-type faunas" (Brouwer 1965, Gradstein & Berggren 1981, Kaminski et al. 1988) have also been retrieved from the Gurnigel Nappe in the Romand Prealps (Van Stuijvenberg 1979).

3.5 Fiol

Locality

This section is located in a stream adjacent to "chez Fiol", 5km NE of Bonne in the Voirons massif, Haute-Savoie, France (coord: 908, 800-140, 510, alt. 995m) (Figure 1).

Previous studies

A *Lithothamnium* limestone lens was discovered by Pilloud (Lombard 1940). He noted from this lens the occurrence of *Lithothamnium* and bryozoan fragments, discocyclinids, rotaliids and textulariids. The occurrence of *Nummulites striatus*, *Discocyclina scalaris*, *Asterocyclina stellaris*, *Heterostegina helvetica* indicated a Priabonian, late Eocene age. Kerrien et al. (1996) (Det. R.Wernli) confirmed this age by the presence of *T. cerroazulensis* and *T. cerroazulensis cocoaensis* for the explication note of the Annemasse 1: 50000 map and is attributed to a tectonic slice within the Wildflysch zone. The occurrence of *G. corpulenta*, *G. praeturritilina*, *G. yeguaensis*, *G. euapertura*, *G. tripartita*, *G. pseudovenezuelana*, *G. increbescens* within the shales indicated a late Eocene age, close to the Oligocene boundary.

Lithostratigraphy

This section consists of tectonised calcareous shales which include a *Lithothamnium* rich limestone block of metric scale. Vegetation is very dense and obscures the stratigraphy of these sediments. This calcareous block is highly bioclastic and is enveloped by calcareous shales. Samples An3s140, UFIOL3-8 were derived from the calcareous shales positioned below the bioclastic limestone block. Further above (approximately 20m altitude), samples UFIOL2 and UFIOL1 were taken from a small outcrop of also structurally compressed shales. The washed residues generally contain abundant micaceous calcite quartz lithoclasts, frequent quartz grains, calcite fragments and skeletal material.

Biostratigraphy

Distribution of microfossils

Foraminifers represent the most common skeletal element within these sediments. Radiolarians, pteropods, fish teeth, ostracods, sponge spicules and echinoid debris are rare to

frequent within the section. The percentage of planktonic foraminifers is generally moderate (13-66%) except for sample UFIOL1 (87%) from the uppermost part of the section (Figure 13).

Nannofossil assemblages from UFIOL4 are attributed to NP19/20 zones, defined by the presence of *Discoaster saipanensis* and *Isthmolithus recurvus*, which correspond to the latest P15-P16 planktonic foraminiferal zones. The dinocyst assemblages include species which are restricted to the Eocene (*Aerosphaeridium diktyoplopus*, *Diphyes colligerum*) and other forms which range from the early Eocene-early Oligocene (*Areosphaeridium arcuatum*, *A. pectiniforme*, *Phthanoperidinium comatum*, *Kisselovia coleothrypta*, *Deflandrea phosphoritica*) middle Eocene-early Oligocene (*Rhombodinium draco*) and late Eocene-early Miocene (*Cordosphaeridium cantharellum*) suggesting a late Eocene age.

Distribution of foraminifers

Lituolids are generally abundant throughout these sediments. Astrorhizids, rotaliids and nodosariids are frequent throughout, whilst buliminids and miliolids are very rare and sporadically distributed within this section. Towards the top of the section, globigerinids are abundant, astrorhizids, rotaliids and nodosariids are frequent and lituolids and buliminids are rare.

Bathysiphon eocaenica, *Haplophragmoides* sp.A, *Trochammina* cf. *deformis*, *Eggerella trochoides*, *Chrysalogonium longiscatum*, *Dentalina* sp.A, *Laevidentalina* cf. *communis*, *Chilostomella chilostomelloides*, *Heterolepa* sp.A and *Gyroidinoides soldanni* occur rarely to commonly throughout these sediments (Figure 13).

C. pera, *C. unicava primitiva* and *G. venezuelana* were retrieved rarely to frequently throughout the section. Frequent and common occurrences of *G. increbescens*, *T. cerroazulensis* and *G. eocaena* were also recovered from the uppermost part of the section. The presence of these species with *G. angiporoides*, *G. suteri*, *H. alabamensis*, *P. micra*, *G. ampliapertura*, *G. tripartita*, *T. cerroazulensis cocoaensis*, *G. pseudoampliapertura*, *G. index tropicalis*, *G. ciperoensis angustiumbilitata*, *G. ouachitaensis ouachitaensis* and *G. ouachitaensis gnaucki* suggest a late Eocene age, corresponding to the P16 planktonic foraminiferal zone (Figure 13). The absence of *T. cerroazulensis cunialensis* may indicate that these sediments belong to the lower part of the P16 zone.

Paleoecology

Foraminiferal species diversities are generally high (α 4.25-12) reflecting well oxygenated, open marine conditions (Figure 13). The low percentage of planktonic foraminifers and the presence of *Reticulophragmium amplexans*, *Bathysiphon eocaenica*, *Triloculina* sp.A, *Pullenia quinqueloba*, *Chilostomella cylindroides*, *Chilostomella chilostomelloides*, a rich assemblage of nodosariids suggests an outer shelf to upper bathyal environment. The appearance of *Nuttallides truempyi*, *Bulimina jarvisi*, absence of miliolids and an increase in planktonic foraminifers within the upper part of the section suggests that well oxygenated, lower bathyal conditions prevailed.

3.6 Juffly

Locality

This section, which outcrops poorly, is situated along the Juffly to Buisson Rond road in the Voirons massif, Haute-Savoie, France (coord: 909, 700-138, 00), alt. 920m) (Figure 1). Two shaly samples were taken from around the 80-85m mark from the uppermost beds pertaining to "talus 2" (Jan du Chêne et al. 1975).

Previous studies

Based on nannofossils and dinocyst associations, this section was defined as late Paleocene to early Eocene in age and was attributed to the Voirons sandstones (Jan du Chêne et al. 1975). The samples collected in this study were taken from the upper part of "talus 2" (Jan du Chêne et al. 1975) which contained nannofossils of the NP5-NP6 zones and a *Deflandrea speciosa* dinocyst association, suggesting a Thanetian age.

Lithostratigraphy

The sampled interval outcrops extremely poorly and consists mainly of thick sandstone beds intercalated with very thin shaly horizons. Residues from the lowermost sample contain abundant quartz grains, frequent wood debris and no skeletal debris. Sample UJ2 contains abundant quartz grains, frequent micaceous calcite lithoclasts, rare glauconite and skeletal debris.

Biostratigraphy

Distribution of microfossils

The 2 samples which were processed, are extremely poor in microfossil content. Assemblages are represented by a few rare benthic agglutinated foraminifers and rare fish teeth.

Distribution of foraminifers

The presence of *Rhabdammina discreta*, *Dorothia* cf. *retusa* and *Trochamminoides irregularis* in sample UJ2 suggests a Paleocene age for these sediments.

Paleoecology

The rarity of fauna and frequent occurrence of *Rhabdammina discreta* suggests that deposition occurred in a cold, deep marine, probably dysaerobic environment.

3.7 Montauban

Locality

This section is divided into two intervals. The first interval is situated along the second hairpin bend at an altitude of about 780m, coord: 907, 300-143, 200. The second interval is located on the same road, between Dombres and Montauban, just around the corner from the first interval, at the height of the third turn (coord: 907, 100-142, 800, alt. 820). These sediments are situated in the Voirons massif, Haute Savoie, France (Figure 1).

Globigerinids represent the largest component of the assemblages. Many forms are poorly to moderately preserved and represent products of reworking. *C. unicava primitiva*, *A. bullbrooki*, *A. brodermanni* and *T. gr. cerroazulensis* are the most frequent species within the section. The occurrence of *G. gr. praebulloides*, *G. ampliapertura*, *G. increbescens*, *G. suteri* and *G. tapurensis* suggests that these sediments were deposited during the early Oligocene, corresponding to P18-P19 planktonic foraminiferal zones (Figure 14). However, a younger age cannot be ignored, due to the significant proportions of reworked forms. Cretaceous and Eocene reworking is suggested by the abundance of *Globotruncana* spp. and *G. praeturritilina*, *G. cf. mexicana mexicana*, *T. rohri*, *T. gr. cerroazulensis*, *A. bullrooki*, *A. brodermanni*, *Acarinina* spp. and *M. aragonensis*.

Paleoecology

Palynofacies assemblages in sample UM10 includes abundant equant shaped phytoclasts indicating a close proximity to a fluvio-deltaic source. Samples UM7 and UM24 also contain a high quantity of phytoclasts and were interpreted as turbidites of low transport distance. The common occurrence of plant remains and wood fragments suggests that deposition was influenced by a continental source. The presence of rare faunal elements, turbiditic sedimentary features, rare planktonic foraminifers indicates that restricted marine conditions occurred within the neritic zone. Furthermore, the presence of hummocky cross bedding suggests shallow water deposition. More open marine, shelf deposition occurred within the uppermost part of the upper interval based on high foraminiferal diversity (α 12.5), a high percentage of planktonic foraminifers and the occurrence of *Patellina* sp.A (Figure 14).

3.8 Saxel

Locality

The studied outcrop measures 35m and forms the base of a thick succession exposed within a stream which cuts the village of Saxel at 6 23, SE, 46 14,7 N in the Voirons massif, Haute-Savoie, France, at an altitude of 935m (Figure 1).

Previous studies

Van Stuijvenberg & Jan du Chêne (1981) defined the Boège marls based on this outcrop. They suggested that these sediments are of early late Eocene age, defined by *Rhombodinium perforatum* dinocyst associations and nannofossil assemblages belonging to the NP18 zone. These zones correspond to the planktonic foraminiferal P15 zone. They further suggested that sedimentation probably occurred on the continental slope.

Lithostratigraphy

The section consists predominantly of shaly intervals of metric scale which are intercalated by usually thin sandstone beds of centimetric and more rarely metric scale. Thick sandstone beds are occasionally amalgamated (Figure 15). Sample URS15 contains predominantly quartz grains and minor lithoclasts in a sparry calcite matrix. Rare, probably reworked, red algae fragments and

small miliolids are also present. Washed samples contain abundant ferruginised quartz, mica, carbonate lithoclasts and free quartz grains. Skeletal material is rare.

Biostratigraphy

Distribution of microfossils

Microfossils are very rare throughout the section. Assemblages consist of very rare fish teeth, bivalve fragments, radiolarians, sponge spicules, ostracods and more frequently, foraminifers at the base of the section (Figure 15).

Distribution of foraminifers

The foraminiferal assemblage is highly diverse (α 9). *Bathysiphon* sp.B is frequent particularly in the upper part of the section (Figure 15). Sample URS3 is relatively rich in moderately well preserved planktonic foraminifers. The presence of *G. increbescens*, *T. cerroazulensis cerroazulensis*, *G. cf. semiinvoluta*, *A. rotundimarginata* and *G. suteri* suggest that these sediments are of late Eocene age corresponding to the planktonic foraminiferal P15 to P16 zones (Figure 15).

Paleoecology

The frequent presence of simple agglutinated benthic foraminifers and rarity of fauna probably indicates low oxygenated conditions. However, the presence of *Nuttallides truempyi*, high species diversities and a high percentage of small planktonic foraminifers suggests that deposition partly occurred in a more open marine, well oxygenated, lower bathyal environment.

3.9 Signal Voirons A

Locality

This outcrop lies along a forest protected road which runs off the D50 road from the Col de Saxel to the Bethlehem monastery in the western and northwestern flank of the Voirons massif, Haute-Savoie, France (Figure 1). The section is situated in the Signal des Voirons, (coord: 910, 00-145, 00, alt. 1200m).

Previous studies

This outcrop was studied by Van Stuijvenberg & Jan du Chêne (1981) and attributed to the Voirons sandstones. Their nannofossil assemblages suggested a late Paleocene age defined by the presence of *Fasciculithus tympaniformis* which is attributed to the NP5 zone. This nannofossil zone corresponds to the upper part of the P3 and lower part of the P4 planktonic foraminiferal zones.

Lithostratigraphy

The section is composed predominantly of thick, coarse grained sandstone beds of metric scale. These beds, often thicker than 5m, are conglomeratic at their base and are intercalated by thin shaly horizons. The sandstone beds often display groove casts and bioturbation on their basal surfaces. The presence of graded bedding, mud pebbles, traction carpets, amalgamated beds and

SIGNAL VOIRONS A

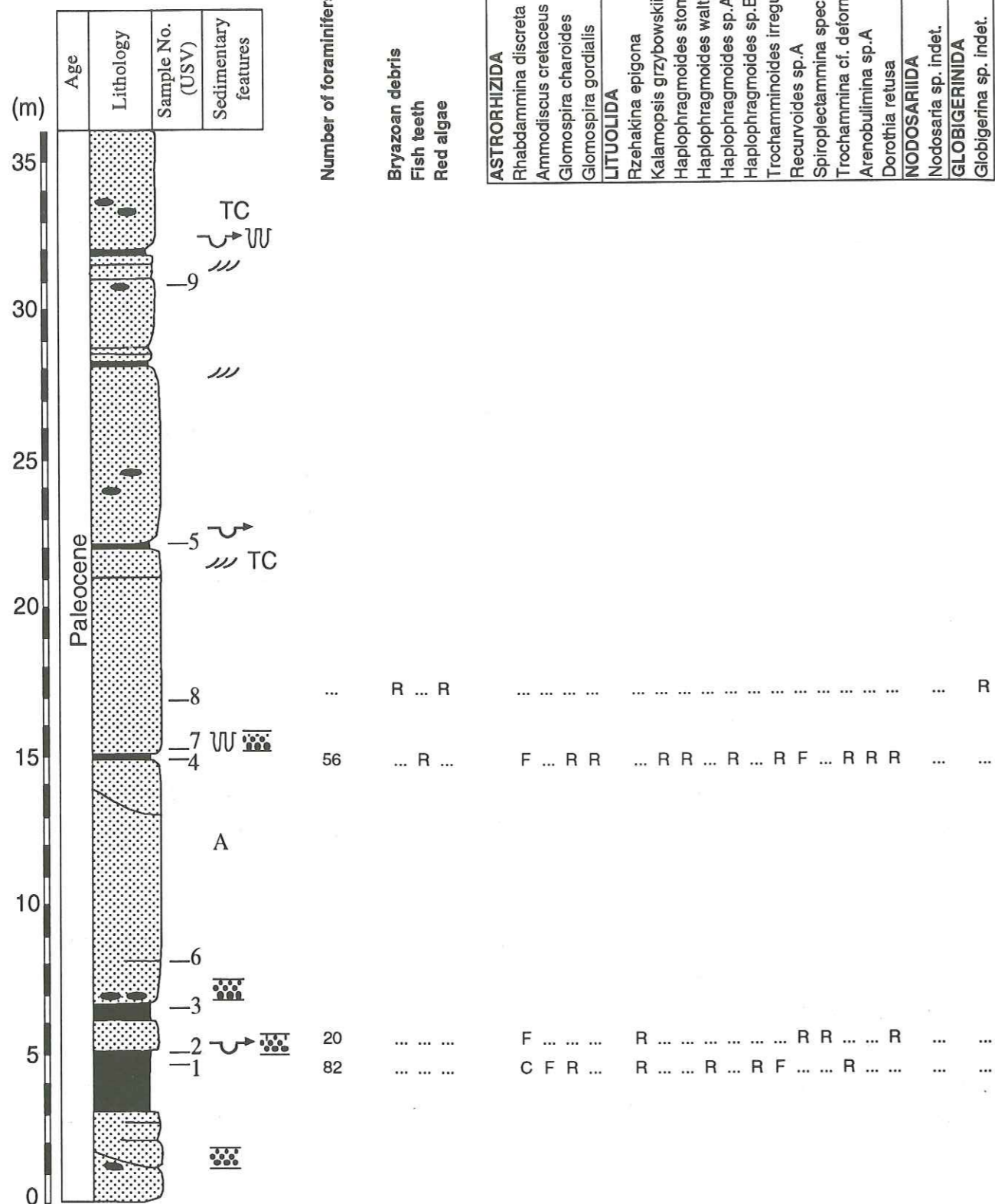


Figure 16: Lithological log of the Signal Voirons A section with foraminiferal species distributions

and entire Bouma sequences suggesting turbiditic sedimentation (Figure 17). They contain abundant quartz in a dominant calcitic matrix. Mica, calcite rich lithoclasts are the most abundant component in the sediment fractions. Quartz grains and skeletal material are also frequent. Glauconite was observed in sample USVB6.

Biostratigraphy

Distribution of microfossils

Foraminifers represent the most abundant skeletal component in the microfossil assemblages. Fish teeth, sponge spicules, echinoid debris and radiolarians are rarely and sporadically present. Planktonic foraminifers form 60-90% of the foraminiferal assemblages (Figure 17).

Nannofossil assemblages from sample USVB6 are attributed to the NP8 zone, defined by the presence of *Heliolithus riedelii*, which is equivalent to the P4 planktonic foraminiferal zone. Dinocyst assemblages including *Alisocysta marginata* and *Isabelidinium cf. viborgense* are attributed to D3 and D4 zones, corresponding to P3b-P4 planktonic foraminiferal zones.

Distribution of foraminifers

Assemblages within the lower shaly interval are poor and possess low species diversity. Within the upper interval, faunas are richer and highly diverse, suggesting that the depositional environment changed from more restricted to more open marine conditions. The foraminiferal rich assemblages are dominated by globigerinids, and in particular by *G. triloculinoidea* and *M. pseudobulloidea*. Their concurrent presence with *M. trinidadensis* and *P. compressa* indicate an early to middle Paleocene age, corresponding to the P1d to P2 planktonic foraminiferal zones. *M. pseudobulloidea* is also common in the sandstone sample USVB2 (Figure 17). Assemblages are also well represented by astrorrhizids and lituolids. *Rhabdammina discreta*, *Saccammina placenta*, *Trochamminoides irregularis*, *Recurvoides sp.A*, *Ammodiscus cretaceus* and *Arenobulimina sp.A* are found rarely to frequently more or less throughout the section (Figure 17). Rotaliids, nodosariids and buliminids form more minor components of the assemblages. Frequent occurrences of *Bulimina trinitataensis*, *Pyramidina rudita*, *Anomalinoidea affinis* and *Cibicides sp.A* occur within the upper part of the section.

Paleoecology

The presence of *Aragonia velascoensis*, *Bulimina trinitataensis*, *Pyramidina rudita*, *Nuttallides truempyi*, *Pullenia quinqueloba* and *Pullenia cf. bulloidea* suggest middle bathyal depths between 500 and 2000m (Figure 17). The frequent occurrence of simple agglutinated benthic foraminifers including *Bathysiphon sp.A*, *Rhabdammina discreta*, *Saccammina placenta* and more complex Haplophragmoididae forms also suggests deep water deposition. The high planktonic to benthic foraminiferal ratios, generally high foraminiferal species diversities, presence of glauconite and rich faunal associations also suggest that sediments were deposited in well oxygenated, open marine, bathyal conditions. The benthic faunal composition, increasing species

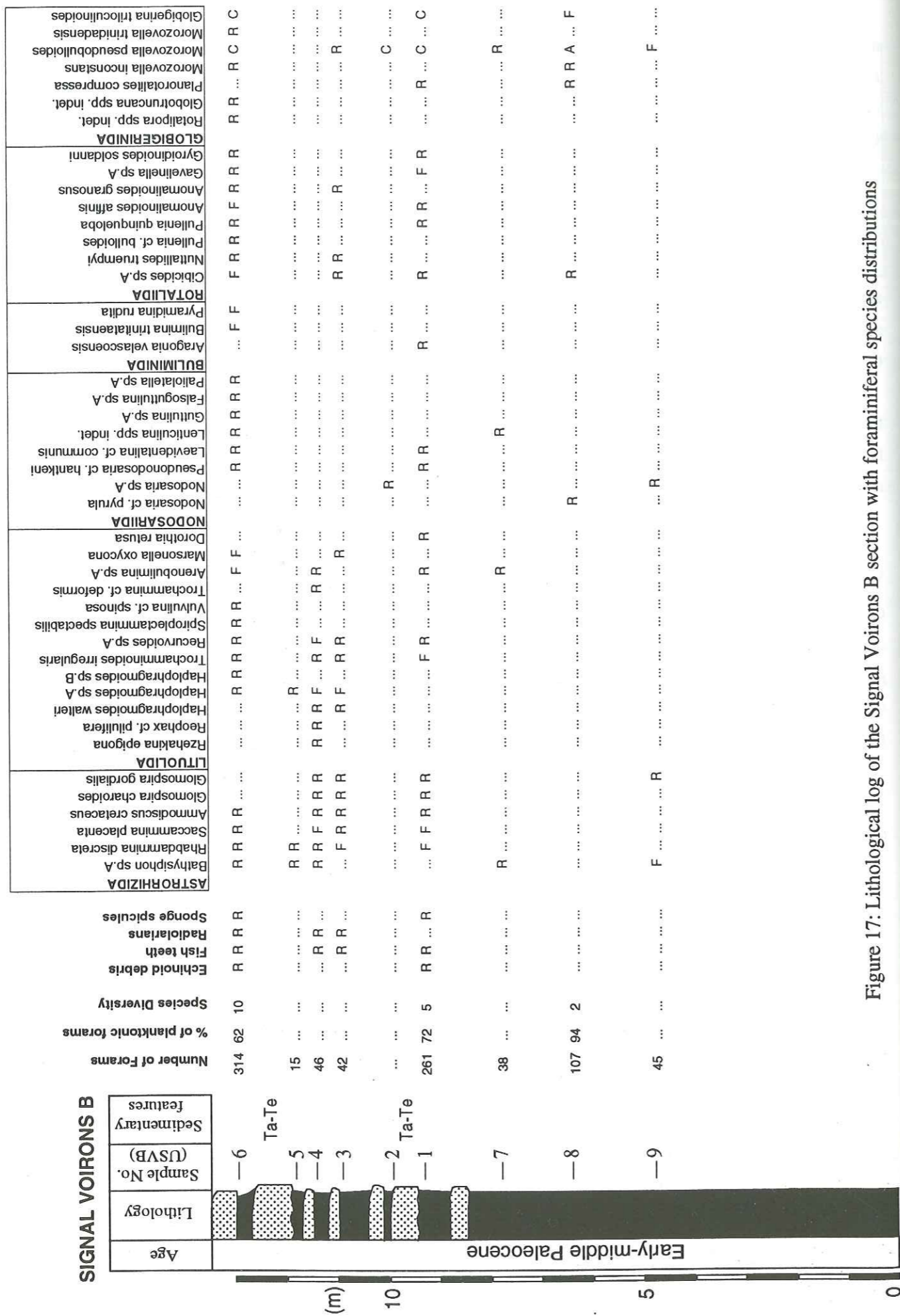


Figure 17: Lithological log of the Signal Voirons B section with foraminiferal species distributions

diversity and decreasing percentage of planktonic foraminifers upsequence suggests shallowing from lower bathyal to middle or upper bathyal depths.

3.11 Supersaxel

Locality

Samples USS1 and USS2 were collected from a small road outcrop along the road which is situated between the Col de Saxel and Supersaxel, Voirons massif, Haute-Savoie, France (coord: 913, 800-146, 300) (Figure 1). Sample USS3 was taken adjacent to Supersaxel.

Previous studies

Van Stuijvenberg & Jan du Chêne (1981) studied outcrops belonging to the Boège marls between Supersaxel and le Cova. These, together with other sections, concluded an early late Eocene age (NP18 nannofossil zone) and continental slope deposition.

Lithostratigraphy

The outcrop consists mainly of homogenous, laminated, altered brownish-red shales of centimetric scale which are intercalated by thin, grey sandstone beds. Washed residues from 3 samples, consist of quartz grains, ferruginised mica, calcite, quartz rich lithoclasts and very rare foraminifers.

Biostratigraphy

Distribution of microfossils

The samples consist of a few rare, small, moderately well preserved planktonic foraminifers and very rare benthic foraminifers (Figure 18).

Distribution of foraminifers

The rare concurrent occurrences of *A. rotundimarginata*, *G. suteri*, *Catapsydrax pera* and *G. gr. subconglobata* suggests that these sediments are of middle to late Eocene age corresponding to the planktonic foraminiferal P13-P16 zones (Figure 18).

Paleoecology

The rarity of well preserved benthic foraminifers prevents an interpretation of the depositional environment. However the similitude of these sediments with those at Saxel and Chauffemerande allows correlation. Therefore, these sediments were most likely deposited in a upper bathyal environment under fluctuating oxygen conditions.

Sample Number (USS)	1	2	3
Number of foraminifers	18	14	11
NODOSARIIDA			
Nodosaria sp. indet.	...	R	...
BULIMINIDA			
Globocassidulina globosa	R	...	...
ROTALIIDA			
Cibicides sp.A	R	...	...
Chilostomella sp. indet.	...	...	R
Anomalinoidea granosus	R	R	...
Gyroidinoidea soldanni	R	...	...
GLOBIGERINIDA			
Acarinina cf. rotundimarginata	...	...	R
Catapsydrax pera	R	R	...
Globorotaloides suteri	R	...	R
Globigerina officinalis	R	R	F
Globigerina sp. indet.	F	F	F
Globigerinatheka subconglobata	...	R	...

Figure 18: Foraminiferal distributions at Supersaxel

NORTHERN SUBALPINE CHAINS

3.12 Brizon

Locality

This section outcrops along the D186 road to Brizon and forms the synclinal part of the Plateau d'Andey in the Bornes massif of the subalpine chains, Haute-Savoie, France (Figure 1).

Previous studies

None.

Lithostratigraphy

The section is composed of thick sandstone beds which are intercalated by thin shaly intervals. Numerous sedimentary features are visible, including groove casts and graded bedding. This section probably belongs to the Val d'Ille Formation.

*Biostratigraphy*Distribution of microfossils

No microfossils were retrieved from the processed samples. However, a middle Eocene age was predicted for sample UBR18, based on the occurrence of *Areosphaeridium arcuatum*, *H. floripes* and *Homotryblum oceanicum* (D9-D11 zones). Late Paleocene to early Eocene forms (*Apectodinium* sp., *?C. diebelii*) were also observed indicating the presence of reworking. This age

is a very rough estimate due to the absence of reliable and frequent biomarkers. No foraminifers were retrieved from the 22 shaly samples studied.

Paleoecology

The outcrop sedimentary features, abundance of phytoclasts and presence of a few damaged dinocysts in the palynomorph assemblages, suggests turbiditic deposition.

3.13 Dessy

Locality

This section lies near Bonneville along the D12 road, situated in the north eastern part of the Bornes massif of the subalpine chains, Haute-Savoie, France (coord: 912, 55-124, 87) (Figure 1).

Previous studies

Charollais & Wellhauser (1962) noted the absence of the Foraminiferal marls which are observed to overly the Priabonian smaller *Nummulites* and coral rich limestones in the region. They also retrieved an assemblage rich in globigerinids from the Meletta shales. Charollais (1963) described the lithological succession of this section. Segonzac & Charollais (1974) studied the algae from the smaller *Nummulites* and coral rich limestones. Later Charollais et al. (1975) determined an early Oligocene age for the Meletta shales based on dinocysts, nannofossils and planktonic foraminifers. This was followed by a comprehensive study on the Foraminiferal marls and Meletta shales by Charollais et al. (1980), which included this section. These authors retrieved a foraminiferal fauna within the Meletta shales poor in diversity and early Oligocene in age, due to the presence of *G. ouachitaensis*, *G. officinalis* and *G. praebulloides*.

Lithostratigraphy

Sampling from this section was concentrated in 3 intervals. The lowermost interval is composed of the Meletta shales. The overlying upper intervals are predominantly composed of shales which are punctuated by thin sandstone beds (Figure 19). The sandstone beds are often laminated, quartz rich and fine grained. These sedimentary packages are considered to form the Marno-micacés (micaceous marls), the middle unit of the Val d'Ille Formation (Lateltin 1988).

Washed residues consist predominantly of mica, carbonate rich lithoclasts. Quartz and glauconite form minor components of these sediments.

*Biostratigraphy*Distribution of microfossils

A highly diverse assemblage, containing abundant benthic foraminifers, rare planktonic foraminifers (3% of the foraminiferal assemblage), rare fish teeth, coral debris and echinoid fragments, was derived from the base of the section. The overlying sediments of the lower interval contain predominantly planktonic foraminifers (88-100% of the foraminiferal assemblages). The

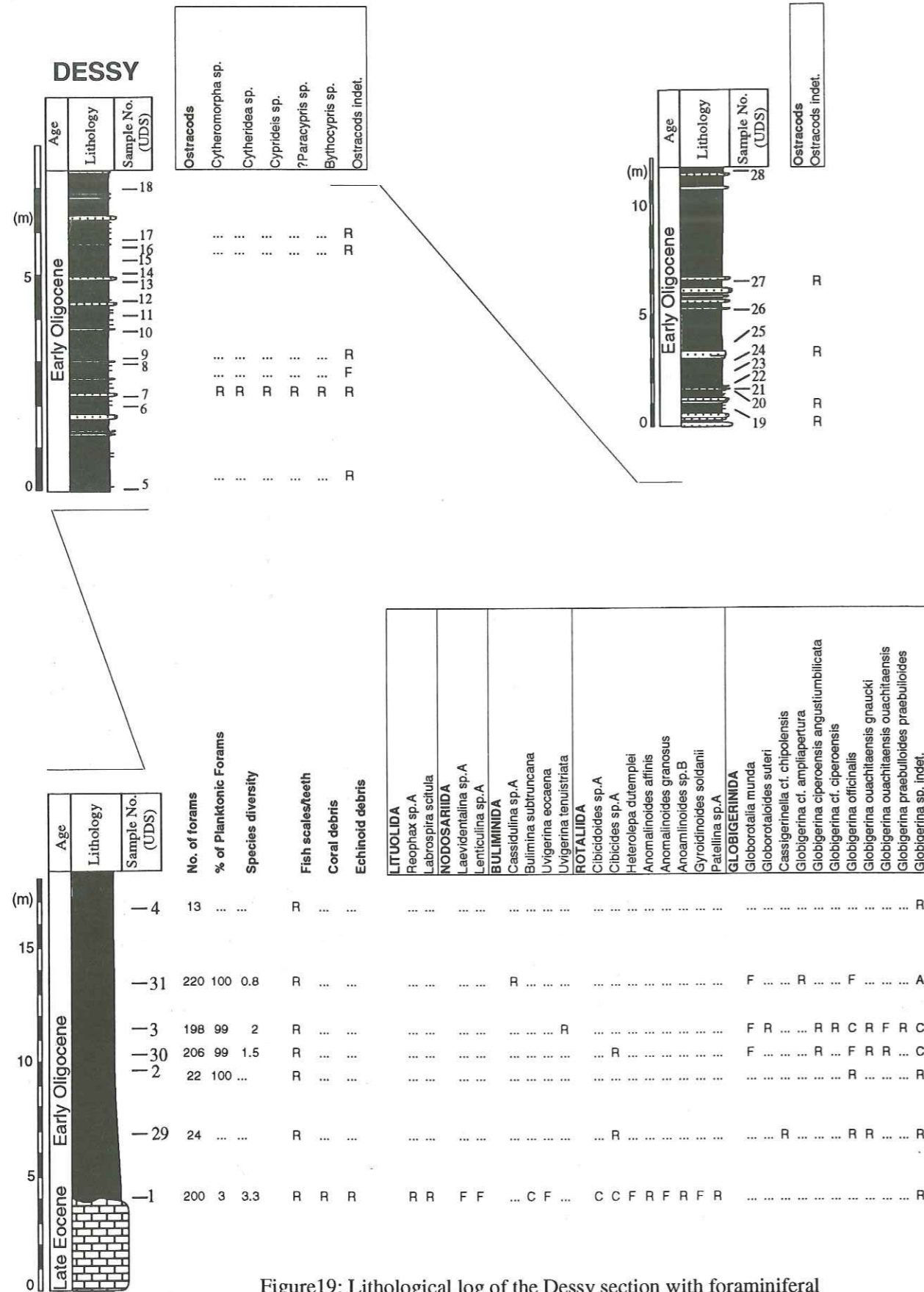


Figure 19: Lithological log of the Dessy section with foraminiferal and ostracod species distributions

foraminiferal species diversity is very low ranging from $\alpha 3.75$ at the base to $\alpha 0.75$ towards the top of the lower Meletta shales interval (Figure 19).

Rare ostracods are sporadically distributed within the upper alternating sandstone/shale intervals. Small well preserved reticulate forms including *Cytheromorpha* sp. and large, smooth, well preserved forms (often fragmented) pertaining to *Cytheridea* sp., *Cyprideis* sp., *?Paracypris* sp. and *Bythocypris* sp. suggest a shallow water depositional environment (Figure 19). Assemblages from these sediments are completely absent of foraminifers.

Sample UDS3 revealed mixed dinocyst assemblages pertaining to the late Paleocene to early Eocene (*Apectodinium homomorphum*, *Apectodinium quinquelatum*), early Eocene-Late Eocene (*Diphyes colligerum*), Oligocene (*Areospaeridium arcuatum*), early Eocene-early Oligocene (*Kisselovia coleothrypta*, *Deflandrea phosphoritica*) and middle Eocene-late Oligocene (*Chiropteridium mespilanum*, *Membranophoridium aspinatum*).

Distribution of foraminifers

Sample UDS1 is composed of a rich benthic calcareous fauna consisting principally of rotaliids and buliminids. Nodosariids are frequent whilst globigerinids and lituolids are rare. *Bulimina subtruncana*, *Uvigerina eocaena*, *Cibicidoides* sp.A and *Cibicides* sp.A are the principal elements of this assemblage. *Lenticulina* sp.A, *Laevidentalina* sp.A, *Heterolepa dutemplei*, *Anomalinoidea granosus* and *Gyroidinoides soldanii* occur also frequently. Assemblages derived from overlying horizons within the Meletta shales consist largely of very small, moderately well preserved planktonic foraminifers, including rare to common occurrences of *G. officinalis*, *G. munda*, *G. ouachitaensis ouachitaensis* and *G. ouachitaensis gnaucki* more or less throughout this interval (Figure 19).

The occurrence of *C. chipolensis*, *G. munda*, *G. cf. ciproensis*, *G. ciproensis angustiumbilitata*, *G. cf. ampliapertura* and *G. ouachitaensis gnaucki* suggest an early Oligocene age (P18-P20 planktonic foraminiferal zones).

Paleoecology

The rich benthic foraminiferal assemblage containing well ornamented and thick shelled *Uvigerina* and *Bulimina* specimens suggest that deposition occurred in a well oxygenated outer neritic to upper bathyal environment. However, the presence of *Patellina* sp.A indicates that deposition may of been restricted to outer neritic, shelf depths. The presence of lowly diverse foraminiferal assemblages dominated by small, planktonic foraminifers indicates that deposition probably continued at slightly greater depths, probably in the upper bathyal zone, under more dysaerobic conditions.

3.14 Sage

Locality

Sample ULS1 was taken along the road between Delaire and Thuet (Figure 1). Sample ULS2 was derived from a small outcrop of Meletta shales situated behind a farmhouse in the Plateau d'Andey of the Bornes Massif, Haute-Savoie, France (coord: 913, 90-124, 50).

Previous studies

Charollais et al. (1980) indicated a early Oligocene age on the basis of *G. opima opima* and *G. munda* corresponding to the P19-P20 planktonic foraminiferal zones. Furthermore, these authors recovered a rich *Bulimina* and *Uvigerina* benthic fauna which they suggested may have been reworked due to its similarity with benthic faunas from the Foraminiferal marls.

Lithostratigraphy

The washed residues are composed of calcareous rich lithoclasts containing minor amounts of glauconite and quartz grains, and are rich in skeletal material.

Biostratigraphy

Distribution of microfossils

The microfossil assemblages are composed entirely of moderately to well preserved foraminifers. Poorly preserved *Nummulites* fragments were also observed. Planktonic foraminifers represent 44-60% of the foraminiferal assemblages. Rare sponge spicules were also retrieved.

Distribution of foraminifers

The foraminiferal assemblages are highly diverse (α 7.5-9.5), in contrast to those from Dessy, and consist predominantly of globigerinids, rotaliids and buliminids. Nodosariids are also frequent. Robertinids were also retrieved from sample ULS2. Benthic foraminiferal assemblages consist predominantly of large, highly ornamented *Bulimina subtruncana* and *Uvigerina eocaena* specimens. *Lenticulina* sp.A, *Gyroidinoides soldanni*, *Nonionella* sp.C, *Globocassidulina globosa* and species of *Anomalinoidea* form significant percentages of these assemblages (Figure 20).

The occurrence of *G. munda*, *C. chipolensis*, *G. angiporoidea* and *G. increbescens* suggest an early Oligocene age (P18-P19 planktonic foraminiferal zones). The presence of *G. cf. opima opima* suggests sedimentation pertaining to the P19 planktonic foraminiferal zone. Berggren & Miller (1988) stated that large specimens of *G. opima* are found immediately after the last occurrence datum of *Pseudohastigerina*, that is, from the beginning of the P19 zone.

Paleoecology

The rich, diverse benthic foraminiferal assemblage containing well ornamented and thick shelled *Uvigerina* and *Bulimina* specimens suggest that deposition occurred in a well oxygenated outer neritic to upper bathyal environment. The presence of large sized planktonic foraminifers also indicates well oxygenated, open marine conditions. However, the percentage of planktonic foraminifers and the presence of *Patellina* sp.A and *Carterina* sp.A indicates that deposition may

	SAGE		VENAY		VACHERIE	
	ULS1	ULS2	UV1	UV2	UVA1	UVA2
MELETTA SHALES						
Sample Number	240	227	217	290	247	257
Number of foraminifers	44	60	100	38	68	53
% of planktonic foraminifers	9.5	7.5	1.25	8.5	8.25	8
Species diversity						
ASTORRHIZIDA						
Bathysiphon eocaenica	...	...	...	...	R	F
LITUOLIDA						
Vulvulina haeringensis	...	...	...	R	R	R
Vulvulina spinosa	...	...	...	R	...	...
Trochammina cf. deformis	...	...	...	F	F	...
Tritaxia szaboi	...	...	...	C	R	...
Marsonella oxycona	...	...	...	...	R	F
Dorothia pupa	...	...	...	...	R	F
NODOSARIIDA						
Nodosaria pyrula	R	...	...	...	...	...
Nodosaria sp.A	R	R	...	...	...	...
Nodosaria sp.C	...	...	...	R	...	...
Pseudonodosaria cf. hantkeni	R	...	...	...	...	...
Dentalina cf. acuta	...	...	...	F	...	F
Dentalina sp.A	...	R	...	...	...	...
Laevidentalina cf. communis	R	R	...	F	...	F
Chrysalogonium longiscatum	...	...	...	R	...	R
Lenticulina sp.A	F	F	...	F	F	F
Amphicoryna badenensis	...	...	...	...	...	R
?Vaginulinopsis sp.indet	...	...	...	R	...	R
Polymorphina sp.A	...	...	...	...	...	R
Guttulina sp.A	...	...	...	...	R	R
Parafissurina sp.A	...	...	...	...	...	R
Pleurostomella bellardi	...	...	...	...	R	...
Stilostomella cf. conspurcata	...	...	...	F	...	...
ROBERTINIDA						
Hoeglundina elegans	...	F	...	...	...	...
BULIMINIDA						
Bolivina vacckibavarica	...	R	...	...	...	...
Globocassidulina subglobosa	R	F	...	...	F	...
Bulimina subtruncana	F	F	...	...	...	R
Praeglobobulimina pupoides	...	R	...	...	...	...
Praeglobobulimina pyrula	R	...	...	...	...	...
Uvigerina eocaena	F	F	...	...	...	...
Uvigerina moravia	F	R	...	...	...	...
Trifarina cf. sp.A	R	...	...	...	...	...
ROTALIIDA						
Cibicides sp.A	...	R	...	...	...	...
Cibicides sp.A	F	...	...	R	R	R
Nonionella sp.B	F	...	...	...	...	...
Nonionella sp.C	F	R	...	...	...	...
Pullenia quinqueloba	...	...	...	R	...	...
?Melonis sp. indet.	...	...	...	...	...	R
Heterolepa dutemplei	...	F	...	...	F	F
Heterolepa sp.B	...	...	...	F	F	F
Anomalinoidea affinis	F	...	...	...	R	...
Anomalinoidea granosus	R	F	...	...	...	...
Anomalinoidea sp.A	R	F	...	...	...	...
Gyroidinoides soldanni	R	F	...	C	F	F
Gavelinella acuta	...	...	...	...	R	F
Hanzawaia ammophila	...	...	...	F	F	F
Patellina sp.A	R	...	...	...	...	...
Carterina sp.A	R	...	...	...	...	...
GLOBIGERINIDA						
Globorotalia increbescens	F	R	R	R	R	...
Globorotalia munda	...	R	...	R	R	...
Catapsydrax dissimilis	...	R	...	...	...	...
Catapsydrax pera	R	R	R	C	R	F
Catapsydrax unicava primitiva	...	F	R	F	R	F
Catapsydrax sp.A	...	...	...	R	...	...
Globorotaloides suteri	...	...	...	R	...	...
Cassigerinella cf. chipolensis	R	...	...	...	...	...
Globigerina ampliapertura	...	...	...	R	R	...
Globigerina angiporoidea	F	R	...	...	R	F
Globigerina ciperoensis angustiumbilicata	...	...	...	R	R	...
Globigerina cf. corpulenta	...	...	R	R	...	...
Globigerina gortanii	...	...	...	R	...	...
Globigerina officinalis	F	R	F	F	R	F
Globigerina opima nana	...	...	R	...	...	...
Globigerina cf. opima opima	R	...	...	R	...	...
Globigerina ouachitaensis ouachitaensis	R	R	...	R	R	...
Globigerina praebulloides praebulloides	F	R	...	...	...	...
Globigerina cf. senilis	R	...	...	...	...	...
Globigerina cf. tapuriensis	R	F	...	...	...	...
Globigerina utilis index	...	...	...	...	R	F
Globigerina venezuelana	...	...	...	F	...	...
Globigerina sp. indet.	...	...	A	F	C	C

Figure 20: Foraminiferal species distributions at Sage, Venay and Vacherie

have been restricted to outer neritic, shelf depths for the sediments belonging to ULS1. The higher percentage of planktonic foraminifers and the presence of *Heterolepa dutemplei* and *Globocassidulina subglobosa* in sample ULS2 suggests that deposition occurred within the outer neritic zone to perhaps slightly greater depths, possibly in the upper bathyal zone (Figure 20).

3.15 Vacherie

Locality

Situated in the Nom valley between St Jean-de-Sixt and Thônes, southwest of Villards-sur-Thônes near Vacherie in the subalpine chains, Haute-Savoie, France (Figure 1). More precisely, this 10m section lies along a small road which runs from Vacherie to Fételay, after a bifurcation with the Lachat road, at an altitude of about 850m. (coord: 911, 60-108, 75).

Previous studies

Charollais et al. (1980) attributed this section to the upper part of the Foraminiferal marls and recovered an early Oligocene age based on foraminiferal and dinocyst assemblages.

Lithostratigraphy

This section consists of calcareous shales, blue-grey to reddy-yellow on the surface due to oxydization. One shaly sample was taken from the base and one towards the top of the section. Residues are very rich in calcareous lithoclasts and skeletal material.

Biostratigraphy

Distribution of microfossils

At the base of the section, the microfossil residues were dominated by foraminifers. Rare occurrences of pteropods (*Limacina*), ostracods and echinoid debris were observed. Rarely preserved burrows were also retrieved. Planktonic foraminifers form 68% of the foraminiferal assemblage at the base. From sample UVA2, the percentage of planktonic foraminifers was reduced slightly to 53%. The two studied samples also possess high foraminiferal species diversities (α 8-8.25) (Figure 20).

Distribution of foraminifers

The assemblages contain common occurrences of well preserved globigerinids and rotaliids. Nodosariids, litiolids and astrorhizids are also frequent. *Lenticulina* sp.A, *Heterolepa dutemplei*, *Heterolepa* sp.B, *Gyroidinoides soldanni* and *Hanzawaia ammophila* are found frequently throughout the section (Figure 20).

The presence of *G. ciproensis angustiumbilicata*, *G. utilisindex*, *G. ouachitaensis ouachitaensis*, *G. increbescens*, *G. ampliapertura* and *G. angiporoides* indicates an early Oligocene age (P18-P19 planktonic foraminiferal zones) (Figure 20).

Paleoecology

The high foraminiferal species diversities, presence of a thick shelled calcareous fauna and large planktonic foraminiferal test size indicate a well oxygenated, open marine environment. The presence of *Hanzawaia ammophila*, *Heterolepa dutemplei*, *Marsonella oxycona* and *Globocassidulina globosa* and the planktonic foraminiferal percentages suggest outer neritic to upper bathyal depths. The presence of species pertaining to bathyal genera including *Pleurostomella* and *Bathysiphon*, further support an upper bathyal depositional environment (Figure 20).

3.16 Venay

Locality

This outcrop is situated on the right bank of the Chinaillon creek, between the col de la Colombière and Chinaillon, near the Venay bridge in the Subalpine chains, Haute-Savoie, France at an altitude of 1304m (coord: 914, 46-116, 91) (Figure 1).

Previous studies

Charollais et al. (1980) recorded an association of dinocysts and the presence of a foraminiferal assemblage including *G. gortanii gortanii*, *G. postcretacea* and *P. naguewichiensis* characteristic of the P17-P19 zones. This section was attributed to the upper part of the Foraminiferal marls.

Lithostratigraphy

Residues are rich in calcareous mica rich lithoclasts and skeletal material.

Biostratigraphy

Distribution of microfossils

Foraminifers commonly occur in the lowermost sample. Pteropods pertaining to the genus *Limacina*, frequent in the assemblage. Rare fish teeth were also noted. Planktonic foraminifers form 100% of the foraminiferal assemblage. The percentage of planktonic foraminifers decreases to 38% in sample UV2 which was taken a few metres above (Figure 20). Foraminifers are common and form the greatest proportion of the skeletal assemblage. Ostracods are rare as are also burrow traces.

Distribution of foraminifers

The lowermost sample (UV1) is composed entirely of pyritised planktonic foraminiferal tests which are often compressed due to deformation processes. *G. officinalis* represents the most common determinable foraminiferal species. The presence of *G. increbescens* indicates that these sediments are of late Eocene to early Oligocene age (P15-P19 planktonic foraminiferal zones) (Figure 20).

The assemblage is lowly diverse ($\alpha 1.25$) in comparison to the highly diverse ($\alpha 8.5$) foraminiferal assemblage derived from the overlying sediments of sample UV2 (Figure 20). Benthic foraminifers are very common in the uppermost sample, forming about 60% of the foraminiferal fauna. Globigerinids, rotaliids and litiolids are very common and nodosariids frequent. *Tritaxia szaboi*, *Catapsydrax pera* and *Gyroidinoides soldanni* are the commonest species.

The presence of *G. munda*, *G. ampliapertura*, *G. gortanii*, *G. ciproensis angustiumbilitata*, *G. opima nana*, *G. cf. opima opima*, *G. ouachitaensis ouachitaensis* suggests an early Oligocene age, equivalent to the P18-P20 planktonic foraminiferal zones (Figure 20).

Paleoecology

Low foraminiferal species diversity and a high percentage of large, planktonic foraminifers indicate that deposition occurred in a dysaerobic, upper bathyal environment for the lower part of the section. Further upsequence, the environment became well oxygenated, encouraging a diverse, thick shelled foraminiferal assemblage. The presence of numerous nodosariids and rotaliids (including *Hanzawaia ammophila*, *Heterolepa dutemplei* and *Pullenia quinqueloba*) suggest an outer neritic depositional environment. This is further supported by the low percentage of planktonic foraminifers.

ROMAND PREALPS

3.17 Cucloz

Locality

Situated within the "Colline de Cucloz", at the front of the Romand Prealps, Switzerland (coord: 557, 8-148, 6) (Figure 1).

Previous studies

Weidman et al. (1982), on the basis of one sample from Corminboeuf (1959), determined an early Oligocene age defined by planktonic foraminifers attributed to P18-P20 planktonic foraminiferal zones. These authors also interpreted a depositional environment below the wave base.

Lithostratigraphy

Five samples were derived from the lower shaly interval and 3 samples from thin shaly horizons within the upper part of the upper sandy interval. For a full description of the sedimentary facies see Weidman et al. (1982).

Biostratigraphy

Distribution of microfossils

No microfossils were identified from the washed residues.

3.18 Fayaux A

Locality

This section is located near Blonay, in a quarry which is situated along the road between Montreux and l'Alliaz in the Romand Prealps, Switzerland (coord: 559, 8-146, 5) (Figure 1).

Previous studies

The nannofossil, palynomorph and sedimentology of this section was studied in detail by Van Stuijvenberg et al. (1976), who attributed these sediments to Gurnigel Flysch. A *Deflandrea striata* dinocyst association suggested an early Paleocene to lowermost late Paleocene age. The nannofossil faunas were very poor in content and were attributed to the NP5 zone though a late Paleocene (base of the Thanetian) age was suggested. An early Lutetian age was also derived on the basis of absolute ages for a sandstone bed at the base of the section containing 40% glauconite. Benthic foraminiferal faunas consisting of unilocular and multilocular forms were also studied which they suggested to define an abyssal depositional environment.

Crimes et al. (1981) looked closely at the trace fossil assemblages and sedimentology suggesting that these sediments were deposited as distal fan fringe to basin plain deposits. The presence of network types also suggested a low energy environment. The water depth was estimated on the basis of the faunas and calcium carbonate content of the hemipelagic shales as between 2500-5000m (Brouwer 1965, Van Stuijvenberg 1979).

Lithostratigraphy

For detailed sedimentology and lithostratigraphy see Van Stuijvenberg et al. (1976) and Crimes et al. (1981). Samples were derived from shaly horizons. Sandstones are quartz rich, fine grained, often laminated and well sorted.

Biostratigraphy

Distribution of microfossils

Benthic foraminifers represent the most common component of the microfossil assemblages. Rare, well preserved fish teeth were retrieved throughout the section. Burrows occur rarely within the lower part of the section.

Distribution of foraminifers

Assemblages show low foraminiferal species diversities, ranging between $\alpha 2-3$, throughout the section and consist predominantly of astrophidids and litiolids. Astrophidids are dominant except for samples UFAYA12, 14 and 16. *Rhabdammina discreta*, *Bathysiphon sp.A*, *Trochamminoides irregularis*, *Recurvoides sp.A* and *Saccammina placenta* represent the most common species and occur rarely to commonly throughout the section. The occurrence of *Trochamminoides irregularis*, *Glomospira irregularis*, *Dorothia retusa* and *Kalamopsis grzybowski* suggest a Paleocene age. However, sporadic occurrences of *Reophax cf. pilulifera* and *Ammodiscus latus* suggest that a middle Eocene to Oligocene age cannot entirely be excluded (Figure 21).

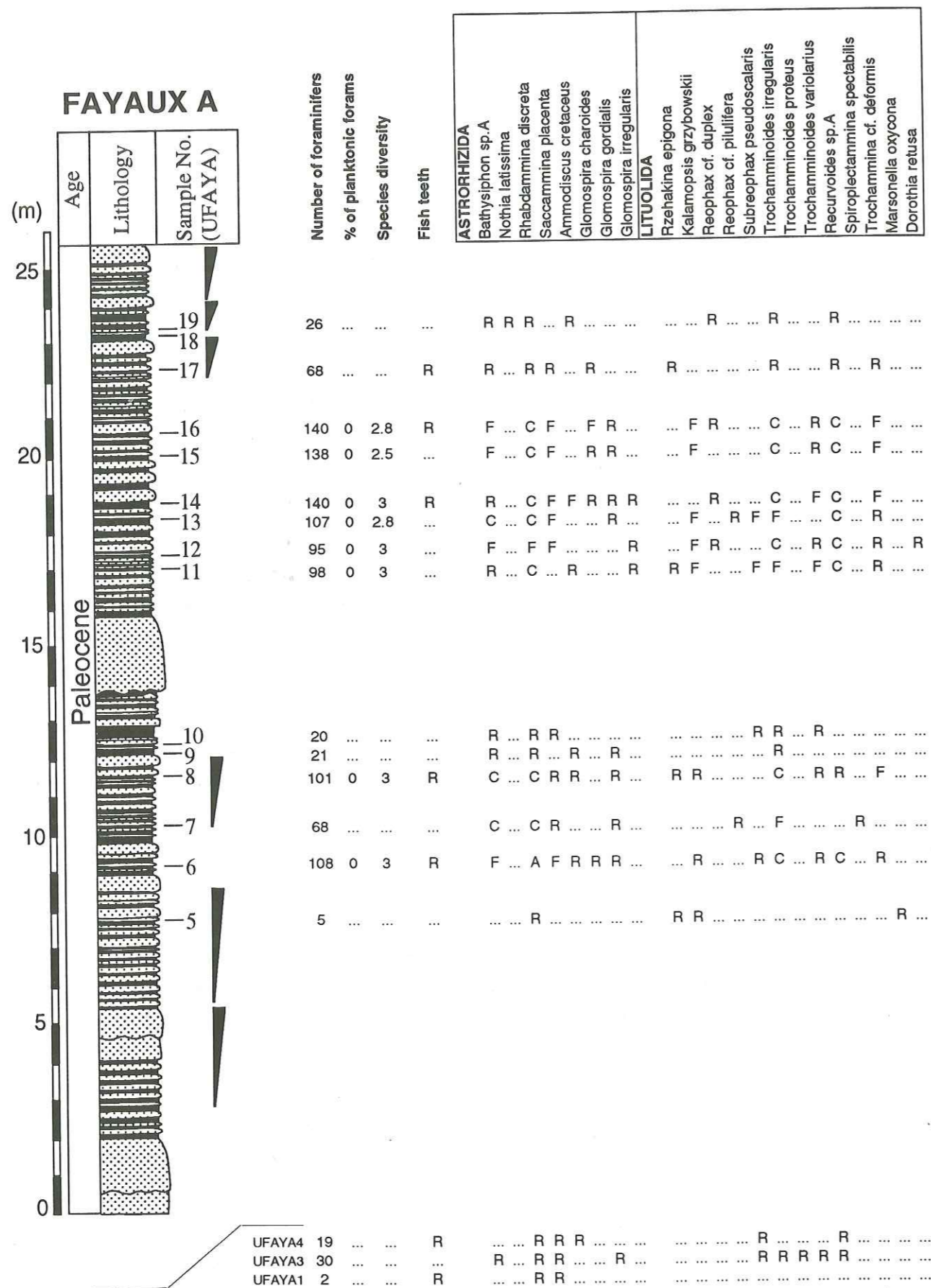


Figure 21: Lithological log of the Fayaux A section (modified from Van Stuijvenberg et al. 1976) with foraminiferal species distributions

Paleoecology

The occurrence of a rich agglutinated benthic fauna, absence of a calcareous benthic and planktonic foraminifers, low foraminiferal species diversities, suggests deep marine, dysaerobic sedimentation probably below the CCD.

3.19 Fayaux B

Locality

This section is located near Blonay, in a quarry which is situated along the road between Montreux and l'Alliaz in the Romand Prealps, Switzerland (coord: 560, 0-146, 5) (Figure 1).

Previous studies

Nannofossil assemblages were attributed to the NP6-NP8 zones, indicating a late Paleocene (Thanetian) age (Van Stuijvenberg et al. 1976). Their dinocyst associations indicated a Danian to lowermost Thanetian age. This section was attributed to Gurnigel Flysch.

Lithostratigraphy

Sandstone beds are often quartz rich, fine grained and laminated. They often possess a large quantity of calcitic matrix.

Biostratigraphy

Distribution of microfossils

Microfossil assemblages consist predominantly of benthic foraminifers. A few, rare fish teeth were retrieved from 2 samples. Small burrows were also recorded from washed residue at the base of the section. Rare specimens of red algae were observed from UFAYB3 (Figure 22).

Distribution of foraminifers

The foraminiferal assemblages are composed predominantly of astrorhizids and lituolids. Very rare occurrences of rotaliids are also sporadically distributed within the section. Rotaliid specimens are poorly preserved and were probably reworked from shallower sites. At the base of the section, a relatively rich and diverse foraminiferal assemblage ($\alpha 6$) was retrieved. Samples from overlying beds are very poor in foraminiferal content. *Rhabdammina discreta*, *Saccammina* throughout the section. The concurrent occurrences of *Trochamminoides irregularis*, *Glomospira irregularis*, *Dorothis retusa*, *Kalamopsis grzybowski* and *Rzehakina epigona* indicate that these sediments were deposited during the Paleocene. Rare specimens of rotaliids, lituolids and globigerinids were also observed from thin section (Figure 22).

Paleoecology

The agglutinated benthic foraminiferal dominated faunas and rarity of calcareous benthic and planktonic foraminifers suggest deep marine, dysaerobic sedimentation. However, the relatively high foraminiferal species diversity observed at the base of the section indicates normal marine conditions with a substrate that was occasionally oxygenated. The abundance of

Rhabdammina suggests that the basin was below the continental shelf but probably above the CCD due to the occurrence of rare calcareous forms.

Sample number (UFAYB)	Number of forams	% of planktonic forams	Species diversity	Fish teeth	Red algae	ASTRORHIZIDA	LITUOLIDA	ROTALIIDA	GLOBIGERINIDA
7	81	...	...	R	...	... R R ... R R R R ...	R R ... R ... R R R R R ...	R ... R ... R ... R ... R ...	...
6	39	...	...	...	...	... R R ... R ...	... R ... R ... R R ... R ...	...	...
5	5	...	...	...	...	R ... R ... R ...	... R ... R ...	...	...
4	...	...	...	...	...	...	...	R	...
3	...	...	...	R	...	...	...	R	R
2	45	...	...	...	...	... R ... R ... R R ...	R R ... R ... R R ... R R ...	...	R ...
1	141	0	6	R	...	... C F ... F R ... R	F R R R R C ... F C ... F F R ...	... R R ...	R
8	75	...	...	...	...	... R R ... R ... R ...	... R ... R ... R R ...	...	...

Figure 22: Foraminiferal species distributions from the Fayaux B section

CHABLAIS PREALPS

3.20 Dranse

Locality

Located along the left bank of the Dranse river between Thonon-les-Bains and Armoay, Haute-Savoie, France in the outskirts of the Chablais Prealps (Figure 1).

Previous studies

Jan du Chêne et al. (1975) established that this section is of upper Priabonian age based on dinocyst associations and does not belong to the Voirons sandstones but to the "ecailles des Flyschs Noirs" due to lithological, geophysical and biostratigraphic differences.

Lithostratigraphy

Consists of alternating shales and sandstones. Bedding is often disrupted by minor folding and slumping, particularly towards the upper part of the section. Sandstones may display groove casts on their basal surfaces, lenticular bedding and parallel laminations. Sandstones are dominated by a micritic matrix, are fine grained and often laminated (Figure 23). Authigenic glauconite and quartz grains were observed in residues from the upper part of the section. Skeletal material is also abundant within the same intervals.

Biostratigraphy

Distribution of microfossils

Foraminifers are generally rare to frequent throughout the section. Abundant occurrences of foraminifers were encountered within the uppermost part of the section. Rare, sporadic occurrences of sponge spicules, ostracods, radiolarians, fish teeth, soft coral spicules, gastropods and bryozoan, echinoid and coral debris. Red algae fragments are rare within the sandstones. The percentage of planktonic foraminifers in the rich fossiliferous samples, including UDR12 and UDR14, is high (71-90%) in contrast to UDR13 (2%) which is rich in agglutinated foraminifers (Figure 23).

The nanofossil assemblage in sample UDR13 was attributed to the NP16-NP17 zones, based on *Reticulofenestra umbilicus*, *Chiasmolithus grandis* and *Criboecentrum reticulatum*, corresponding to the P12-P15 planktonic foraminiferal zones, of the late middle Eocene. The dinocyst assemblage in sample UDR12 consisting of *Rhombodinium perforatum*, *Aerosphaeridium diktyoplokus*, *A. arcuatum*, *A. pectiniforme*, *Phthanoperidinium comatum*, *Rhombodinium draco* indicates a late Eocene age. Sample UDR2 within the lower part of the section was absent of dinocysts.

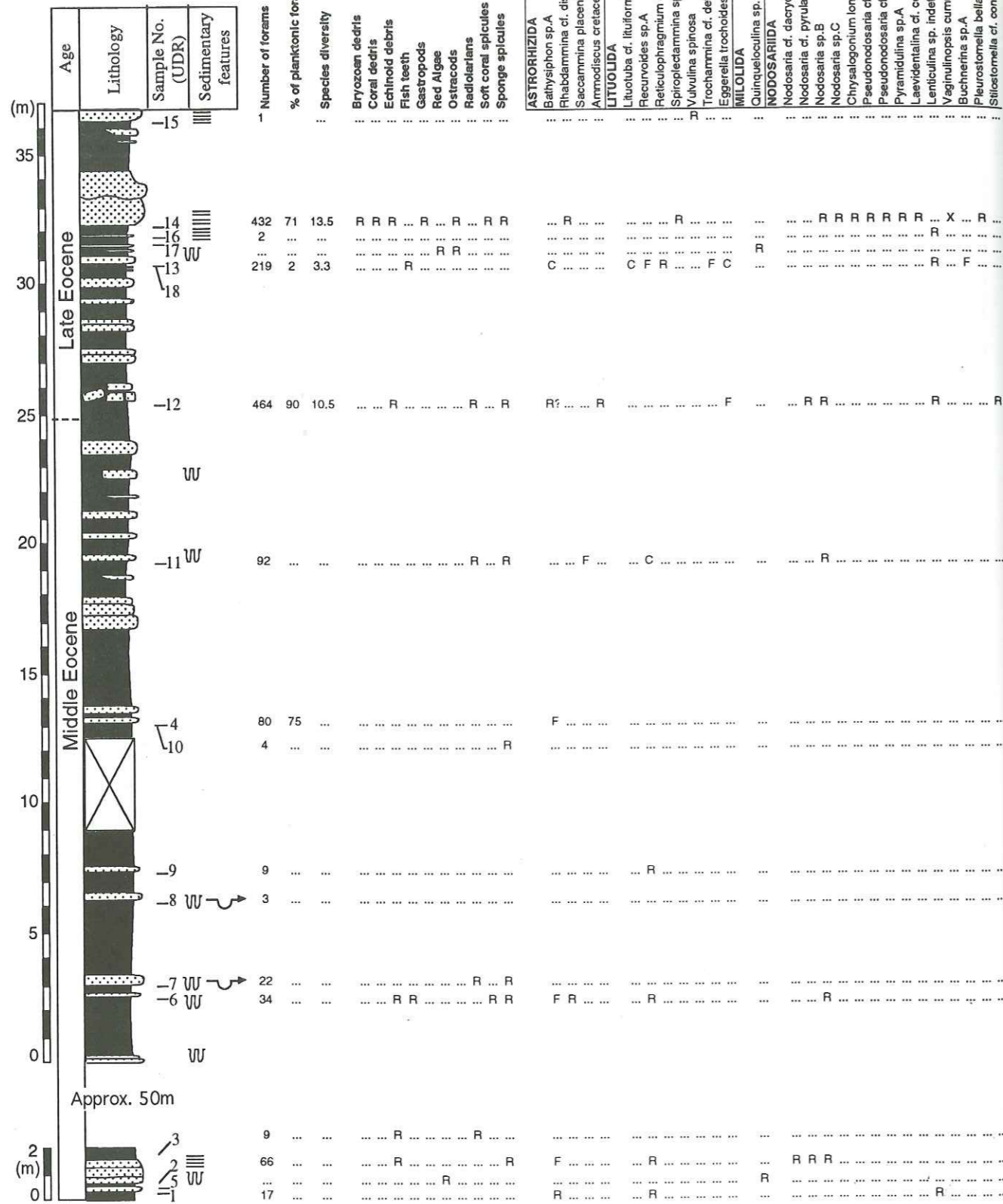
Distribution of foraminifers

Assemblages within the lower part of the section are poor and consist predominantly of small, moderately well preserved, acarinate planktonic foraminifers attributed to *A. rotundimarginata*. This species has been known to flood intervals within Caucasian Paleogene sediments which are thought to be anaerobic (Subbotina 1953, *Pers. comm.* Luterbacher 1996). Astrorhizids and lituolids dominate the benthic foraminiferal assemblages. Foraminiferal faunas within the upper part of the section (UDR12, UDR14) are abundant and highly diverse (α 10.5- α 13.5) and contain abundant globigerinids, rotaliids and nodosariids. Buliminids, astrorhizids and lituolids are very rare. Sample UDR13 also situated within the upper part of the section, is poor in planktonic foraminifers, rich in lituolids and relatively undiverse (α 3.25) (Figure 23).

Continuous, rare to common occurrences were noted for *Bathysiphon* sp.A, *Recurvoides* sp.A, *Nodosaria* sp.B, *Cibicides* sp.A and *Chilostomella cylindroides*. *Lituotuba* cf. *lituiformis*, *Trochammina* cf. *deformis*, *Eggerella trochoides*, *Buchnerina* sp.C, *Anomalinoidea affinis*, *Pararotalia* sp. indet. were frequently to commonly observed towards the top of the section (Figure 23).

Globigerina linaperta, *C. pera*, *C. unicava primitiva*, *G. increbescens*, *G. corpulenta*, *G. gr. praebulloides*, *T. cerroazulensis cerroazulensis*, *T. cerroazulensis cocoaensis* and *G. cf. semiinvoluta* were observed frequently within the upper part of the section. The presence of these species with *G. cf. tripartita*, *G. pseudoampliapertura*, *G. ouachitaensis ouachitaensis*, *G. cf. ampliaperura*, *G. cf. suteri*, *G. euapertura* and *G. cf. ciperoensis angustiumbilitata*, *G. angiporoides* and *G. venezuelana* indicates a late Eocene age, corresponding to the P16 planktonic foraminiferal zone. The absence of *Turborotalia cerroazulensis cunialensis* may suggest early P16 sedimentation. The occurrence of *A. rotundimarginata* in the lower part of the section suggests a middle Eocene age, corresponding to the P13-15 zones. *A. rotundimarginata* was also observed

DRANSE



ASTROHIZIDA	Bathysiphon sp.A	Rhabdammina cf. discreta	Saccammina placenta	Ammodiscus cretaceus
UTUOLIDA	Litucluba cf. lituiformis	Recurvirodes sp.A	Reticulophragmium cf. ampletens	Spiroplectammina sp.A
	Vulvulina spirrosa	Trochammina cf. deformis	Eggerella trochoides	
MILLOLIDA	Quinqueloculina sp. indet.			
NODOSARIIDA	Nodosaria cf. decrydium	Nodosaria cf. pyrula	Nodosaria sp.B	Nodosaria sp.C
	Chysalagonium longiscatum	Pseudonodosaria cf. hantkeni	Pseudonodosaria cf. radicola	Pyramidulina sp.A
	Laevitalina cf. communis	Lenticulina sp. indet.	Vaginulinopsis cumulicostata	Buchnerina sp.A
	Pleurostomella bellardi	Pleurostomella cf. conspurcata		

SILICOSTOMELLA	Silicostomella cf. aldophina
BULIMINIDA	Bulimina sp.A
	Globocassidulina globosa
	Praglobobulimina bathyalis
	Praglobobulimina ?pyrula
	Uvigerina ?tenuistriata
	Trifarina sp.A
ROTALIIDA	?Cibicides sp.B
	Planulina sp.A
	Cibicides sp.A
	Cibicides sp.B
	Cibicides sp.D
	Nuttallides truempyi
	Chilostomella chilostomelloides
	Chilostomella cyindroides
	Chilostomella czizeki
	Osangularia sp.A
	Heterolepa sp.B
	Heterolepa sp. indet.
	Anomalinoidea affinis
	Gyroidinoides soldanni
	Paratalia sp. indet.
	Nurmulites sp. indet.
	Patellina sp.A
GLOBIGERINIDA	Chiloberolina cf. cubensis
	Globobulimina sp. indet.
	Globobulimina increbescens
	Turbotalia cerroazulensis
	Turbotalia cerroazulensis coccaensis
	Turbotalia cerroazulensis cf. pomeroli
	Acarina bullbrookii
	Acarina rotundimarginata
	Acarina sp. indet.
	Catapsydrax dissimilis
	Catapsydrax pera
	Catapsydrax univava primitiva
	Globobulimina cf. caroselleensis
	Globobulimina cf. suteri
	Pseudohastigerina micra
	Globigerina angiporoides
	Globigerina angiporoides
	Globigerina ?ciperoensis angustilimbata
	Globigerina copulenta
	Globigerina eocaena
	Globigerina euapertura
	Globigerina linaperta
	Globigerina ouachitaensis gnaucdi
	Globigerina ouachitaensis ouachitaensis
	Globigerina praebulimoides leroyi
	Globigerina praebulimoides praebulimoides
	Globigerina pseudocampilapertura
	Globigerina pseudovenezuelana
	Globigerina venezuelana
	Globigerina cf. venezuelana
	Globigerina spp. indet.
	Globigerinatheka cf. index rubriformis
	Globigerinatheka cf. seminvoluta
	Globigerinatheka subonglobata cf. subonglobata
	Globigerinatheka sp. indet.

Figure 23: Lithological log of the Dranse section with foraminiferal species distributions

rarely within sandstone sample UDR5 and *T. cerroazulensis cerroazulensis* within sandstone sample UDR17 (Figure 23).

Paleoecology

The scarcity of fauna, presence of *Bathysiphon* sp.A, *Chilostomella* specimens and *A. rotundimarginata* indicates that the lower part of the section (samples UDR1-UDR11) was deposited in a restricted, cold, low oxygenated upper bathyal environment. The high percentage of planktonic foraminifers, high foraminiferal species diversity, presence of *Nuttallides truempyi* and *Chilostomella* spp. suggests that sediments from sample UDR12 were deposited in an upper bathyal, aerobic environment. In sample UDR13, a return to deep marine, cold, dysaerobic, upper bathyal conditions is highlighted by a low percentage of planktonic foraminifers, low foraminiferal species diversity and the presence and dominance of *Bathysiphon* sp.A and *Lituotuba* cf. *lituiformis* concurrently occurring with *Reticulophragmium* cf. *amplectens*, *Nuttallides truempyi* and *Chilostomella cylindroides*. The uppermost part of the section is marked by high foraminiferal species diversity, a high percentage of planktonic foraminifers. This with the abundant occurrence of nodosariids and rotaliids suggests that these sediments were formed in a well oxygenated, aerobic environment. The presence of *Pleurostomella bellardi*, *Nuttallides truempyi* and a rich, large planktonic foraminifers indicates upper bathyal deposition. However, the occurrence of *Pararotalia* sp., indet. *Nummulites* sp. indet. and *Patellina* sp.A, a highly diverse fauna, including bryozoan, coral, soft coral and echinoid debris and the presence of authigenic glauconite points towards more open marine, outer shelf sedimentation (Figure 23).

3.21 St. Gingolph

Locality

Located in a quarry, in the french, eastern end of Lake Geneva, near St Gingolph in the eastern part of the Front of the Chablais Prealps (Figure 1).

Previous studies

None.

Lithostratigraphy

The washed residues are predominantly composed of micaceous, carbonate lithoclasts. Very rare glauconitic grains were also observed. Two sandstone beds were sampled and reveal 30-50% quartz in a calcitic matrix.

Biostratigraphy

Distribution of microfossils

Assemblages are very poor and consist of a few agglutinated benthic foraminifers and rare pyritised burrows.

Distribution of foraminifers

The very poor foraminiferal assemblages contain rare occurrences of astrorhizids and lituolids. The presence of *Trochamminoides irregularis*, *Saccammina placenta* and *Kalamopsis grzybowski* suggests a late Cretaceous to late Paleocene age. *Discocyclusina* and *Nummulites* were frequently observed within UGD4. Globigerinids and rotaliids are also rare within the sandstones (Figure 24).

Paleoecology

The occurrence of only agglutinated foraminifers suggest that the depositional environment was possibly below the CCD, poorly oxygenated and possessed cold temperatures.

Sample number (UGD)	2	3	4	5
Number of foraminifers	10	31	...	...
ASTRORHIZIDA				
Bathysiphon sp.A	R	R	...	...
Rhabdammina discreta	...	R	...	...
Saccammina placenta	R	R	...	...
Ammodiscus cretaceus	R	R	...	...
Glomospira gordialis	R	R	...	...
LITUOLIDA				
Kalamopsis grzybowski	...	R	...	...
Trochamminoides irregularis	R	R	...	...
Trochamminoides variolarius	...	R	...	...
Recurvoides sp.A	R	R	...	...
ROTALIIDA				
Nummulites sp. indet.	...	...	R	...
Discocyclusina sp. indet.	...	...	F	...
Rotaliida indet.	...	...	...	R
GLOBIGERINIDA				
Globigerina sp. indet.	...	...	R	...

Figure 24: Foraminifera species distributions at St Gingolph

THÔNES SYNCLINE

3.22 Combes

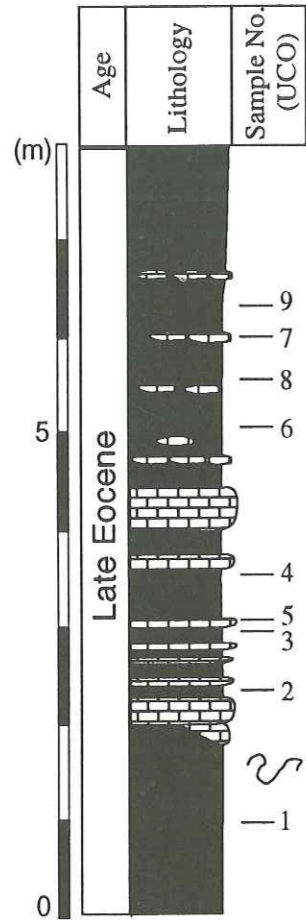
Locality

Situated along the departmental D12 road between Serraval and St. Ferréol in the eastern flank of the Thônes syncline, Haute Savoie, France (coord: 909, 39-95, 25) (Figure 1).

Previous studies

Rosset et al (1976) studied this section and indicated a late Eocene age based on planktonic foraminifers. They also listed the presence of benthic foraminiferal genera. Furthermore, they attributed this section to an Ultrahelvetic origin.

COMBES



Sample No. (UCO)	Number of forams	% of planktonic forams	Species diversity	Number of forams		% of planktonic forams		Species diversity	
				Bryozoan debris	Bivalve debris	Coral debris	Echinoid debris	Fish teeth	Ostracods	Red algae	Sponge spicules
9	270	81	8	...	...	...	...	...	...
7	...	...	...	R	...	...	...	C	...
8	284	77	11	R	R	...	...	R	F
6	280	89	5.3	...	R	...	...	...	...
4	270	93	4.5	...	R	...	...	R	R
5	...	...	...	...	...	...	...	F	...
3	293	85	5.8	R	R	...	...	R	R
2	294	84	8	...	R	...	...	R	R
1	267	89	5.5	...	R	...	...	R	R

Species Name	Sample 9	Sample 7	Sample 8	Sample 6	Sample 4	Sample 5	Sample 3	Sample 2	Sample 1
<i>Litellina</i>
<i>Planulina</i>
<i>Cibicides</i>
<i>Natalides</i>
<i>Melonis</i>
<i>Chilostomella</i>
<i>Heterolepa</i>
<i>Anomalinoidea</i>
<i>Gavelinella</i>
<i>Gyrogoninoides</i>
<i>Nummulites</i>
<i>Discocyclina</i>
<i>Asterocyclina</i>
<i>Patellina</i>
<i>Globobulimina</i>
<i>Turborotalia</i>
<i>Catapsydrax</i>
<i>Catapsydrax</i>
<i>Hasigirina</i>
<i>Globigerina</i>
<i>Globigerina</i>
<i>Globigerina</i>
<i>Globigerina</i>
<i>Globigerina</i>
<i>Globigerina</i>
<i>Globigerina</i>
<i>Globigerina</i>
<i>Globigerina</i>
<i>Globigerina</i>
<i>Globigerina</i>
<i>Globigerina</i>

Figure 25: Lithological log of the Combes section with foraminiferal species distributions

Lithostratigraphy

The section is represented by chaotic facies, including calcareous shales, conglomerates, microbreccias, calcarenitic intervals (displaying lenticular bedding) and sandy horizons (Figure 25). Skeletal material is abundant throughout the section. Calcarenitic beds often show a packstone petrography, consisting of 60-70% bioclasts.

Biostratigraphy

Distribution of microfossils

Foraminifers are common throughout the section and form the largest proportion of the microfossil assemblages. Planktonic foraminifers constitute 60-93% of the foraminiferal assemblages. Ostracods, fish teeth, sponge spicules, echinoid and coral debris, bryozoan and bivalve fragments were observed rarely and sporadically within the section. Red algae was very commonly observed from thin section (Figure 25).

Distribution of foraminifers

Foraminiferal assemblages are highly diverse (α 4.5-11) throughout the section and consist predominantly of globigerinids. Rotaliids are the most frequent group of benthic foraminifers. Nodosariids and litiolids are also frequent whilst astrorhizids, robertinids and buliminids are generally rarer in comparison.

Cibicidoides sp.A is the commonest benthic species and is found rarely to commonly throughout these sediments. *Bathysiphon eocaenica*, *Vulvulina haeringensis*, *Vulvulina spinosa*, *Marsonella oxycona*, *Laevidentalina* cf. *communis*, *Lenticulina* sp.A, *Heterolepa dutemplei*, *Heterolepa* sp.B, *Gyroidinoides soldanni* and *Hanzawaia ammophila* were observed rarely to frequently throughout the section. Frequent occurrences of *Hoeglundina elegans* at the base and *Gavelinella acuta* within the upper part of the section were noted. *Nummulites*, *Discocyclina* and *Asterocyclina* are common in thin section (Figure 25).

Planktonic foraminifers are moderately well preserved and are often compressed due to post deposition tectonic forces. *T. cerroazulensis cerroazulensis*, *C. pera*, *C. unicava primitiva*, *G. eocaena*, *G. linaperta* and *G. index index* were recovered frequently to commonly throughout the section. *G. venezuelana* was also observed rarely but continuously throughout the section. The presence of these species with *G. increbescens*, *G. angiporoides*, *G. gr. index*, *G. cf. semiinvoluta* and *G. subconglobata luterbacheri* suggests a late Eocene age pertaining to P15-early P16 planktonic foraminiferal zones (Figure 25).

Paleoecology

The presence of diverse foraminiferal assemblages, high percentages of planktonic foraminifers and *Pleurostomella alternans*, *Nuttallides truempyi*, *Hanzawaia ammophila*, *Heterolepa dutemplei*, *Melonis* sp., *Hoeglundina elegans*, *Chilostomella cylindroides* and *Bathysiphon eocaenica* indicates a well oxygenated, open marine, upper bathyal depositional environment for the sediments attributed to the lower part of the section (Combes1-5, UCO1-2) (Figure 25). Diverse foraminiferal assemblages, high percentages of planktonic foraminifers and

the concurrent occurrence of *Pullenia quinqueloba*, *Patellina* sp.A, *Nummulites* spp. with *Hanzawaia ammophila*, *Heterolepa dutemplei*, and *Bathysiphon eocaenica* suggests that sediments from the upper part of the section (UCO3-9) were deposited in a well oxygenated, open marine, outer neritic environment (Figure 25).

3.23 Marais

Locality

This section occurs along the Marais creek (coord: 911.1-96.0, 650-665m), southwest of Serraval, and about 25km southeast of Annecy, in the western part of the Sulens Klippe, Ultrahelvetic Prealps, Haute Savoie, France (Figure 1).

Previous studies

This section was first studied by Miglietti (1986). Kindler et al. (1995) studied the Grésoglaucouneuse Formation, previously attributed to the Aptian-Albian, and assigned a middle Eocene age on the basis of planktonic foraminifers.

Lithostratigraphy

A sample was collected from the Calcaires marneux plaquetés Formation which forms less than 2m of thin bedded calcareous shales which overlie the Grésoglaucouneuse Formation. A few samples were sporadically collected from the thick overlying, flysch succession which consists predominantly of alternating sandstone beds intercalated by shaly horizons (Figure 26)..

Biostratigraphy

Distribution of microfossils

Foraminifers are the most frequent skeletal component in the residues. Planktonic foraminifers form 76% of the foraminiferal assemblage in sample KS44 from the Calcaires marneux plaquetés formation. Foraminifers are rarer within the overlying flysch sediments. Ostracods are very rare within both the Calcareous shales and flysch formations. Nannofossils from sample KS44 were attributed to the NP16 zone, defined by the presence of *Criboecium reticulatum* and *Sphenolithus furcatolithoides* which is equivalent to the P12-P13 planktonic foraminiferal zones.

Distribution of foraminifers

The rich foraminiferal assemblage in sample KS44 is highly diverse (α 10.75) and consists predominantly of very large, well preserved globigerinids. *Globigerina linaperta* is very common and *C. pera*, *C. unicava primitiva*, *G. eocaena* and *G. venezuelana* are frequent. Rotaliids and nodosariids are frequent and litiolids and buliminids rare. *Nodosaria* sp.C, *Laevidentalina* cf. *communis*, *Cibicides* sp.A, *Cibicides* sp.B and *Melonis* sp.A are the most frequent species in this interval (Figure 26).

The presence of *A. bullbrooki*, *G. cf. pseudoampliapertura*, *G. eocaena*, *T. cerroazulensis cerroazulensis*, *C. pera*, *H. alabamensis* and *G. venezuelana* confine the Calcareous shales to zones

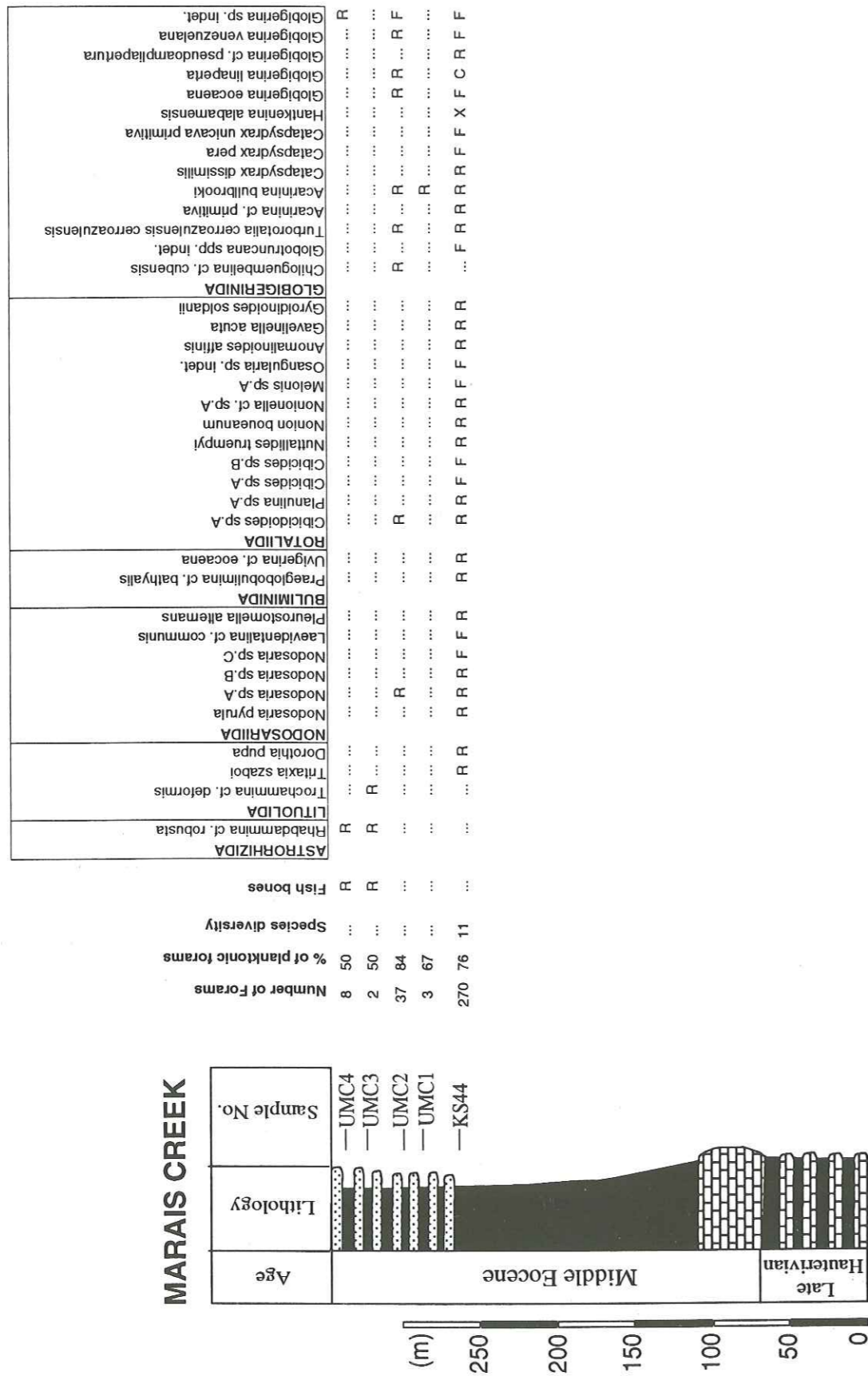


Figure 26: Schematic log of the Marais Creek section with foraminiferal species distributions

P12-P14 of the middle Eocene. The presence of *A. bullbrooki* and absence of younger elements suggests that the superimposed flysch sediments were deposited also during the same period as the Calcareous shales Formation (Figure 26).

Paleoecology

The high foraminiferal species diversity, high percentage of large planktonic foraminifers, presence of *Nuttallides truempyi*, *Pleurostomella alternans* and *Melonis* sp. suggests that the Calcareous shales at Marais were deposited in a well oxygenated, upper bathyal environment (Figure 26).

The presence of *Rhabdammina* cf. *robusta* and rarity of microfossils in the upper part of the flysch formation indicates that these sediments were deposited in a restricted, dysaerobic, deep marine, bathyal environment.

3.24 Nantbellet

Locality

Located along the St Ferréol to Nantbellet road (coord: 910, 0-93, 6, 850-920m), in the Sulens Klippe, Ultrahelvetic Prealps of the Haute Savoie, France (Figure 1). Two samples were derived from along the road, whilst other samples were retrieved from a creek which descends from the road (910, 0-94, 0, 905m).

Previous studies

First examined by Charollais et al. (1970) and later revised by Charollais et al. (1981). The Calcaires plaquetés Formation was considered as a set of tectonic slices. However, the blocky shape of the upper Cretaceous limestone beds, as well as the absence of any evidence of faulting, suggests that this interval represents a slump facies at the base (Kindler et al. 1995).

Lithostratigraphy

All except one sample, from the overlying flysch, were derived from the Calcaires plaquetés Formation (Figure 27). Washed residues contain abundant skeletal material consisting principally of foraminifers, rare to abundant proportions of pyrite, glauconite, carbonate, mica and quartz. Glauconite is generally of an authigenic type and often forms the internal moulds of microfossils.

Biostratigraphy

Distribution of microfossils

Moderately well preserved foraminifers are common throughout the section. Planktonic foraminifers form generally more than 60% of the foraminiferal assemblages apart from in samples UNB1 and UNB6 where they constitute only 30% of the assemblages. Bivalve fragments, sponge spicules, fish teeth, radiolarians and ostracods are also rarely and sporadically distributed (Figure 27).

Distribution of foraminifers

Globigerinids and rotaliids represent the largest components of the foraminiferal assemblages throughout the section. Nodosariids and litiolids are generally rare though present throughout. However, litiolids and nodosariids are common and frequent respectively in sample UNB6. *Ammodiscus cretaceus*, *Tritaxia szaboi*, *Cibicidoides* sp.A, *Cibicides* sp.A, *Anomalinoidea affinis* and *Gyroidinoides soldanni*, occur rarely to commonly throughout the section (Figure 27).

A. bullbrooki, *M. aragonensis*, *C. pera* and *G. linaperta* are the most frequently distributed planktonic foraminifers throughout the section. Morozovellids, which in part are probably reworked, are more frequent here within the Calcareous shales Formation in comparison to equivalent sediments within the Marais creek section. The occurrence of *A. bullbrooki*, *A. broedermanni*, *C. pera*, *P. renzi*, *T. cerroazulensis*, *G. unicava*, *G. venezuelana* and *G. yeguaensis* indicates that these sediments are of middle Eocene age, equivalent to the P12 planktonic foraminiferal zone. Early Eocene reworking is represented by *A. soldadoensis*, *A. pseudotopilensis* and *M. aragonensis* (Figure 27).

Paleoecology

The presence of a high percentage of planktonic foraminifers (80%), high foraminiferal species diversity ($\alpha 10.5$), frequent occurrence of *Rhabdammina discreta* and occurrence of *Pleurostomella alternans* suggests that sample KS54 was deposited in a well oxygenated, upper bathyal environment (Figure 28).

The presence of a high percentage (67%) of planktonic foraminifers, high foraminiferal species diversity ($\alpha 14$) and presence of *Pullenia quinqueloba* indicates a well oxygenated, outer neritic depositional environment for sample KS8 (Figure 28).

The occurrence of abundant *Nummulites* sp. indet. specimens, low percentage of planktonic foraminifers, low foraminiferal species diversity suggest that the lowermost part of the section was deposited in an inner neritic environment. Throughout the remainder of the section, the generally high foraminiferal species diversity, percentage of planktonic foraminifers, sporadic occurrences of *Nummulites* sp., *Heterolepa dutemplei* and scarcity of bathyal forms, indicates that deposition probably continued to occur on a well oxygenated shelf, in the outer neritic zone.

4. PROBLEMS ASSOCIATED WITH BIOSTRATIGRAPHY AND PALEOECOLOGY OF PALEOGENE DEEP WATER SEDIMENTS

4.1 Reworking

Post-mortem influences modify the ideal fossil assemblage in respect to what is recovered in the sediment. The processes involved are transport, mixing and the destruction of tests. The reworking of foraminiferal tests is the result of these processes and can lead to serious problems in biostratigraphic and paleoecologic interpretations. However, reworking may often be identified within foraminiferal assemblages with the use of well established planktonic foraminiferal zonation e.g. Caron (1985), Tourmakine & Luterbacher (1985) and Bolli & Saunders (1985). It is possible to determine the presence of reworked planktonic foraminifers using the known stratigraphic ranges derived from these standard zonation. Reworking of Aptian-Albian planktonic foraminifers into a middle Eocene basin were observed from the Marais creek and Nantbellet sections (Kindler et al. 1995). Up to 99% of the assemblages consist of reworked planktonic foraminifers, emphasizing the difficulty of recognizing reworking processes in fine grained sediments. The first and last occurrences for Tertiary smaller benthonic foraminifers may also be used but with more caution as they are geographically and bathymetrically more easily constrained. However, a number of zonation for benthic foraminifers remain useful and complementary to planktonic foraminiferal biozonations. Reworked Tertiary smaller benthic foraminifers may also be determined by preservation and the occurrence of coexisting reworked planktonic foraminifers.

In deep marine environments, microfossils may be transported in suspension by freshwater plumes occupying the upper part of the water column. For example, near the mouth of Mobile Bay, Gulf of Mexico, fresh water rides over salt water in a lens up to metres thick extending laterally for over 50 km. Haig (1994) studied Pliocene foreland basin sequences in Papua New Guinea which contained Cretaceous nannofossils, dinocysts together with well preserved Pliocene foraminifers. He suggested that the reworked nannofossils and dinocysts were probably derived from onshore Cretaceous formations and transported, due to their light weight, by rivers to the basin whilst heavier material including Cretaceous foraminifers remained onshore in the rivers' bedload. Bottom currents may also resuspend fossils usually less than 200 μ m depending on oceanic stability. Tests may remain in suspension as long as there is sufficient turbulence to keep them there. Von Daniels (*pers. comm* 1995) has also found in Paleogene sediments from northern Germany, that foraminiferal biostratigraphy often provides the youngest ages in comparison to nannofossils and dinocysts. Berger (1992 and 1995) also pointed out the possibility of attaining reworked nannofossils, dinocysts and foraminifers in molasse sediments and compared the advantages and disadvantages of each group.

The micropaleontological results from the Voiron sandstones emphasizes the complexity of reworking phenomena. At Bons, early Eocene microfossils are more abundant than those of middle Eocene age. This can be simply explained by turbidity- or contour-current reworking of early Eocene material into a middle Eocene basin. At Fillinges, late Eocene forms are predominant in the

foraminiferal assemblage (older forms are rare), whereas Paleocene to early Eocene forms represent the bulk of the palynomorph and nannofossil assemblages (younger forms are rare). The reworking process is therefore more complex, and could involve offshore transport of fine grained material (Paleocene to early Eocene palynomorphs and nannofossils) by fresh-water surface plumes from river discharge to distal parts of a late Eocene basin, whereby the sediment was further remobilized by turbidity currents. The rarity of Paleocene to early Eocene foraminifers in our assemblages could then be explained by the settling out of heavier particles from the fresh-water plumes close to the river mouth, upstream from the source area of turbiditic material (Figure 29).

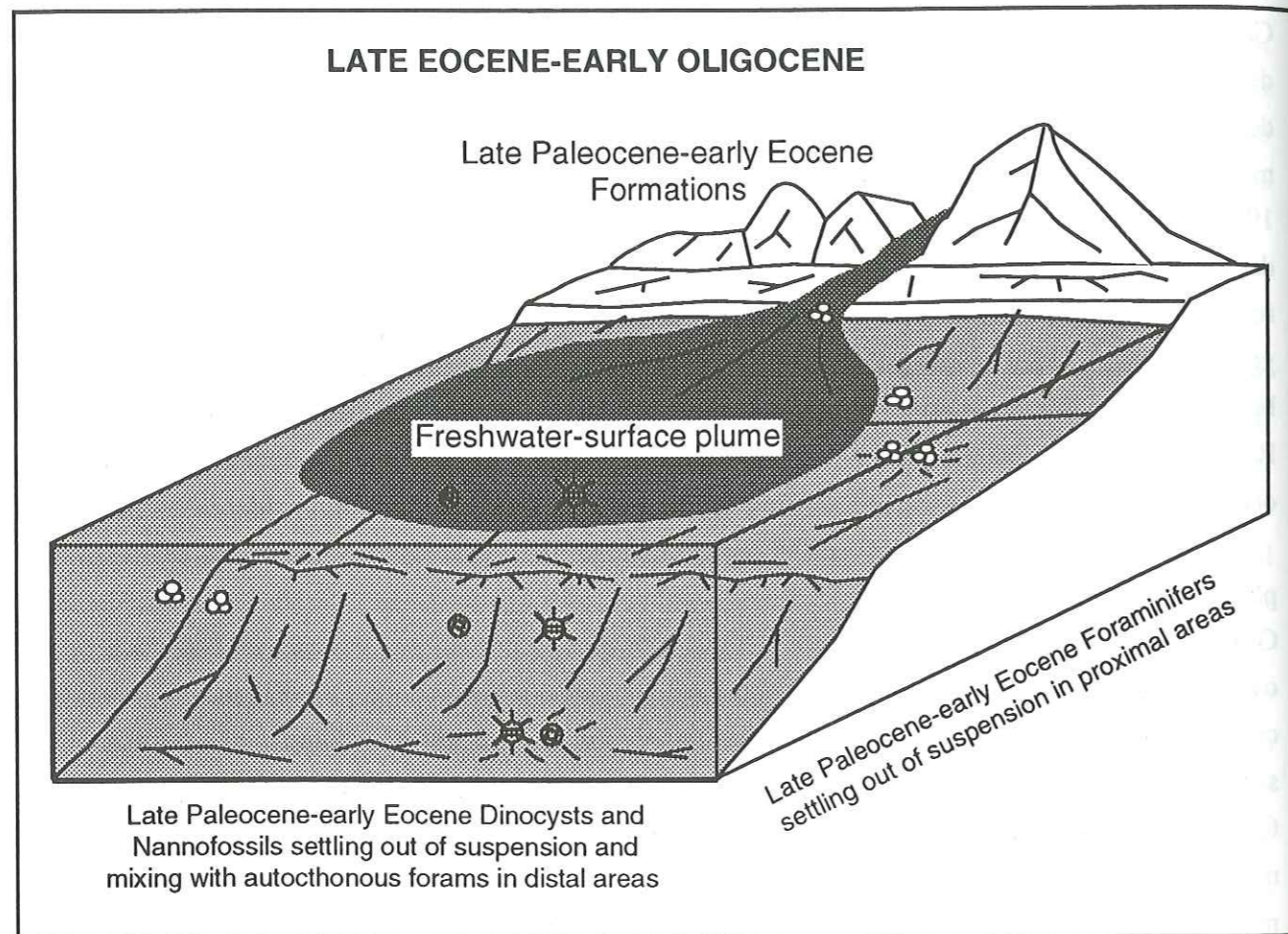


Figure 29: Freshwater-surface sedimentary plume; reworking fine-grained material from the continent out into the late Eocene-early Oligocene basin.

At Bellevue, nannofossils and dinocysts define a late Eocene age in contrast to an early-middle Oligocene age as defined by the planktonic foraminifers. Krhovský (*Pers. comm.* 1996) believes that recognition of early Oligocene nannofossils is a typical problem in early Oligocene nannofossil biostratigraphy. The NP20/NP21, NP21/NP22 and NP22/NP23 biozone boundaries are defined by the last occurrences of index species. In the case of redeposition of these index species in the early Oligocene the true biozones cannot be recognized. Pairis (1988) also emphasized the difficulty of distinguishing the Eocene-Oligocene boundary with nannofossils, doubting the age determinations in

Lateltin & Müller (1987). Charollais et al. (1980) also concluded that nannofossil zonation was unapplicable to the Oligocene Foraminiferal marls and Meletta shales due to the rarity or absence of markers.

The presence of Eocene nannofossils and dinocysts could also be the result of fresh-water plume deposition. The absence of Oligocene dinoflagellates and nannoplankton may be explained by the fact that they were unable to support the turbid, surface waters and were therefore absent from the water column. The freshwater located at the surface may have been a reason for their absence. In contrast, planktonic foraminifers were able to adapt to deeper parts of the water column. Alternatively, they occupied the overlying water column, but either the abundance of Paleocene dinocysts and nannofossils obscured their presence, or bottom currents prevented them from being deposited due to their light weight.

Mixing of assemblages may also be due to bioturbation. Downward movement can be caused by surface material falling into open burrows (Murray 1991). This could be important for the deposition of the Gurnigel and Voirons flysch where trace fossils are extremely abundant.

4.2 Dissolution

Flysch are sediments accumulated in deep sea canyons, slopes and on deep sea basin floors (Homewood & Lateltin 1988). Dissolution occurs commonly in deep marine environments and therefore influences the composition of microfossil assemblages from flysch deposits. Berger (1971) estimates that from 6-10% of the living population of planktonic foraminifers leave empty tests every day, mostly as a result of reproduction. These tests settle quite rapidly and are less susceptible to dissolution than coccoliths (which lack organic outer layers), except when they approach the carbonate lysocline. The level connected with depth and reflecting a sharp increase in dissolution rate of carbonate on the sea bottom is the carbonate lysocline (CL). The boundary between carbonate and noncarbonate sediments is associated with an increase in the rate of solution of calcium carbonate; the Carbonate compensation depth (CCD). Studies of the distribution patterns of planktonic foraminifers has made it possible to establish the existence of another bathymetrically higher level; the foraminiferal lysocline (FL). Pronounced changes in planktonic foraminiferal assemblages, due to selective dissolution, are confined to this level. Biological productivity, planktonic foraminiferal productivity, dilution of biogenic noncarbonate and terrigenous material, rate of sedimentation, water chemistry and bottom water circulation patterns are the main factors influencing the FL, CL and CCD changes and the vertical range of zones between these levels (Belyaeva & Burmistrova 1985) (Figure 30). Fluctuations in the depth of the CL during Mesozoic and Cainozoic times are now known to have caused cycles of deposition and dissolution (Berger 1973), selectively removing some of the smaller or more delicate forms and rendering the fossil record of the deep sea much less complete than might be wished.

Hyaline tests undergo a progressive series of changes when subject to dissolution. Initially, the surface acquires a dull texture and becomes opaque through etching, this then becomes pitted and the chamber walls begin to break. This seems to be a common effect with foraminiferal assemblages from Oligocene sediments e.g. Bellevue, Dessy, Sage, Venay and Vacherie sections. Carbonate

dissolution is most common in ocean basins but is also known to take place in some shelf seas (Alexanderson 1978).

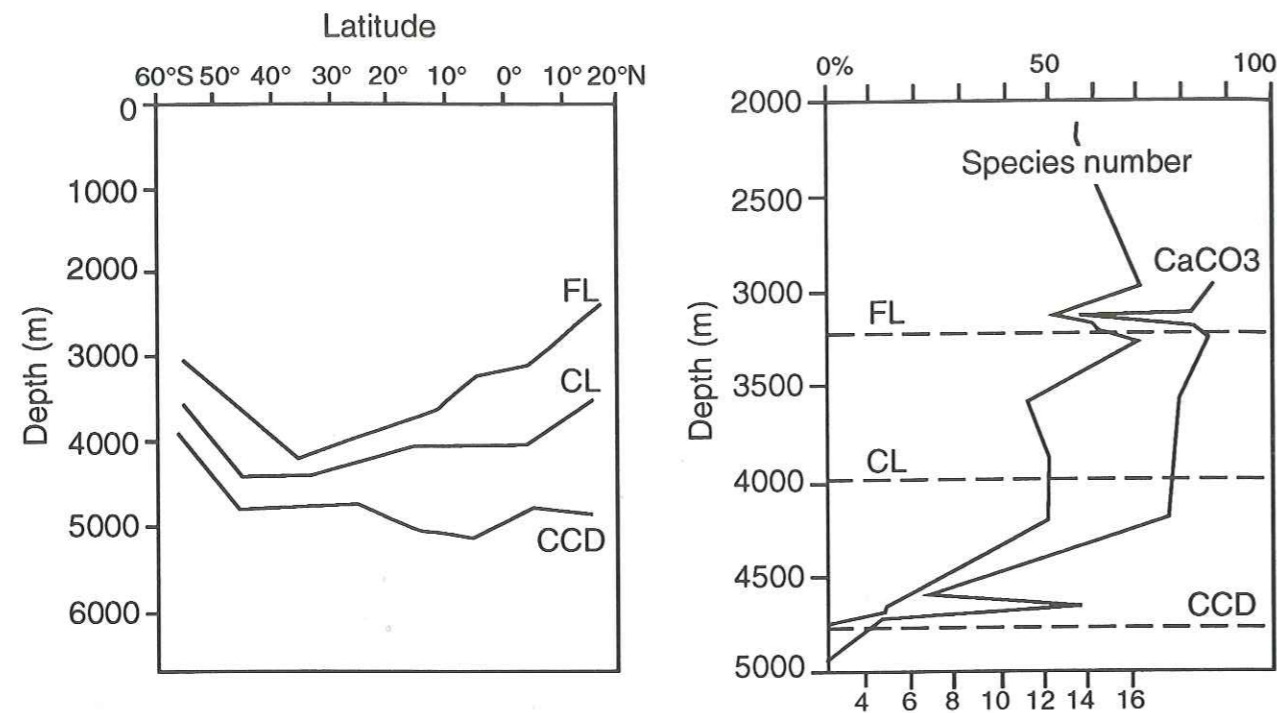


Figure 30: Foraminiferal and Carbonate lysoclines and Carbonate Compensation depths, number of planktonic foraminiferal species and calcium carbonate V's depth trends in the Indian Ocean (Modified after Belyaeva & Burmistrova 1985).

4.3 Tectonism

Flysch and Molasse sediments were related to pre and post-collision orogeny. Along the Alpine front of the Western Alps, the change in regime from flysch to molasse (i.e. from trench and forearc or retro-arc, to foreland basin deposits) suggests that a major deep-seated inversion structure was situated near the Helvetic-Ultrahelvetic boundary (Homewood & Lateltin 1988). Major sedimentary basins were being modified as a result of compression, flexural loading, subsidence and extension during flysch and molasse sedimentation. As a consequence, foraminiferal tests are often slightly to greatly compressed and deformed due to existing tectonic forces. This is most common within flysch and widflysch successions e.g. Bellevue, Fiol and Combes. Planktonic foraminifers seem to be more easily affected. This is often a problem at species level, where well preserved features such as test, chamber and aperture shape are essential.

If reworking, dissolution and tectonism are not taken seriously into account, incorrect biostratigraphic and paleoecologic interpretations are made. Possible identification of the amount of reworking may only be recognized when several biostratigraphic tools (e.g. foraminifers, nannofossils and dinocysts) are employed e.g. Fillinges and Bellevue sections. These problems also

have a direct effect on the degree of preservation of the foraminiferal tests. Preservation may also be an important means in recognizing reworking, dissolution and tectonism particularly within fine grained sediments where macro sedimentary structures are usually absent. For example, well preserved internal moulds composed of pyrite, limonite or dark clays may be distinguished from reworked calcareous tests. Therefore, these problems may often be detected and can serve as indicators of autochthonous assemblages.

5. MAJOR FORAMINIFERAL TRENDS: A BASIS FOR PALEO GEOGRAPHIC RECONSTRUCTION

The principal biostratigraphic and paleoecologic results from this study, which represent a basis for paleogeographic reconstruction, are broadly illustrated in figure 31.

5.1 Early-Middle to late Paleocene

5.1.1 Biostratigraphy

Early-middle Paleocene sediments in the Voiron massif contain unique, rich, diverse calcareous benthic assemblages and abundant planktonic foraminiferal assemblages. However, the planktonic foraminiferal assemblages display low species diversity and have been observed within the early Paleocene of tropical, Mediterranean and southern Alpine regions (e.g. Bolli 1957, Delteil & Toumarkine 1975, Luterbacher 1964, 1975). Paleocene planktonic assemblages occur in the North Sea and in Denmark, but are scarce or absent in other parts of the northwest European basin (Spiegler et al. 1988).

Paleocene faunas documented from the Alpine domain are usually composed of typical flysch-type benthic agglutinated foraminiferal assemblages or DWAF (Deep water agglutinated foraminiferal faunas). The Signal Voiron B section includes numerous species of buliminids and rotaliids representing a variation in the composition of typical Paleocene alpine faunas. Only half of the 38 benthic species recorded from this section, are agglutinated. This benthic fauna possesses similarities with Atlantic-Tethyan Paleocene faunas and supports Berggren & Aubert's (1975) statement that the Paleocene was the last period of worldwide similarities of benthic microfauna after the late Cretaceous. A few of these species were also recorded from northern Italy (Braga et al. 1975).

The Fayaux sections which are considered of late Paleocene age, represent typical Alpine DWAF. Twenty nine foraminiferal species were recorded from the Fayaux and Signal Voiron A sections including 10 astrorhizid, 14 lituolid, 4 rotaliid and 1 globigerinid species. The assemblages are characterised by *Rhabdammina discreta*, *Saccamina placenta*, *Trochamminoides irregularis*, *Kalamopsis grzybowskii*, *Rzehakina epigona* and *Recurvoides* sp.A and have been previously observed from the Gurnigel and Schlieren flysch (Brouwer 1965, Van Stuijvenberg 1981, Winkler 1983). Although the faunas are poor at St. Gingolph, they appear to be closely associated to the *Rhabdammina* dominated assemblages observed at Fayaux. Other major studies which also record many of these species from the Carpathians, North Sea, Labrador Sea and northern Morocco include Geroch & Nowak (1983), Gradstein & Berggren (1981), Gradstein et al. (1988), Kaminski et al. (1988, 1990, 1996), Charnock & Jones (1990), Kuhnt & Kaminski (1990), Kaminski & Geroch (1993).

5.1.2 Paleoecology

The early-middle Paleocene, represented by the Signal Voiron B section in the Voiron massif, is represented by a rich calcareous hyaline fauna, composed predominantly of globigerinids.

The rarity of biserial heterohelicid planktonic foraminifers suggests that the water column was well oxygenated (Boersma & Premoli Silva 1987) despite a most likely dysaerobic sea floor indicated by agglutinated assemblages. The presence of rotaliid and buliminid species including *Aragonia velascoensis*, *Bulimina trinitataensis*, *Pyramidina rudita*, *Nuttallides truempyi*, *Pullenia quinqueloba* and *Pullenia* cf. *bulloides*, typical of middle-lower bathyal depths (Tjalsma & Lohmann 1983, van Morkhoven et al. 1986), were also recorded from the Atlantic (Tjalsma & Lohmann 1983).

"*Rhabdammina*" faunas have a cosmopolitan distribution and occur principally in orogenic belts with a strong terrigenous influence (Brouwer 1965, Gradstein & Berggren 1981). They are generally thought to be controlled by deep-water, cool, low oxygenated abyssal sedimentation (Brouwer 1965, Van Stuijvenberg 1981, Winkler 1983). Ksiazkiewicz (1975) and Jurkiewicz (1967) interpreted bathyal depths above the CCD around 1000m for Carpathian flysch. However, Moorkens (1976) suggested that the composition, pH and Eh values of the sediment further control the composition of these assemblages. Gradstein & Berggren (1981) also highlighted that paleobathymetry may not be the key factor controlling the presence of flysch-type faunas, although great depth below a CL or CCD creates favourable conditions (rapid deposition of organic-rich fine grained clastics, restricted bottom water circulation leading to low pH and Eh values) for these assemblages. They also suggested that minimum water depth to maintain these conditions is thought to be in the order of 200m, well below wave base. Nevertheless, the composition of the late Paleocene assemblages from the Voiron massif and Romand Prealpine front indicate an orogenic associated, cool, dysaerobic and deep water fauna.

5.1.3 Palaeogeographic implications

The Voiron sandstones in the Signal Voiron B region were deposited in part during the early-middle Paleocene but under shallower, more oxygenated conditions in comparison to the Gurnigel flysch deposits at Fayaux. The deep water Penninic basin probably possessed shallow water zones which were influenced by Atlantic-Tethyan waters. Benthic species retrieved from this area, form components of a much more diverse Atlantic-Tethyan "Velasco-type" fauna defined by Berggren & Aubert (1975) and illustrate Atlantic influence on the area during this time. As these authors suggested, the fact that many Paleocene species are found on both sides of the Atlantic and throughout the Tethys indicates that the Tethys was a corridor for some species, a filter for some and a barrier for others.

Gramann & von Daniels (1988) emphasized that Paleocene sediments possessing a *Rhabdammina* biofacies in northwestern Europe were confined to stagnant parts of the basin as their first sedimentation cycle during the early to middle Paleocene was generally composed of warm, shallow water marine and deeper epibathyal facies in the North Sea. Evidence of midway-type faunas, of outer neritic to upper bathyal depths, in northern Europe occurred in the late Paleocene-early Eocene. At this time the alpine regions were undergoing more isolated, stagnant, deeper water deposition.

5.2 Middle Eocene

5.2.1 Biostratigraphy

The foraminiferal faunas derived from the Bons section represent the first middle Eocene residual assemblages observed within the Voirons massif. The planktonic foraminiferal assemblages, are composed of numerous *Globigerina*, *Acarinina* and *Morozovella* species and are very similar in species composition to the early Eocene faunas described by Hillebrandt (1976) in the SE of Spain. *Catapsydrax*, *Globigerinatheka*, *Chiloguembelina* and *Hastigerina* forms are rare.

The middle Eocene within the Sulens Klippe contain diverse, rich assemblages consisting predominantly of *Catapsydrax pera*, *Catapsydrax unicava primitiva* and *Acarinina bullbrookii* and are very similar to those of Mediterranean provinces (Delteil & Toumarkine 1975, Toumarkine & Luterbacher 1985). The assemblages are highlighted by the rare presence of *H. alabamensis*. Toumarkine & Bolli (1975) observed this species from the middle and late Eocene of northern Italy and suggested that tropical zonations remain valid for areas north of the Mediterranean. However this species is very rare throughout the Eocene in the studied region. *Turborotalia* gr. *cerroazulensis* and *Pseudohastigerina micra* were also rarely observed and seemed to become more significant in the region during the late Eocene.

The lower part of the Dranse section, in the prealpine front of the Chablais Prealps, contains assemblages dominated by small *Acarinina* planktonic foraminifers. The most common species is affiliated to *Acarinina rotundimarginata*. This species forms an important upper middle Eocene subzone from the Caucasus mountains (Subbotina 1953, Berggren 1960).

5.2.2 Paleoecology

The middle Eocene assemblages from the Voirons massif are indicative of deep water, well oxygenated, bathyal assemblages. They are more diverse and contain higher percentages of planktonic foraminifers in comparison to the studied Paleocene assemblages from the Fayaux sections. The benthic assemblages contain some reworked shelf forms mixed with autochthonous, deeper water nodosariids, rotaliids, astrophorids and litiolids. The planktonic assemblages combined with the presence of a rich calcareous fauna, including *Nuttallides truempyi* and *Pleurostomella* sp.A, absence and rarity of miliolids and buliminids suggests a more oxygenated, shallower water depositional environment in comparison to the Paleocene assemblages from the Romand Prealpine front. The frequent occurrence of pleurostomellids and stilostomellids, as suggested by Berggren & Aubert (1975) became significant in the middle Eocene. Warm surface waters are suggested by the abundance of morozovellids and rarity of chiloguembelinids (Boersma & Premoli Silva 1989, 1991).

The middle Eocene sediments from the Sulens Klippe contain smaller foraminiferal assemblages indicative of warm, well oxygenated, outer neritic to upper bathyal environments. Large acarininids form the dominant planktonic group. The benthic assemblages consist of large, thick-walled nodosariids and rotaliids. Agglutinated forms became less significant within the area during this time. The occurrence of *Acarinina* and *Hantkenina* indicates the presence of warm waters.

The upper middle Eocene exhibits a dysaerobic, cool water fauna, at least within sediments from the Chablais prealpine front, indicated by the occurrences of small *Acarinina* dominated

assemblages (Subbotina 1953, Luterbacher *pers. comm.* 1996). Also the presence of astrophorids, litiolids and chilostomellids indicate cool, dysaerobic, bathyal conditions representing a change in environmental conditions within sediments from the Voirons massif and Sulens Klippe (Nantbellet unit) from more oxygenated, neritic-upper bathyal, during the early part of the middle Eocene, to more restricted, dysaerobic, bathyal conditions. The development of cooler water assemblages in the area may represent the Bartonian-Priabonian event which occurred around the P14-P15 boundary, which was the second event of a series of stepwise cooling events, after the predominantly warm early and middle Eocene, leading up to the Eocene-Oligocene boundary (Prothero 1989).

5.2.3 Palaeogeographic implications

The occurrence of middle Eocene, well oxygenated, bathyal assemblages from the Bons section, until now attributed to the Voirons sandstones, indicates that these sediments either 1) belong to the Voirons flysch but possess a different paleogeographic origin, at least in comparison to typical Gurnigel flysch, or 2) represent a tectonic slice of Ultrahelvetic origin, as Lombard (1940) suggested, within the Prealpine mélange and is separated from the main body of the Voirons flysch.

Gramann & von Daniels (1988) noted that the middle Eocene, defined by their B4 zone, is based on a widespread development of calcareous sediments with diverse foraminiferal faunas in most of northern Europe. The middle Eocene was a period of extensive shelf sedimentation in the Helvetic domain/Alpine foredeep (Herb 1988, Ziegler 1990). Similarities in benthic faunal composition with other European regions were observed (Sztrakos 1987, 1993).

Although possibly younger in age, the lower part of the Dranse section contains foraminiferal assemblages lower in abundance and diversity in comparison to the middle Eocene assemblages from the Voirons massif and Sulens Klippe, suggesting a different paleogeographic provenance.

5.3 Late Eocene

5.3.1 Biostratigraphy

Events occurring around the Eocene-Oligocene boundary are well documented in the literature. It seems that it was not a catastrophic event nor was it characterised by mass extinctions but is defined rather by the overturn of calcareous planktonic and benthic foraminifera (Corliss 1981, Corliss et al. 1984, Pomerol & Premoli Silva 1986, Premoli Silva & Boersma 1988, Prothero 1989, Prothero & Berggren 1992). This period consisted of stepwise extinctions due to a decrease in temperature and enhanced changes in the trophic resources and euphotic habitats which were the results of climatic change. The well described Terminal Eocene event which occurred around the P17-P18 boundary was actually marked by few extinctions amongst the foraminifers and rather was the result of an increase in the dominance of cold water opportunistic forms (Corliss 1981, Corliss et al. 1984, Keller 1983, Prothero 1989, Boersma & Premoli Silva 1991).

The assemblages from the Böège marls in the Voirons massif are generally poor in abundance and diversity. The planktonic assemblages consist of small globigerinid (e.g. *Globigerina* gr. *praebulloides*) species, which also occur commonly during the Oligocene. Variation in benthic composition is observed by fluctuations between agglutinated and calcareous dominated faunas.

Assemblages at Fillinges consist predominantly of calcareous benthics, including *Chilostomella*, *Praeglobobulimina* and *Nonionella* as well as agglutinated forms and small globigerinids and bear close similarities with the early Oligocene Bavarian, Austrian and Subalpine Molasse (Rieser 1987, Wenger 1987, Dohmann 1991, Rögl 1994, Ujetz et al. 1994).

The upper late Eocene is defined by the *Turborotalia cerroazulensis* zone, and although rare, is recognized within the Combes section, Sulens Klippe and from the Fiol section, Voirons massif confirming its validity within the studied region. However, *Turborotalia cerroazulensis cunialensis* was never observed probably due to its very thin carbonate test which is often subjected to dissolution. It may also suggest that the sediments that were assigned to the late Eocene, corresponding to the P15-P17 planktonic foraminiferal zones may be more closely attributed to the late P16-P17 zones. The extinction of *Turborotalia cerroazulensis cunialensis*, *Turborotalia cerroazulensis cocoaensis* and the Hantkeninidae are used to indicate the Eocene-Oligocene boundary from the Mediterranean and northern Italy (e.g. Toumarkine & Luterbacher 1985, Coccioni et al. 1988). Many of the planktonic species from the upper part of the Dranse section, including forms belonging to the *Turborotalia* and *Globigerinatheka* groups, have been observed from classic Eocene-Oligocene deposits in northern Italy (Nocchi et al. 1988, Premoli Silva et al. 1988, Coccioni et al. 1988). Late Eocene assemblages from the external Polish Carpathians are low in species diversity and absent of the *Turborotalia cerroazulensis* and *Globigerina tripartita* groups (Van Couvering et al. 1981). Species of *Hantkenina* and *Cribrohantkenina* are absent within the upper part of the Dranse section, probably due to their greater susceptibility to cool water temperatures in comparison to the other warm water species. However, *Hantkenina alabamensis* was recorded by Eckert (1963) from late Eocene foraminiferal marls in central Switzerland. Rare specimens were also recorded at Fiol from the Voirons massif. Pomerol & Premoli-Silva (1986) suggested that the Eocene/Oligocene boundary be defined on the basis of the last occurrences of *Hantkenina*, *Cribrohantkenina*, large sized *Pseudohastigerina* and *Turborotalia* gr. *cerroazulensis*. The latter group, and particularly *Turborotalia cerroazulensis cocoaensis*, seems to be the most useful in determining the latest Eocene in the region.

Similar faunas to those at Dranse were also retrieved from late Eocene deposits from the Fiol section in the Voirons massif and the Combes section in the Sulens Klippe. Occurrences of *Globigerina* cf. *gortanii* and *Globigerina ciperoensis angustiumbilitata* may suggest that the sediments at Fiol were deposited closer to Eocene-Oligocene boundary than the sediments at Combes and Dranse. During the late Eocene, highly diverse planktonic and benthic foraminiferal faunas developed on a well oxygenated carbonate rich shelf. The diverse planktonic assemblages found at Combes are composed of species described from the Mediterranean region (Delteil & Toumarkine 1975).

5.3.2 Paleocology

The benthic assemblages within the Boège marls suggest a generally dysaerobic, bathyal depositional environment and are probably indicative of the late Priabonian event (P15-P16 boundary) of enhanced cooling which began in the middle Eocene (Prothero 1989). *T. cerroazulensis*, *G.* gr. *subconglobata* and *G.* cf. *semiinvoluta* were rarely observed but suggest that occasional pulses or periods of aerobic, warmer water circulation occurred. At Fillinges, the occurrence of smooth-walled,

unornamented *Chilostomella*, *Praeglobobulimina*, *Nonionella* species, astrophorids and globigerinids suggest dysaerobic, cool water, bathyal depths. The absence of shallow water benthics and rarity of warm water planktonics such as *T. cerroazulensis* and *Globigerinatheka* further indicate a deep, cool water environment. The sediments from the Boège marls and from Fillinges indicate that the earliest part of the late Eocene, was an enhanced period of cool, deep water sedimentation which continued from the late middle Eocene as suggested by the lower part of the Dranse section.

In contrast, the upper part of the Dranse section demonstrates a change to more warmer, shallower, well oxygenated shelf conditions highlighted by the occurrence of thick shelled nodosariids. In contrast (*Vaginulinopsis*, *Pseudonodosaria*, *Stilostomella*, *Fissurina*) and rotaliids (*Anomalinoidea*, *Gyroidinoides*). The frequent occurrences of large *Globigerina eocaena*, *Globigerina corpulenta*, *Turborotalia cerroazulensis*, *Turborotalia cerroazulensis cocoaensis*, *Catapsydrax* and *Globigerinatheka* forms and the rare occurrences of *P. micra*, *H. alabamensis* and *G. carcoselleensis* further indicate warm water conditions and a Mediterranean influence. Boersma & Premoli Silva (1988) suggested that oxygen minima was poorly developed during the late Eocene in the Atlantic ocean.

5.3.3 Palaeogeographic implications

The Boège marls, which pertain to the uppermost unit of the Gurnigel nappe in the Voirons massif (Jan du Chêne et al. 1975), are of late Eocene age and were deposited in fluctuating aerobic to dysaerobic bathyal conditions. This suggests that these deposits may have a different paleogeographic origin in comparison to Gurnigel flysch. The uppermost part of the Dranse section which is attributed to the late Eocene, contains faunas similar to the sediments at Combes of Ultrahelvetic origin and to the wildflysch at Fiol in the Voirons massif.

In determining the provenance of the Fillinges turbidites, it should be recognized that they were deposited in relatively deep water during the late Eocene, and that their petrographic composition is similar to the Voirons sandstones. Therefore, the Fillinges sandstones can either be considered as a part of the Prealpine melange or a unit of the Gurnigel nappe which was deposited under different conditions during a slightly later period of time. These sediments could be interpreted as a large block of flysch that was dragged along the basal thrust plane of the Gurnigel nappe. Similar large blocks of North Helvetic flysch have already been identified within the Prealpine mélangé at the base of the Voirons massif (Lombard 1937, Ujetz et al. 1994). The Fillinges sandstones do not contain characteristic mafic volcanic fragments (Sawatzki 1975) like those found in North-Helvetic flysch but possess a similar petrographic composition to turbidite deposits from Ultrahelvetic units. In particular, the Samoëns sandstones (Internal Ultrahelvetic Prealps, Haute-Savoie) and the Fillinges-Voirons sandstones are petrographically similar, both containing typical calcareous particles and cement (Lillie 1937, Collet 1955, Kindler 1988). The flysch sediments from the Ultrahelvetic units are of middle to late Eocene in age (Charollais et al. 1978, Caron et al. 1989), which is coherent with the age obtained for the Fillinges turbidites in this study. Kindler (1988) found reworked planktonic foraminifers of latest Eocene age within the Samoëns sandstones.

The Fillinges turbidites may belong to the Voirons flysch that also possess similar

petrographical and sedimentological features. Similar biostratigraphic results from other outcrops in the Voiron massif would radically modify our perception of Alpine paleogeography and geodynamics. This would suggest that at least part of the Gurnigel flysch was not deposited in a south-penninic subduction trench (Caron 1976, Caron et al. 1980, Caron et al. 1989, Homewood & Caron 1982) where sedimentation ceased before the middle Eocene (Trümpy 1980), but rather in a foreland basin setting on the northern Alpine margin. Confirmation of our results would indicate that the Gurnigel nappe represents a parautochthonous sheet which was thrust early over the external part of the molasse basin.

5.4 Early Oligocene

5.4.1 Biostratigraphy

Contrary to the fact that the number of described planktonic species was reduced from 225 to 75 between the Eocene and Oligocene (Tappan & Loeblich 1973), the early Oligocene in the region is generally represented by rich, diverse foraminiferal assemblages as observed within the foraminiferal marls in the subalpine chains. Fluctuations in the conditions of the depositional environment resulted in changes in faunal composition as observed within the lower part of the Venay section. *Uvigerina* species are thick walled, costate and are similar to forms from the central Paratethys (Cicha et al. 1986). At Montauban, faunas are very poor and contain a significant proportion of reworked forms. However, the rare presence of *G. tapuriensis* specimens, indicate an early Oligocene age. This species is very rare. The presence of *G. gr. praebulloides*, *G. cf. ampliapertura*, *G. officinalis*, *G. utilisindex* and forms of the *Catapsydrax* group, show a resemblance to faunas from the Meletta shales and Foraminiferal marls from the Subalpine chains.

The Meletta shales from Sage contain rich, diverse faunas similar to those observed within the foraminiferal marls elsewhere in the subalpine chains. Also the very base of the Dessy section consists of assemblages similar to those observed from the Plateau d'Andey. The remaining part of the Dessy section sees a change in the faunal composition provoked by more restricted depositional conditions resulting in the distribution of small planktonic foraminiferal dominated assemblages. Similarities in faunal composition occur between the late Eocene of central Italy (Parisi & Coccioni 1988) and early Oligocene of the Subalpine chains.

Sediments from the Val d'Illez formation at Bellevue are more diverse in comparison to the Meletta shales at Dessy. However, the dominance of small globigerinids are also observed. Berggren (1969) emphasized the widespread occurrence of faunas dominated by small globigerinids, primarily pertaining to *G. officinalis* and *G. ouachitaensis* s.s. The transition between *G. ouachitaensis* and *G. ouachitaensis gnaucki* together with *G. tapuriensis* and *G. angiporoides* is generally assigned to the lower Oligocene in northern Europe (Berggren 1969). He also suggested that the recognition of *G. munda* and *G. ciperoensis* may be useful in the recognition of Rupelian sediments. These species are present but rare. Hofker (1963) suggested that the Rupelian in Belgium and Holland corresponds to the *G. opima opima* zone of Trinidad. However, as Berggren (1969) stated, many species which occur in the Rupelian of northern Europe also occur in the *G. ampliapertura* zone of Bolli (1957), Bolli & Saunders (1985). Furthermore, many of the species observed in the early Oligocene are long

ranging species (e.g. *G. gr. praebulloides*, *G. dissimilis*, *G. opima nana*, *G. gr. ouachitaensis*). An approximate relationship between the planktonic foraminiferal zones defined in low latitudes may be made, reflecting the difficulties in dating Oligocene sediments.

The presence of *Cassigerinella chipolensis* for indicating the early Oligocene has often been neglected. However, rare specimens were retrieved from Bellevue, Dessy and Sage confirming its validity in north alpine biostratigraphy. Baumann (1970) offered a slight variation to the defined zones of the Mediterranean by introducing *G. gortanii* zone for the early Oligocene defined by the extinction of *Hantkenina* and the first occurrence of *G. sellii*. However, typical *G. sellii* has never been observed within the Oligocene in the studied region.

Rögl et al. (1975) indicated a similarity in faunal composition between south Alpine, upper bathyal sediments of middle-late Oligocene age near Como in northern Italy with faunas from the Austrian and Bavarian molasse within the central Paratethys. Castellarin & Cita (1969) observed early Oligocene faunas poor in diversity from northern Italy. These authors considered that the early Oligocene of northern Europe is characterised by assemblages containing *G. ouachitaensis*, *G. ouachitaensis gnaucki*, *G. tapuriensis* and *G. angiporoides*. Furthermore they suggested that the Eocene-Oligocene boundary is biostratigraphically more easily identifiable in southern European, Mediterranean regions in comparison to northern provinces.

5.4.2 Paleoecology

Pyritised benthic faunas composed predominantly of *Chilostomella* and *Praeglobobulimina* have been recorded frequently from the Oligocene Molasse of southern Germany (Rieser 1987, Wenger 1987, Dohmann 1990) and central Paratethys (Sztrakos 1979, 1982, Baldi 1984, Cicha et al. 1996). However, benthic assemblages from more northern provinces tend to contain a larger proportion of miliolids which are extremely rare in the region reflecting slightly shallower water deposition. Rigassi (1958) suggested that the Oligocene subalpine faunas are similar to the Rupelian sediments in Hungary and are different to the more shallow water Rhine Graben faunas. Doebel (1976) indicated that the Rhine Graben, possessing shelf faunas was influenced by the North Sea. Although similarities in general generic composition occur with the faunas studied here, only a dozen species among the 144 species listed were observed from the Oligocene in this study. The benthic associations are highlighted by many shallow water species. From the fish shales, although predominantly dysaerobic, periods of increased oxygenation as suggested by levels of increased foraminiferal species diversity occurred (Doebel 1976). Shallow water Rupelian foraminifers from the Rhine graben were also documented by Huber (1994) further indicating the difference in the paleoecological conditions between the two areas.

As Charollais et al. (1980) suggested, The north Alpine Oligocene faunas from central Switzerland (Blau 1966, Scherer 1966) and the Rhine Graben (Martin 1958, Fischer 1965, Doebel 1976) are characterised by small planktonic foraminifers belonging to *G. officinalis*, *G. ouachitaensis* and *G. praebulloides*. These often poor faunas of low species diversity, suggest that cooler conditions prevailed in comparison to more southerly regions. They correspond to increasing confinement of marine basins north of the Alps. Stagnant, dysaerobic conditions probably prevailed

6. SYSTEMATIC PALAEOONTOLOGY

The foraminiferal species identified from from Paleogene alpine flysch deposits in the Voirons massif, Subalpine chains, Romand Prealps, Chablais Prealps and Thônes syncline are described below. Their distributions and abundances are charted in figures in chapter 3. The foraminiferal order classification follows Haynes (1981). Each foraminiferal species is classified to superfamily, family and generic level according to the scheme outlined by Loeblich and Tappan (1988). The purpose of this chapter is to record the foraminiferal species recovered, describe morphological characteristics where necessary, and outline their geographic and stratigraphic distributions within the studied areas. Although morphological characteristics are sometimes discussed and compared, this chapter is not intended as a systematic revision of foraminiferal species.

For each benthic species named, the original reference and, where possible, a more recent reference which aided identification of the species is given. Recent references are indicated in the References at the end of this manuscript. Type references were either obtained from the Catalogue of Foraminifera by Ellis and Messina (1940 et. seq.) or from more recent references and are therefore not cited in the references list. The majority of planktonic species recorded here were identified in Torumakine & Luterbacher (1985) and Bolli & Saunders (1985). Therefore type references and descriptions of species illustrated in these papers will not be given. However, references for planktonic species which do not appear in these studies are listed in this chapter and in the references list. Biostratigraphic and paleoecologic distributions of benthic and planktonic species from neighbouring sedimentary basins are also noted: Rögl (1994), Cicha et al. (1996) for the central Paratethys, Reiser (1987), Wenger (1987) and Dohmann (1991) for the German Molasse, Sztrakos (1979, 1982, 1987) from Hungary and Mathelin & Sztrakos (1993) for the south west of France (1993) and Tjalsma & Lohmann (1983) and Van Moorkhoven et al. (1986) from the Atlantic ocean. Gradstein et al. (1986), Gradstein et al. (1988), King (1989) and Charnock & Jones (1990) illustrate occurrences of agglutinated benthic species within the North Sea whilst Geroch & Nowak (1983) and Kaminski & Geroch (1993) from Carpathian flysch. All species, except for those which were most likely reworked, are illustrated by scanning electron photographs (plates 1-11).

Order ASTORRHIZIDA
Superfamily ASTORRHIZACEA
Family BATHYSIPHONIDAE
Genus BATHYSIPHON

Bathysiphon eocaenica (Cushman & Hanna) (Pl. 1, Figs. 3-4)

1927 *Bathysiphon eocenicus* Cushman & Hanna, p. 210, pl. 13, figs. 2-3.
1990 *Bathysiphon eocenicus*; Bellagamba & Coccioni, p. 897, pl. 1, fig. 1.
1993 *Rhabdammina eocaenica*; Mathelin & Sztrakos, pl. 1, figs. 1-2.

Remarks: Rare to common throughout Fiol, Combes and the Vacherie sections. Also rare and sporadic occurrences were retrieved from Fayaux B and Bons. The specimen figured by Sztrakos (1993) probably belongs to this species. He also recorded this species in the latest Eocene of Hungary (Sztrakos 1982). Bellagamba & Coccioni (1990) also observed this form from late Eocene sediments in Italy. Represents a geographically widespread species of late Eocene intermediate water depths (Kaiho 1992). King (1989) suggested a late Cretaceous-Oligocene stratigraphic range for this species in the north sea.

Bathysiphon sp.A (Pl. 1, Figs. 1-2)

Remarks: Possesses a relatively finely agglutinated surface texture in comparison to *Bathysiphon eocaenica*. Retrieved rarely from the Bons, St Gingolph, Signal Voirons B and Fayaux B sections. Continuously frequent throughout Fayaux A and at the base of the Fillinges section.

Bathysiphon sp.B

Remarks: Frequently observed from Saxel and Chauffemerande. Common to abundant within the Fillinges section.

Genus NOTHIA

Nothia latissima (Grzybowski) (Pl. 1, Figs. 5-6)

1898 *Dendrophyra latissima* Grzybowski, pl. 10, fig. 8.
1993 *Nothia latissima*; Kaminski & Geroch, p. 245, pl. 1, figs. 1, 14.

Remarks: Rare within Fiol and in the upper parts of the Bellevue and Fayaux A sections.

Family RHABDAMMINIDAE
Genus RHABDAMMINA

Rhabdammina discreta Brady (Pl. 1, Figs. 7-8)

1881 *Rhabdammina discreta* Brady, p. 48, pl. 22, figs. 7-10.
1990 *Rhabdammina ex gr. discreta*; Bellagamba & Coccioni, p. 898, pl. 1, figs. 2-3.

Remarks: Rare to common numbers of this species were recovered from St Gingolph, Nantbellet, Signal Voirons A & B and Fillinges. Bellagamba & Coccioni (1990) illustrate two morphologically different forms belonging to the same species which were recognized rarely within the Fillinges and Fayaux B sections. Typical forms are frequent throughout the Fayaux B section. King (1989) preferred the genus *Psammosiphonella*, as *Bathysiphon* is typically fine grained and thick walled and *Rhabdammina* is probably best restricted to branching, tubular forms. *Rhabdammina* is here preferred for consistency with previous literature. Cicha et al. (1996) attribute this form to *Psammosiphonella cylindrica* (Glaessner) which ranges from the late Eocene to late Oligocene in the Paratethys. Charnock & Jones (1990) suggest a Turonian-middle Miocene stratigraphic range.

Rhadamina cf. robusta (Grzybowski) (Pl. 1, Figs. 9-10)

1902 *Dendrophyra robusta* var. *maxima* Grzybowski, p. 460, pl. 22, fig. 4.
1993 *Rhabdammina robusta*; Kaminski & Geroch, p. 247, pl. 1, figs. 7-9.

Remarks: Sporadic, rare occurrences from Fiol, Marais, Saxel, Bons, Montauban and Fayaux B. Frequent to common within Dranse and Fillinges. Santonian-early Miocene stratigraphic distribution (Charnock & Jones 1990).

Rhabdammina sp. A (Pl. 1, Figs. 11-12)

Remarks: The small test possesses a finely agglutinated surface texture and is circular in cross section. Branching forms were also recognized. Rare to frequent numbers occur throughout the Bellevue section.

Family SACCAMMINIDAE
Genus SACCAMMINA

Saccamina placenta (Grzybowski) (Pl. 1, Figs. 13-14)

1898 *Reophax placenta* Grzybowski, p. 276-277, pl. 10, figs. 9-10.
1993 *Saccamina placenta*; Kaminski & Geroch, pl. 2, figs. 5-7.

Remarks: Possesses a small neck which is very rarely preserved. Rare to frequent and sporadically distributed within Signal Voirons B, Fayaux A and B, Fillinges, Dranse and St Gingolph. Latest Cretaceous-early Miocene range (Charnock & Jones 1990).

Superfamily AMMODISCACEA
Family AMMODISCIDAE
Genus AMMODISCUS

Ammodiscus cretaceus (Reuss) (Pl. 1, Figs. 15-16)

1895 *Operculina cretacea* Reuss, p. 35, pl. 13, figs. 64-65.
1981 *Ammodiscus cretaceus*, Gradstein & Berggren, p. 241, pl. 2, figs. 12-13.

Remarks: Rarely to frequently observed from Fiol, St. Gingolph, Signal Voirons B, Fayaux A and B, Nantbellet, Combes, Dranse, Fillinges and Bons. This species has been recorded from the Albian to Oligocene (King 1989, Charnock & Jones 1990).

Genus GLOMOSPIRA

Glomospira charoides (Jones & Parker) (Pl. 1, Fig. 17)

1860 *Trochammina squamata* Jones & Parker var. *gordialis* Jones & Parker, p. 304.
1979 *Glomospira charoides*; Van Stuijvenberg, pl. 2, fig. 10.
1990 *Glomospira charoides*; Klasz & Klasz, p. 405, pl. 2, figs. 6-7.

Remarks: Common throughout Bons. Rare, sporadic occurrences from Montauban, Signal Voirons A and B, Nantbellet, Combes and Fillinges. Early Cretaceous to late Miocene (King 1989, Charnock & Jones 1990). Cicha et al. (1996) traced this species, under the generic assignment of *Repmanina*, from the late Eocene to early Miocene.

Glomospira gordialis (Jones & Parker) (Pl. 1, Figs. 18-19)

1860 *Trochammina squamata* Jones & Parker var. *gordialis* Jones & Parker, p. 304.
1979 *Glomospira charoides*; Van Stuijvenberg, pl. 2, fig. 7.
1990 *Glomospira charoides*; Klasz & Klasz, p. 405, pl. 2, figs. 9.

Remarks: Rare, sporadic occurrences from St. Gingolph, Signal Voirons A and B and Fayaux B. Rare and continuous throughout the Fayaux A and Fillinges sections. Kaminski et al. (1988) illustrated specimens of *Glomospira peruvianus* which are similar to *Glomospira gordialis*. Deep water foraminifer, restricted to bathyal-abyssal depths (2225-5775m) and ranges from the early Cretaceous to the Oligocene (Charnock & Jones 1990).

Glomospira irregularis (Grzybowski) (Pl. 1, Fig. 20)

1898 *Ammodiscus irregularis* Grzybowski, p. 285, pl. 11, figs. 2-3.
1990 *Glomospira irregularis*; Charnock & Jones, p. 157, pl. 2, fig. 14, pl. 14, fig. 11.

Remarks: Very rare specimens were recovered from the Fayaux sections. Possesses a Campanian-Eocene stratigraphic range (Charnock & Jones 1990).

Order LITUOLIDA
Superfamily RZEHAKINACEA
Family RZEHAKINIDAE
Genus RZEHAKINA

Rzehakina epigona (Rzehak) (Pl. 1, Figs. 21-22)

1895 *Silicina epigona* Rzehak, p. 214, pl. 6, figs. 1a-c.
1979 *Rzehakina epigona*; Van Stuijvenberg, pl. 2, fig. 14.
1990 *Rzehakina epigona*; Charnock & Jones, p. 159, pl. 3, figs. 1-2, pl. 14, fig. 14.

Remarks: Rare from the Signal Voirons A, Fayaux A & B and Fillinges outcrops. This species is considered to be a useful late Cretaceous to Paleocene marker (King 1989 and Charnock & Jones 1990).

Superfamily HORMOSINACEA
Family ASCHEMOCELLIDAE
Genus KALAMOPSIS

Kalamopsis grzybowski (Dylazanka) (Pl. 1, Figs. 23-24)

1923 *Hyperammia grzybowski* Dylazanka, p. 65-66, pl. 7, fig. 5.
1993 *Kalamopsis grzybowski*; Kaminski & Geroch, pl. 17, figs. 5-8.

Remarks: Sporadic and rare to frequent from St. Gingolph, Signal Voirons A, Fillinges, Fayaux B, and Fiol. Rare to frequent throughout Fayaux A. Charnock & Jones (1990) illustrated that this species ranges from the Santonian to Eocene. Geroch & Nowak (1983) suggested a late Cretaceous to middle Eocene range for the outer Carpathians in Poland.

Family HORMOSINIDAE
Genus REOPHAX

Reophax cf. duplex Grzybowski (Pl. 1, Figs. 25-26)

1896 *Reophax duplex* Grzybowski, p. 276, pl. 8, figs. 23-25.
1990 *Reophax duplex*; Klasz & Klasz, p. 276, pl. 8, figs. 23-25.

Remarks: Rare to frequent occurrences were recorded from the Fayaux A and B sections.

Reophax cf. pilulifera Brady (Pl. 1, Figs. 27-28)

1884 *Reophax pilulifera* Brady, pl. 30, figs. 18-20.
1979 *Reophax pilulifera*; Sztarkos, pl. 1, fig. 11.
1981 *Reophax pilulifera*; Gradstein & Berggren, pl. 2, figs. 10-11.

Remarks: Rare within Signal Voirons B, Fayaux A, Fiol and Bons. Cicha et al. (1996) observed this species within the Oligocene to early Miocene.

Reophax sp.A (Pl. 1, Figs. 29-30)

Remarks: This species possesses 4 large, globular chambers, a finely agglutinated texture and a small spine located on its basal chamber. Rare at the base of the Dessy and within the Fiol sections.

Genus SUBREOPHAX

Subreophax pseudoscalaris (Samuel) (Pl. 1, Figs. 31-32)

1977 *Reophax pseudoscalaria* Samuel, p. 36, pl. fig. 4.
1988 *Subreophax pseudoscalaria*; Kaminski et al., p. 187, pl. 3, figs. 5-6.
1990 *Subreophax pseudoscalaris*; Klasz & Klasz, p. 408, pl. 3, fig. 7.

Remarks: Chambers vary more in width in comparison to the specimen illustrated by Klasz & Klasz (1990). The specimens from this study are more similar to Kaminski et al. (1988). Rarely recorded from the Fayaux sections.

Superfamily LITUOLACEA
Family HAPLOPHRAGMOIDIDAE
Genus HAPLOPHRAGMOIDES

Haplophragmoides cf. stomatus (Grzybowski) (Pl. 1, Figs. 33-34)

1898 *Trochammina stomata* Grzybowski, pl. 11, figs. 26-27.
1993 *Haplophragmoides stomatus*; Kaminski & Geroch, p. 264, pl. 11, figs. 1-2.

Remarks: Rare from the Signal Voirons A and Fillinges sections. Occurs throughout the Paleocene-Eocene of the Polish Carpathians (Kaminski & Geroch 1993).

Haplophragmoides walteri (Grzybowski) (Pl. 1, Figs. 35-36)

1898 *Trochammina walteri* Grzybowski, p. 290, pl. 11, fig. 31.
1993 *Haplophragmoides walteri*; Kaminski & Geroch, p. 263, pl. 10, figs. 3-7.

Remarks: Rare from the Saxel and Signal Voirons A sections. A few specimens were found within the Fiol section. Cosmopolitan species of Paleogene sediments (Kaminski & Geroch 1993) and ranges from the Late Cretaceous to middle Miocene (King 1989 and Charnock & Jones 1990).

Haplophragmoides sp.A (Pl. 1, Figs. 37-38)

Remarks: Very finely agglutinated, translucent, reddish brown in colour. Between 2-6 chambers in the final whorl. Wide distribution in the late Eocene. Sporadically and rarely to frequently distributed within Montauban, Saxel, Fillinges, Bons, Bellevue, Signal Voirons A and B. Frequent to common throughout Fiol.

Haplophragmoides sp.B (Pl. 1, Figs. 39-40)

Remarks: This large, coarsely agglutinated species is partially evolute. Rare from the Signal Voirons A, Fiol and Bons sediments suggesting a Paleocene to late Eocene distribution for this study. A juvenile form was also recovered from the Signal Voirons B section.

Haplophragmoides sp.C (Pl. 1, Figs. 41-42)

Remarks: Possesses a very coarsely agglutinated wall, 4 globular chambers in the final whorl, lobulate peripheral outline and involute coiling. Retrieved rarely from Combes.

Haplophragmoides sp.D (Pl. 1, Fig. 43, Pl. 2, Fig. 1)

Remarks: This very small form possesses a finely agglutinated wall texture, flush sutures and a thin, basal aperture. It was recovered from the early Paleocene sediments located at Fayaux.

Labrospira scitula (Brady) (Pl. 2, Figs. 2-3)

1881 *Haplophragmium scitulum* Brady, p. 50.
1989 *Cribrostomoides scitulus*; King, p. 455, pl. 9.2, figs. 9-10.
1990 *Labrospira scitula*; Charnock & Jones, p. 173, pl. 6, figs. 9-10.

Remarks: A few rare specimens were retrieved from the base of the Dessy section as well as a dubious form at Nantbellet. Santonian to Oligocene (Charnock & Jones 1990) and Middle Eocene-early Oligocene (King 1989) ranges have been suggested. The latter authors admit that the generic assignment is uncertain as the aperture is not visible.

Family LITUOTUBIDAE
Genus LITUOTUBA

Lituotuba cf. *lituiformis* (Brady) (Pl. 2, Figs. 4-5)

1879 *Trochammina lituiformis* Brady, p. 59, pl. 5, fig. 16.
1988 *Lituotuba lituiformis*; Kaminski et al., p. 190, pl. 4, figs. 14-15.

Remarks: Possesses large, flattened chambers planispirally coiled in its large juvenile stage. Kaminski et al. (1988) illustrated a small specimen with a more inflated initial stage in comparison to specimens from this study. Very common within one sample from the upper part of the Dranse section.

Lituotuba sp.A (Pl. 2, Figs. 6-7)

Remarks: The juvenile stage possesses numerous, small, globular chambers. Sutures are both depressed and raised. Rare forms were recovered only from Eocene sediments of the Thônes syncline at Nantbellet and Combes.

Genus TROCHAMMINOIDES

Trochamminoides irregularis White (Pl. 2, Figs. 8-9)

1928 *Trochamminoides irregularis* White, p. 307, pl. 42, fig. 1.
1979 *Trochamminoides irregularis*; Van Stuijvenberg, pl. 2, fig. 12.
1988 *Trochamminoides irregularis*; Kaminski et al., p. 191, pl. 4, fig. 18.

Remarks: Rarely and sporadically distributed within St Gingolph, Signal Voirons A and B, Fillinges, Bons, Fiol and Combes. Rare to common throughout the Fayaux sections. Late Cretaceous to Paleocene range (Kaminski et al. 1988 and King 1989).

Trochamminoides proteus (Karrer) (Pl. 2, Figs. 10-11)

1866 *Trochammina proteus* Karrer, pl. 1, fig. 8.
1990 *Trochamminoides proteus*; Kuhnt & Kaminski, p. 487, pl. 4, figs. 4a, d.

Remarks: Occurs in Paleocene deposits (Kaminski et al. 1988) and just below the Eocene-Oligocene boundary in Italy (Bellegamba & Coccioni 1990). Rare occurrences from Fayaux and Bons.

Trochamminoides cf. *variolaris* (Grzybowski) (Pl. 2, Figs. 12-13)

1898 *Trochammina variolaria* Grzybowski, pl. 11, fig. 15.
1993 *Trochamminoides variolaris*; Kaminski & Geroch, p. 261, pl. 9, figs. 5-6.

Remarks: Chambers are slightly more inflated in the studied specimens in comparison to typical forms belonging to this species. Rarely observed from St Gingolph and the Fayaux sections. Recorded from Paleogene flysch deposits in the Vienna Basin (Kaminski & Geroch 1993).

Superfamily HAPLOPHRAGMIACEA
Family AMMOSPHAEROIDINIDAE
Genus RECURVOIDES

Recurvoides sp.A (Pl. 2, Figs. 14-15)

Remarks: Large variation in size. Coarsely agglutinated. A very common species which was recovered sporadically within the Chauffemerande, Saxel, Bons, St Gingolph, Signal Voirons A & B sections. Rare to common throughout the Fillinges, Fiol, Dranse and Fayaux sections. Resembles *Recurvoides imperfectus* (Kaminski et al. 1988) but possesses a more coarsely agglutinated wall.

Superfamily CYCLOLINACEA
Family CYCLAMMINIDAE
Genus RETICULOPHRAGMIUM

Reticulophragmium amplexens (Grzybowski) (Pl. 2, Figs. 16-17)

1898 *Cyclammina amplexens* Grzybowski, pl. 12, figs. 1-3.
1993 *Reticulophragmium amplexens*; Kaminski & Geroch, p. 266, pl. 11, figs. 7a-c.

Remarks: Rare within the Fiol and Dranse sections. Early to middle Eocene range, although similar forms probably belonging to a subspecies occur in the late Eocene and Oligocene (Gradstein et al. 1988, King 1989, Charnock & Jones 1990, Kaminski et al. 1990). It is

considered the most distinctive species in Eocene Carpathian flysch (Kaminski & Geroch 1993). Cicha et al. (1996) has reported this species through to the late Oligocene in the central Paratethys.

Superfamily SPIROPLECTAMMINACEA
Family SPIROPLECTAMMINIDAE
Genus SPIROPLECTAMMINA

Spiroplectamina spectabilis (Grzybowski) (Pl. 2, Figs. 18-19)

1898 *Spiroplecta brevis* Grzybowski, p. 293, pl. 12, fig. 13.
1993 *Spiroplectamina spectabilis*; Kaminski & Geroch, p. 267, pl. 12, figs. 3-8.

Remarks: Large variation in morphology concerning the length and size of its juvenile stage. Rare from Signal Voirons A, Fillinges and the upper parts of the Signal Voirons B and Fayaux sections. Campanian to Late Eocene range in the north sea (Gradstein et al. 1988, King 1989). Considered a late Paleocene marker in the Carpathians (Kaminski & Geroch 1993) but ranges into the late Eocene (Geroch & Nowak 1983 and Dohmann 1991). Common from the late Cretaceous to Oligocene and possesses a wide bathymetric range (Tjalsma & Lohmann 1983).

Spiroplectamina sp.A (Pl. 2, Figs. 20-21)

Remarks: Possesses fewer chambers and a more carinate, angular periphery in comparison to *Spiroplectamina spectabilis*. Very rare from the top of the Fiol and Dranse sections.

Genus VULVULINA

Vulvulina haeringensis (Gümbel) (Pl. 2, Figs. 22-23)

1868 *Venilina haeringensis* Gümbel, p. 649, pl. 2, figs. 84.
1996 *Vulvulina haeringensis*; Cicha et al., pl. 5, figs. 12-14.

Remarks: Rare to frequent, sporadic occurrences from Venay, Vacherie and Nantbellet. Rare throughout Combes. Found in Bavaria (Dohmann 1991), Marche Umbria basin (Pairisi & Coccioni 1988), Hungary and southwest of France (Sztrakos 1982, 1987, 1993) and the central Paratethys (Cicha et al. 1996). The latter authors recorded this species from the late Eocene to late Oligocene. Bellagamba & Coccioni (1990) admit that it is difficult to differentiate this species from *Vulvulina spinosa* due to the lack of spines, perhaps due to a bathymetric adaptation.

Vulvulina spinosa Cushman (Pl. 2, Figs. 24-25)

1927 *Vulvulina spinosa* Cushman, p. 111, pl. 23, fig. 1.
1985 *Vulvulina spinosa*; Wood et al., pl. 1, figs. 1-2, 5.
1990 *Vulvulina spinosa*; Bellagamba & Coccioni, pl. 2, figs. 7-9.

Remarks: Retrieved throughout Combes and sporadically from Fiol, Nantbellet, Venay, Dranse and Bellevue. The specimens from Bellevue are slightly smaller and the last chambers are narrower in width. Juvenile specimens are thicker in cross section in comparison to adult specimens. This species extends from the early Eocene where it occupied shallow depths to the middle Eocene where it moved into deeper waters (Tjalsma & Lohmann 1983). Retrieved also from the Oligocene (Reiser 1987).

Superfamily TROCHAMMINACEA
Family TROCHAMMINIDAE
Genus TROCHAMMINA

Trochammina cf. *deformis* (Grzybowski) (Pl. 2, Figs. 26-27)

1898 *Trochammina deformis* Grzybowski, pl. 11, figs. 20-22.
1981 *Trochammina deformis*; Gradstein & Berggren, p. 256, pl. 8, figs. 8-10.
1990 *Trochammina deformis*; Kaminski et al., p. 369, pl. 7, fig. 1.

Remarks: Rare at Marais, Signal Voirons A and B, Bons, Venay, Vacherie, Fillinges and Fayaux. Frequent to common throughout Fiol and within the upper part of the Dranse section.

Genus TRITAXIS

Tritaxis sp.A (Pl. 2, Figs. 28-29)

Remarks: Its small planoconvex test possesses a finely agglutinated wall and flush crescentic sutures. Rare forms were recovered from the Bellevue section. Species belonging to this genus have been described from Holocene sediments (Loeblich & Tappan 1988).

Superfamily VERNEUILINACEA
Family VERNEUILINIDAE
Genus GAUDRYINA

Gaudryina sp.A (Pl. 2, Figs. 32-33)

Remarks: This large form possesses a smooth, coarsely agglutinated wall texture. The biserial stage varies in length. Rare within the Fiol, Combes and Bons sections.

Family TRITAXIIDAE
Genus TRITAXIA

Tritaxia szaboi (Hantken) (Pl. 2, Figs. 34-35)

1860 *Clavulina szaboi* Hantken, p. 83, pl. 1, figs. 4, 6-7.
1991 *Tritaxia szaboi*; Dohmann, p. 237, pl. 9, figs. 1-2
1996 *Tritaxia szaboi*; Cicha et al., pl. 7, figs. 12-13.

Remarks: Typical specimens belonging to this species were recovered from the Marais, the uppermost part of the Fiol and within the Combes, Venay and Vacherie sections. Rare to common throughout the Nantbellet outcrop. Recorded from late Eocene to late Oligocene sediments (Sztrakos 1982, Dohmann 1991 and Cicha et al. 1996). Juvenile forms of *Tritaxia szaboi* resemble figured specimens of *Tritaxia havanensis* (Cushman & Bermudez 1937).

Superfamily ATAXOPHRAGMIACEA
Family ATAXOPHRAGMIIDAE
Genus ATAXOPHRAGMIUM

Ataxophragmium sp.A (Pl. 2, Figs. 36-37)

Remarks: A few rare specimens of this small, coarsely agglutinated species were retrieved from Fillinges.

Genus ARENOBULIMINA

Arenobulimina sp.A (Pl. 2, Figs. 38)

Remarks: This very small form, which is relatively coarsely agglutinated and is rarely to commonly distributed within the Fillinges, Bons, Signal Voirons A and B and Nantbellet sections, seems to be restricted to a Paleocene-Eocene stratigraphic range.

Superfamily TEXTULARIACEA
Family EGGERELLIDAE
Genus EGGERELLA

Eggerella trochoides (Reuss) (Pl. 2, Figs. 30-31)

1845 *Globigerina trochoides* Reuss, p. 36, pl. 12, fig. 32.

1972 *Egerella trochoides*; Kuhn, pl. 3, figs. 8-9.
1988 *Egerella trochoides*; Kaminski et al., p. 195, pl. 9, figs. 12-13.

Remarks: Rare to frequent throughout Fiol and frequent to common within the upper part of the Dranse section. Recorded from the early Oligocene to middle Miocene (Charnock & Jones 1990).

Genus DOROTHIA

Dorothia pupa Reuss (Pl. 3, Figs. 3-4)

1860 *Textularia pupa* Reuss, p. 232, pl. 13, fig. 4.
1990 *Dorothia pupa*, Bellagamba & Coccioni, p. 906, pl. 2, figs. 21-23.

Remarks: Rare at Marais, Vacherie, Bellevue, Nantbellet and within the uppermost beds of the Fiol section. Recorded from the late Eocene to early Oligocene (Dohmann 1991).

Dorothia retusa (Cushman) (Pl. 2, Figs. 39-40)

1926 *Gaudryina retusa* Cushman, p. 588, pl. 16, figs. 10a-b.
1988 *Dorothia retusa*; Kaminski et al., p. 195, pl. 9, figs. 6, 11.

Remarks: Common in the Paleocene of the Signal Voirons and Fayaux sections. Rare to frequent numbers were retrieved throughout the Fillinges section which may have been reworked. Possesses a Campanian to Paleocene range (Gradstein et al. 1988 and Charnock & Jones 1990).

Genus MARSONELLA

Marsonella oxycona (Reuss) (Pl. 3, Figs. 1-2)

1860 *Gaudryina oxycona* Reuss, p. 229, pl. 12, fig. 3.
1990 *Marsonella oxycona*; Charnock & Jones, p. 191, pl. 12, figs. 5-6, pl. 24, figs. 6.

Remarks: This species ranges from the Campanian to the early Eocene (Gradstein et al. 1988, Charnock & Jones 1990). Rare to frequent in the studied Paleocene and Eocene (Fillinges, Fayaux, Signal Voirons B, Combes and Nantbellet sections. This species was also recovered from Vacherie perhaps suggesting a stratigraphic extension into the Oligocene.

Genus KARRERIELLA

Karrerella chilostoma (Reuss) (Pl. 3, Figs. 5-6)

1852 *Textularia chilostoma* Reuss, p. 18, pl. 4, figs. a-b.
1996 *Karrerella chilostoma*; Cicha et al., pl. 9, figs. 1-3.

Remarks: This rare species possesses a smooth, finely agglutinated surface and distinctly raised lip around its basal aperture. Rare within the upper part of the Fiol and within the Combes sections.

Family TEXTULARIIDAE
Genus TEXTULARIA

Textularia sp.A (Pl. 3, Figs. 7-8)

Remarks: Rare species retrieved only from the Bellevue section which possesses a thickened periphery, depressed sutures and basal aperture located in its concave shaped last chamber.

?*Textularia* sp.B

Remarks: Poorly preserved, rare forms within the sediments at Bellevue are probably reworked.

Order MILIOLIDA
Superfamily MILIOLACEA
Family HAUERINIDAE
Genus QUINQUELOCULINA

Quinqueloculina sp. indet.

Remarks: Specimens found at Fillinges and Bellevue are often preserved as pyritised and limonitised internal moulds. Tests are often partially preserved due to dissolution. Some poorly preserved, probably reworked, specimens occur at Chauffemerande and Bellevue.

Genus TRILOCULINA

Triloculina sp.A (Pl. 3, Figs. 9-10)

Remarks: A few moderately well preserved specimens were retrieved from the Fiol section. Some specimens show the effects of dissolution.

Order NODOSARIIDA
Superfamily NODOSARIACEA
Family NODOSARIIDAE
Genus NODOSARIA

Nodosaria cf. *dacrydium* Reuss (Pl. 3, Figs. 11-12)

1866 *Nodosaria dacrydium* Reuss, p. 128, pl. 1, figs. 13-14.
1982 *Nodosaria dacrydium*; Sztrakos, pl. 5, fig. 8.

Remarks: Specimens, usually well preserved as broken fragments, were observed from the Fiol, Combes and Dranse sections. Sztrakos (1982) recorded this species from latest Eocene to earliest Oligocene sediments.

Nodosaria cf. *pyrula* d'Orbigny (Pl. 3, Figs. 13-14)

1826 *Nodosaria pyrula* d'Orbigny, p. 253, fig. 13.
1991 *Nodosaria pyrula*; Dohmann, p. 254, pl. 11, fig. 13.

Remarks: Rare within middle Eocene to early Oligocene sediments in this study. Dohmann (1991) traced this species from the late Eocene to early Oligocene.

Nodosaria sp.A (Pl. 3, Figs. 15-16)

Remarks: This form represents the largest of the *Nodosaria* species from this study, and although was found within late Paleocene through to early Oligocene sediments, are very rare in occurrence. Possesses distinctively thick, depressed sutures. Similar to *Stilostomella kressenbergensis* (Cicha et al. 1996) although this species possesses larger, more globular chambers.

Nodosaria sp.B (Pl. 3, Figs. 17-18)

Remarks: This small species possesses a very smooth surface, thick transparent sutures and occurs frequently in the middle Eocene to early Oligocene of the Voirons massif and Thônes syncline. Chambers are smaller and less inflated in comparison to *Nodosaria* sp.A.

Nodosaria sp.C (Pl. 3, Figs. 19-20)

Remarks: Possesses a bulbous initial chamber and more elongate final chambers. The terminal aperture is situated at the end of a small neck. Rare and sporadic occurrences were observed from the Dranse, Combes, Nantbellet, Venay, Marais and Bellevue sections. Possibly belongs to *Siphonodosaria consobrina* (Cicha et al. 1996), but possesses fewer, more elongate chambers.

Genus PSEUDONODOSARIA

Pseudonodosaria hantkeni (Franzenau) (Pl. 3, Figs. 21-22)

1894 *Glandulina hantkeni* Franzenau, p. 258, pl. 4, fig. 7.
 1979 *Pseudonodosaria hantkeni*; Sztrakos, pl. 14, fig. 13.
 1987 *Pseudonodosaria hantkeni*; Sztrakos, pl. 6, fig. 2.

Remarks: Possesses small initial chambers, a smooth surface and straight, flush sutures. Rare, sporadic abundances were found at Bellevue, Dranse, Sage, Signal Voirons B, Combes and Nantbellet. A few synonomous specimens from Bons were observed. Recorded throughout the late Eocene and Oligocene in Hungary (Sztrakos 1982).

Pseudonodosaria cf. radricula (Linne) (Pl. 3, Figs. 23-24)

1758 *Nautilus radricula* Linné, p. 711, pl. 1, figs. 5a-c.
 1982 *Nodosaria radricula*; Sztrakos, pl. 5, fig. 19.

Remarks: This compressed form is very rare and was observed only from the Dranse section.

Genus PYRAMIDULINA

Pyramidulina sp.A (Pl. 3, Figs. 25-26)

Remarks: Large specimens were retrieved from one sample belonging to the Dranse section. This species is pentagonal in outline marked by its thick, longitudinal costae.

Genus DENTALINA

Dentalina cf. acuta d'Orbigny (Pl. 3, Figs. 27-28)

1846 *Dentalina acuta* d'Orbigny, p. 56, pl. 2, figs. 40-43.
 1979 *Dentalina acuta*; Sztrakos, pl. 10, fig. 11.

Remarks: Rare and restricted to late Eocene to early Oligocene sediments at Combes, Bellevue, Chauffemerande, Venay and Vacherie. Cicha et al. (1996) described this species from the middle Miocene.

Dentalina sp.A (Pl. 3, Figs. 29-30)

Remarks: This species has 4 to 6 chambers which rapidly increase in size. The surface texture is smooth and possesses numerous, finely developed costae. Well preserved specimens, sometimes compressed due to deformation, were retrieved from the Fiol and Sage sections.

Genus LAEVIDENTALINA

Laevidentalina cf. communis (d'Orbigny) (Pl. 3, Figs. 31-32)

1826 *Dentalina communis* d'Orbigny, p. 254.
 1991 *Dentalina communis*; Dohmann, p. 252, pl. 11, figs. 9-10.
 1996 *Laevidentalina communis*; Cicha et al., pl. 21, fig. 3.

Remarks: Test length and chamber shape is highly variable. Very widely distributed in this study, both stratigraphically and geographically, but is most frequent in late Eocene sediments. Represents a geographically widespread species of late Eocene intermediate water depths (Kaiho 1992). Dohmann (1990) and Reiser (1987) observed this species from late Eocene to early Oligocene sediments.

Genus CHRYSALOGONIUM

Chrysalogonium longiscatum (d'Orbigny) (Pl. 3, Fig. 33)

1846 *Nodosaria longiscata* d'Orbigny, p. 32, pl. 1, figs. 10-12.
 1993 *Chrysalogonium longiscatum*; Sztrakos, pl. 5, fig. 14.

Remarks: This species is usually well preserved as broken fragments and is restricted to late Eocene to early Oligocene deposits at Fiol, Dranse, Venay, Vacherie, Montauban and Bellevue. Sztrakos (1987) recorded this species from the middle to late Eocene. Represents a geographically widespread species of late Eocene intermediate water depths (Kaiho 1992).

Genus GRIGELIS

Grigelis sp.A (Pl. 3, Figs. 34-35)

Remarks: A few specimens were studied from the Bellevue, Combes and Fiol sections.

Genus FRONDICULARIA

Frondicularia sp.A

Remarks: One, possibly reworked specimen, was observed from the Fillinges section.

Family VAGINULINIDAE
Genus LENTICULINA*Lenticulina sp.A* (Pl. 3, Figs. 36-37)

Remarks: This very large form is strongly biconvex and possesses a large, transparent umbo and thick sutures. This species is common and widely distributed throughout the field areas.

Lenticulina sp.B

Remarks: This small, rare form has numerous chambers, very curved sutures and a small umbilical boss. Retrieved from Fillinges, Saxel and Chauffemerande.

Genus SARACENARIA

Saracenaria propinqua (Hantken) (Pl. 3, Figs. 38-39)

1875 *Cristellaria propinqua* Hantken, p. 52, pl. 5, fig. 4.
 1996 *Saracenaria propinqua*; Cicha et al., pl. 24, fig. 9.

Remarks: Is characterised by possessing a few chambers in the final whorl, a thin tapering keel and a large apertural face which forms two thirds of the test in peripheral view. Recovered from late Eocene to late Oligocene sediments from the Paratethys (Cicha et al. 1996). Frequent within the Fiol section.

Genus AMPHICORYNA

Amphicoryna badenensis (d'Orbigny) (Pl. 3, Figs. 40-41)

1846 *Nodosaria badenensis* d'Orbigny, p. 38, pl. 1, figs. 34-35.
 1979 *Amphicoryna badenensis*; Sztrakos, p. 63, pl. 9, figs. 19-20.
 1991 *Amphicoryna badenensis*; Dohmann, p. 251, pl. 11, figs. 7-8.

Remarks: This small, rare form was observed sporadically within the Bellevue section. Reiser (1987), Dohmann (1991) and Cicha et al. (1996) observed this species in early Oligocene to middle Miocene, upper bathyal sediments.

Genus ASTACOLUS

Astaculus sp.A (Pl. 3, Fig. 42, Pl. 4, Fig. 1)

Remarks: This very rare species is highly compressed in peripheral view and possesses a small juvenile stage with later increasingly larger chamber. Was found only within the Combes section.

Genus VAGINULINOPSIS

Vaginulinopsis cumulicostata (Gümbel) (Pl. 4, Figs. 2-3)

1868 *Cristellaria cumulicostata* Gümbel, p. 60, pl. 1, fig. 67.
1985 *Vaginulinopsis cumulicostata*; Grunig, pl. 6, fig. 6
1996 *Vaginulinopsis cumulicostatus*; Cicha et al., pl. 26, fig. 3.

Remarks: Found in middle to late Eocene of the foraminiferal marls of the Swiss Alps (Eckert 1963, Kuhn 1972). Recorded from late Eocene to late Oligocene (Cicha et al. 1996), middle to late Eocene (Braga et al. 1975, Grunig 1985, Mathelin & Sztrakos 1993). Represents a rare species in the alpine region and was recovered from the Combes, Dranse and Nantbellet sections.

Vaginulinopsis spp. indet.

Remarks: A few well preserved fragments of *Vaginulinopsis*, of probably different species, were recovered from the Venay and Vacherie sections.

Family LAGENIDAE
Genus LAGENA

Lagena cf. *gracilicosta* Reuss (Pl. 4, Figs. 4-5)

1863 *Lagena gracilicosta* Reuss, p. 327, pl. 3, figs. 42-43.
1996 *Lagena gracilicosta*; Cicha et al., pl. 27, figs. 3-4.

Remarks: Characterised by its globular shape and numerous fine, longitudinal ornamentations. Very rare species which sporadically occurs within Bellevue, Bons, Chauffemerande and Montauban. This species is well illustrated from the middle Eocene to early Oligocene where it is generally more frequent (Reiser 1987, Sztrakos 1979, 1982, 1987, Mathelin & Sztrakos 1993 and Cicha et al. 1996).

Lagena cf. *tenuis* (Bornemann) (Pl. 4, Figs. 8-9)

1855 *Ovulina tenuis* Bornemann, p. 317, pl. 12, fig. 3
1993 *Lagena tenuis*; Sztrakos, pl. 27, fig. 12.

Remarks: Possesses finely developed longitudinal costae which are usually more prominent towards the base of elongate test. Very rare within the Fiol and Bellevue sections.

Lagena sp.A (Pl. 4, Figs. 10-11)

Remarks: Characterised by 3 thick, longitudinal costae. This very rare, well preserved species was observed only from the Fiol section.

Lagena sp.B (Pl. 4, Figs. 12-13)

Remarks: Possesses a smooth surface and rounded aperture which is positioned on a short, terminal neck. This rare poorly preserved species was retrieved from the Combes section. Sztrakos (1982 and 1987) illustrated lateral drawings of *Lagena vulgaris* and Wenger (1987) of *Lagena laevis* which both seem synonymous to this species.

Family POLYMORPHINIDAE
Genus FALSOGUTTULINA

Falsoguttulina sp.A (Pl. 4, Figs. 14-15)

Remarks: A very rare species which was observed in only one sample from the Signal Voirons B section suggesting a late Paleocene distribution. Its slightly raised slit-like aperture suggests a *Falsoguttulina* generic assignment.

Genus POLYMORPHINA

Polymorphina sp.A (Pl. 4, Figs. 16-17)

Remarks: Often preserved as pyritised internal moulds. Characterised by depressed sutures and a large, compressed test. Sparsely distributed within the Fillinges, Vacherie and Combes sections. Some dubious specimens, which possibly pertain to this species, were also observed from Nantbellet and Bons. Small, juvenile forms occur throughout the Bellevue section.

Genus GUTTULINA

Guttulina irregularis (d'Orbigny) (Pl. 4, Figs. 18-19)

1846 *Globulina irregularis* d'Orbigny, p. 226, pl. 13, figs. 9-10.
1980 *Guttulina irregularis*; McDougall, pl. 12, figs. 7-11.
1987 *Guttulina irregularis*; Sztrakos, pl. 6, fig. 21.

Remarks: A few, well preserved specimens were recovered from the Signal Voirons B, Fillinges and Nantbellet sections. Some poorly preserved, probably reworked, specimens were also observed within the Bellevue section.

Family ELLIPSOLAGENIDAE
Genus BUCHNERINA

Buchnerina sp.A (Pl. 4, Figs. 26-27)

Remarks: This species possesses a coarse, perforate surface and a thick peripheral margin with three encircling keels which are separated by two shallow grooves. Its short neck is thick and solid. Rare, sporadic occurrences were observed at Fiol and Dranse.

Genus FAVULINA

Favulina hexagona (Williamson) (Pl. 4, Figs. 6-7)

1939 *Lagena hexagona* Williamson, p. 61, pl. 4, fig. 23.
1987 *Lagena hexagona*; Wenger, p. 260, pl. 5, fig. 9.
1996 *Favulina hexagona*; Cicha et al., pl. 28, fig. 11.

Remarks: One well preserved specimen was observed at Fiol. Distributed within middle Eocene to middle Miocene sediments (Sztrakos 1987, Reiser 1987, Huber 1994 and Cicha et al. 1996). Represents a geographically widespread species of late Eocene intermediate water depths (Kaiho 1992).

Genus FISSURINA

Fissurina sp.A

Remarks: The entosolenian tube is clearly visible and extends from its radiate, terminal aperture to the central portion of its elongate test. Only observed within the Bellevue section.

Genus PALLIOLATELLA

Palliolatella sp.A (Pl. 4, Figs. 24-25)

Remarks: Possesses a triangular, flattened, transparent neck which displays its entosolenian tube. Also characterised by a thick, peripheral keel. May be attributed to the genus *A* few, rare specimens were recovered from the Signal Voiron B and Fiol outcrops.

Genus PARAFISSURINA

Parafissurina cf. *laevigata* Reuss (Pl. 4, Figs. 20-21)

1850 *Fissurina laevigata* Reuss, p. 366, pl. 6, figs. 1a-b.
1993 *Fissurina laevigata*; Mathelin & Sztrakos, pl. 28, fig. 17.

Remarks: Possesses a thin keel, transparent neck which shows its entosolenian tube, and a small slit-like aperture. Very rare and was observed within the Bellevue, Nantbellet, Combes and Fiol sections.

Parafissurina sp.A (Pl. 4, Figs. 22-23)

Remarks: Its globular shaped test possesses a smooth surface and a small, curved, slit-like aperture. The entosolenian tube is not visible amongst the studied specimens. Recovered from the Fiol, Bellevue and Vacherie deposits. Lateral views of *Fissurina inducta* (Mathelin & Sztrakos 1993) and *Fissurina obtusa* (Cicha et al. 1996) could be attributed to this species. *Parafissurina ventricosa* (Jones 1984) also resembles very closely the specimens from this study but were retrieved from Pleistocene to Holocene sediments.

Superfamily PLEUROSOMELLACEA
Family PLEUROSOMELLIDAE
Genus PLEUROSOMELLA

Pleurostomella alternans Schwager (Pl. 4, Figs. 28-29)

1866 *Pleurostomella alternans* Schwager, p. 238, pl. 6, figs. 79-80.
1993 *Pleurostomella alternans*; Mathelin & Sztrakos, pl. 13, figs. 9-10, pl. 35, figs. 13-14.

Remarks: Found within Eocene sediments located in the Nantbellet, Marais and Combes outcrops of the Thônes syncline. One inflated form from the Combes section approaches *Pleurostomella acuta* but may represent a bathymetric variation of *Pleurostomella alternans*. Dohmann (1991) recorded this species from late Eocene bathyal deposits. Sztrakos (1987) and Mathelin & Sztrakos (1993) also recorded this form from the middle Eocene.

Pleurostomella bellardi Hantken (Pl. 4, Figs. 30-31)

1883 *Pleurostomella bellardi* Hantken, p. 146, pl. 2, figs. 1a-b.
1976 *Pleurostomella bellardi*; Berggren & Aubert, pl. 1, fig. 7.

Remarks: Rarely found within the Dranse, Nantbellet and Vacherie sections.

Pleurostomella sp.A (Pl. 4, Figs. 32-33)

Remarks: Its inflated basal chambers distinguishes this species from *Pleurostomella acuta* (e.g. Braga et al. 1975, Thomas 1985, Kaiho 1991 and Milner 1992). This very rare form was observed only at Bons.

Superfamily STILOSTOMELLACEA
Family STILOSTOMELLIDAE
Genus STILOSTOMELLA

Stilostomella cf. *aldophina* d'Orbigny (Pl. 4, Figs. 34-35)

1846 *Stilostomella aldophina* d'Orbigny, p. 51, pl. 2, figs. 18-20.
1993 *Nodogenerina adolphina*; Mathelin & Sztrakos, pl. 13, fig. 15.

Remarks: Sutures are more depressed and chambers more box-like in comparison to the form illustrated by Mathelin & Sztrakos (1993). This species was only found within the Fiol and Dranse sections. Ranges from the latest Eocene to middle Miocene (Reiser 1987, Dohmann 1991 and Cicha et al. 1996).

Stilostomella cf. *conspurcata* Reuss (Pl. 4, Figs. 36-37)

1851 *Nodosaria conspurcata* Reuss, p. 59, pl. 3, fig. 3.
1982 *Stilostomella conspurcata*; Sztrakos, pl. 16, fig. 2.

Remarks: Characterised by its finely pustulate surface. Chambers greatly vary in size. Recovered from the Fiol, Dranse and Venay sections. Resembles *Stilostomella subspinosa* from Tjalsma & Lohmann (1983).

Stilostomella sp.A (Pl. 4, Figs. 38-39)

Remarks: This very rare species is characterised by narrow, elongate chambers and was observed within the Bellevue section.

Order ROBERTINIDA
Superfamily CERATOBULIMINACEA
Family CERATOBULIMINIDAE
Genus PSEUDOLAMARCKINA

?Pseudolamarckina sp. indet.

Remarks: A few, poorly preserved specimens, which were probably reworked, were retrieved from the Bellevue section.

Family EPISTOMINIDAE
Genus HOEGLUNDINA

Hoeglundina elegans (d'Orbigny) (Pl. 5, Figs. 1-2)

1826 *Rotalia (Turbinulina) elegans* d'Orbigny, p. 276.
1986 *Hoeglundina elegans*; Van Morkhoven et al., p. 97, pl. 29, figs. 1-2.

Remarks: A few moderately well preserved specimens were recovered from the Sage and Combes outcrops. A specimen from the Nantbellet section doubtfully belongs to this species. Specimens are often poorly preserved probably due to dissolution. Van Morkhoven et al. (1986), suggested a late Eocene (P16) to Pleistocene (N23) stratigraphic range for this species. Although highest frequencies occur on the outer shelf, it is also present in deeper water. Represents a geographically widespread species of late Eocene intermediate water depths (Kaiho 1992).

Order BULIMINIDA
 Superfamily BOLIVINACEA
 Family BOLIVINIDAE
 Genus BOLIVINA

Bolivina cf. beyrichi Bandy (Pl. 5, Figs. 3-4)

1851 *Bolivina beyrichi* Reuss, p. 83, pl. 6, , fig. 51.
 1996 *Bolivina beyrichi*; Cicha et al., pl. 44, figs. 1-2.

Remarks: Sparsely distributed throughout the Bellevue section. This small form is most frequent in the less than 63µm sediment fraction. Specimens of *Bolivina beyrichi* from the Oligocene central Paratethys (Cicha et al. 1996) and Molasse basin (Reiser 1987) are larger and possess slightly more inflated chambers. Recorded also from the middle Eocene (Sztrakos 1982). Approaches *Bolivina beyrichi carinata* (Reiser 1987).

Bolivina vaceki bavarica Lühr (Pl. 5, Figs. 9-10)

1962 *Bolivina striatocarinata* Cushman *bavarica* Lühr, p. 135, pl. 5, fig. 1.
 1996 *Bolivina vaceki bavarica*; Cicha et al., pl. 42, figs. 1-4.

Remarks: Similar to *Bolivina koessenensis* (Reiser 1987, Dohmann 1991, Cicha et al. 1996) from Oligocene sediments but possesses fewer, finer longitudinal striae. Represents the most common of the *Bolivina* species, recorded frequently from the Voiron massif at Chauffemerande, Fiol and Bellevue, as well as at Sage and Nantbellet located in the subalpine chains and Thônes syncline respectively.

Bolivina sp.A (Pl. 5, Figs. 5-6)

Remarks: Possesses a thicker, flush sutures and a broader outline in cross section in comparison to *Bolivina denticulata*. Occurs rarely within the Bellevue, Dranse and Ruisseau Saxel sections. Some specimens are similar to *Bolivina liebusi* (Cicha et al. 1996), which is generally more highly perforated and possesses more depressed sutures.

Bolivina sp.B (Pl. 5, Figs. 7-8)

Remarks: Displays inflated, more globular chambers in comparison to the other studied *Bolivina* species. This species is similar to *Bolivina molassica* recorded from the Oligocene (Reiser 1987 and Cicha et al. 1996), but possesses fewer chambers which are more inflated in the final stage. Occurs rarely and sporadically within Bellevue.

Superfamily LOXOSTOMATACEA
 Family LOXOSTOMATIDAE
 Genus ARAGONIA

Aragonia velascoensis Cushman (Pl. 5, Figs. 11-12)

1925 *Textularia velascoensis* Cushman, p. 18, pl. 3, fig. 1.
 1983 *Aragonia velascoensis*; Tjalsma & Lohmann, p. 5, pl. 4, fig. 6.
 1986 *Aragonia velascoensis*; Van Morkhoven et al., p. 340, pl. 3A, figs. 1a-3, pl. 3B, figs. 1a-3.

Remarks: One rare, well preserved specimen was retrieved from the Signal Voiron B section. Ranges from late Cretaceous (Campanian) through to late Paleocene (planktonic foraminiferal P5 zone) where it occupied upper bathyal to abyssal depths (Van Morkhoven et al. 1986).

Superfamily CASSIDULINACEA
 Family CASSIDULINIDAE
 Genus CASSIDULINA

Cassidulina laevigata d'Orbigny (Pl. 5, Figs. 13-14)

1826 *Cassidulina laevigata* d'Orbigny, p. 282, pl. 15, figs. 4-5.
 1958 *Cassidulina laevigata*; Martin, p. 282, pl. 15, figs. 4-5.
 1996 *Cassidulina laevigata*; Cicha et al., pl. 45, figs. 2-4.

Remarks: This very rare species possesses a compressed test with inflated chambers and was only observed within Oligocene sediments at Bellevue and Dessy. Recorded from the early Oligocene Molasse in northern Switzerland (Martin 1958) and from the late Oligocene in the central Paratethys (Cicha et al. 1996).

Globocassidulina globosa (Hantken) (Pl. 5, Figs. 15-16)

1875 *Cassidulina globosa* Hantken, p. 64, pl. 16, figs. 2a-b.
 1996 *Globocassidulina globosa*; Cicha et al., pl. 45, figs. 12-14.

Remarks: Although rare, this species is widely distributed and was recorded from the Voiron massif, Thônes syncline and Subalpine chains. This species ranges from the late middle Eocene to early Oligocene (Milner 1992, Cicha et al. 1996, and this study).

Superfamily TURRILINACEA
 Family TURRILINIDAE
 Genus PYRAMIDINA

Pyramidina rudita (Cushman & Parker) (Pl. 5, Figs. 17-18)

1936 *Bulimina rudita*; Cushman & Parker, p. 45.
 1983 *Pyramidina rudita*; Tjalsma & Lohmann, p. 19, pl. 7, fig. 2.

Remarks: Frequent within the uppermost sample of the Signal Voiron B section. Occurs at intermediate depths during the early Paleocene and is rare to common from zones P1 to P5 in the Atlantic ocean (Tjalsma & Lohmann 1983).

Superfamily BULIMINACEA
 Family BULIMINIDAE
 Genus BULIMINA

Bulimina elongata d'Orbigny (Pl. 5, Figs. 19-20)

1846 *Bulimina elongata* d'Orbigny, p. 187, pl. 11, figs. 19-20.
 1937 *Bulimina elongata*; Cushman and Parker, p. 50, pl. 7, figs. 1-3.
 1987 *Bulimina elongata*; Wenger, p. 267, pl. 16, figs. 19-20.
 1996 *Bulimina elongata elongata*; Cicha et al., pl. 47, fig. 5.

Remarks: High variation in chamber shape in adult stage. Occurs within the Bellevue and Fillinges sections. Cicha et al. (1996) observed this species throughout the Oligocene and Miocene. Reiser (1987) and Dohmann (1991) recognized assemblages consisting of this species typically within outer neritic to upper bathyal dysaerobic sediments. Sztrakos (1982) recorded this form already in the middle Eocene.

Bulimina jarvisi Cushman & Parker (Pl. 5, Figs. 21-22)

1936 *Bulimina jarvisi* Cushman & Parker, p. 39, pl. 7, fig. 1.
 1983 *Bulimina jarvisi*; Tjalsma & Lohmann, p. 25, pl. 13, figs. 4-5b.
 1986 *Bulimina jarvisi*; Van Morkhoven et al., p. 184, pl. 62, figs. 1-5.

Remarks: This large species, retrieved from the Fiol section, possesses a distinctive coarsely perforate surface. This form occupied lower bathyal to abyssal depths (Tjalsma & Lohmann 1983) from the late Eocene (P15 zone) to middle Miocene (Van Morkhoven et al. 1986).

Bulimina subtruncana Hagn (Pl. 5, Figs. 23-24)

1954 *Bulimina subtruncana* Hagn, p. 17, pl. 3, fig. 10, pl. 4, fig. 9.
1985 *Bulimina subtruncana*; Grunig, p. 266, pl. 6, fig. 23.

Remarks: Well preserved specimens are very common in samples from the Dessy, Sage and Vacherie sections. More sporadic occurrences within Bellevue, Nantbellet and Montauban suggesting an increase in populations during the early Oligocene. Possibly attributable to *Bulimina sculptilis* Cushman, which was recovered from early Oligocene Paratethyan sediments (Cicha et al. 1996). However, this species seems to possess more thicker and numerous costae in comparison to specimens from this study.

Bulimina trinitatensis Cushman & Jarvis (Pl. 5, Figs. 25-26)

1928 *Bulimina trinitatensis* Cushman & Jarvis, p. 102, pl. 14, fig. 12.
1983 *Bulimina trinitatensis*; Tjalsma & Lohmann, p. 8, pl. 3, figs. 3-4, pl. 14, fig. 1.
1986 *Bulimina trinitatensis*; Van Morkhoven et al., p. 299, pl. 98A, figs. 1a-2c, pl. 98B, figs. 1-4.

Remarks: A few well preserved, rare specimens were recorded from the Signal Voirons B section. Recorded from the early Paleocene (zone P1) to late Eocene (zone p16). Occupied bathyal to abyssal depths during the Paleocene and moved into shallower sites during the Eocene, possessing an upper depth limit of 500-600m (Tjalsma & Lohmann 1983 and Van Morkhoven et al. 1986).

Bulimina sp.A (Pl. 5, Figs. 27-28)

Remarks: This species possesses an aperture at both ends of the test. Chambers are globular, sutures curved and depressed. Rare specimens are preserved as pyritised internal moulds and may represent a pathological form of one of the *Praeglobobulimina* species recovered from the same sample of the Bellevue section.

Genus PRAEGLOBOBULIMINA

Praeglobobulimina bathyalis (Reiser) (Pl. 5, Figs. 29-30)

1987 *Globobulimina bathyalis* Reiser, p. 78, pl.6, figs. 17, 20-21.
1996 *Praeglobobulimina bathyalis*; Cicha et al., pl. 48, figs. 6-8.

Remarks: Preserved as pyritised or ferruginised internal moulds. Retrieved from Dranse, Fillinges, and Bellevue. Some dubious occurrences also at Bons and Marais. Reiser (1987) and Cicha et al. (1996) recorded this species from the Oligocene.

Praeglobobulimina pupoides (d'Orbigny) (Pl. 5, Figs. 31-32)

1846 *Bulimina pupoides* d'Orbigny, p. 185, pl.11, figs. 13-14.
1996 *Praeglobobulimina pupoides*; Cicha et al., pl. 48, figs. 10, 14-17.

Remarks: Usually preserved as pyritised or ferruginised internal moulds. Retrieved from Dranse, Fillinges, Sage, and Bellevue suggesting a late Eocene to Oligocene stratigraphic distribution. Cicha et al. (1996) recorded this species from the early Oligocene. Represents a geographically widespread species of late Eocene intermediate water depths (Kaiho 1992).

Praeglobobulimina pyrula (d'Orbigny) (Pl. 5, Figs. 33-34)

1846 *Bulimina pyrula* d'Orbigny, p. 184, pl.11, figs. 9-10.
1996 *Praeglobobulimina pyrula*; Cicha et al., pl. 48, figs. 11-13.

Remarks: Occurs within the Bellevue, Sage and Fillinges sections. Cicha et al. (1996) recorded this species from the Oligocene and Miocene. Pyritised specimens were recorded frequently by Wenger (1987) and Dohmann (1991) within upper bathyal Oligocene and Miocene sediments.

Superfamily DELOSINACEA
Family CAUCASINIDAE
Genus CAUCASINA

Caucasina coprolithoides (Andreae) (Pl. 5, Figs. 35-36)

1884 *Bulimina coprolithoides* Andreae, p. 305, pl. 6, fig. 4a.
1990 *Caucasina coprolithoides*; Dohmann, p. 264, pl. 13, fig. 1.
1996 *Bulimina coprolithoides*; Cicha et al., pl. 47, fig. 1.

Remarks: Recorded rarely to frequently throughout from the Bellevue section. The generic assignment follows Loeblich & Tappan (1988). Reiser (1987), Dohmann (1990) and Cicha et al. (1996) observed this species from Oligocene, upper bathyal sediments. Wenger (1987) suggested that this species is very common throughout the Oligocene "Bayerischen" Molasse. Sztrkos (1982) and Mathelin & Sztrkos (1993) recorded this form from the middle to late Eocene and Oligocene.

Family UVIGERINIDAE
Genus UVIGERINA

Uvigerina eocaena Gümbel (Pl. 5, Figs. 37-38)

1868 *Uvigerina eocaena* Gümbel, p. 645, pl. 2, fig. 78.
1986 *Uvigerina eocaena*; Cicha et al., pl. 1, figs. 1-6.

Remarks: This species is very frequent within the Dessy, Sage and Combes sections. Specimens possibly pertaining to this species were observed from Montauban and Marais. Traced from the late Eocene to early Oligocene (Cicha et al. 1986). As Berggren & Aubert (1976) suggested, this species occupied bathyal depths.

Uvigerina moravia Boersma (Pl. 5, Fig. 39, Pl. 6, Fig. 1)

1984 *Uvigerina moravia* Boersma, p. 114, pl. 1, figs. 1-4.
1986 *Uvigerina moravia*; Cicha et al., p. 134, pl. 2, figs. 1-7, pl. 12, fig. 7.

Remarks: Possesses fewer and more discontinuous costae per chamber and a more elongate test in comparison to *Uvigerina eocaena*. Occurs frequently at Sage. Represents a useful late Eocene to early Oligocene marker (Cicha et al. 1986, 1996).

Uvigerina tenuistriata Reuss (Pl. 6, Figs. 2-3)

1870 *Uvigerina tenuistriata* Reuss, p. 485, pl. 22, figs. 34-37.
1996 *Uvigerina tenuistriata*; pl. 52, fig. 10.

Remarks: Juvenile forms have slightly less inflated chambers and less marked striae. Frequent within Dessy, Bellevue and Combes with also dubious occurrences at Nantbellet and Dranse.

Uvigerina sp.A (Pl. 6, Figs. 4-5)

Remarks: Small test tapers to the initial stage. Triangular in cross section. Possesses broad chamber faces which are usually concave. Chambers are angled and sharply edged displaying a distinctive zigzag periphery. The aperture is represented by a small rounded opening situated at the end of a short neck. This rare species was observed only within one sample of the Calcaires plaquetés from the Nantbellet section.

Genus ANGULOGERINA

Angulogerina globosa (Stoltz) (Pl. 6, Figs. 6-7)

1925 *Uvigerina tenuistriata* var. *globosa* Stoltz, p. 130.
1996 *Angulogerina globosa*; Cicha et al., pl. 54, figs. 11-12.

Remarks: Very rare occurring only within Bellevue. A comparable specimen was also observed at Nantbellet. Considered as a late Oligocene species from the central Paratethys (Cicha et al. 1996).

Genus TRIFARINA

Trifarina sp.A (Pl. 6, Figs. 8-9)

Remarks: Triangular in cross section and possesses distinctive thick, curved sutures, and a smooth surface. One large, well preserved specimen was retrieved from Nantbellet and a few juvenile specimens from Dranse and Sage.

Superfamily FURSENKOINACEA
Family FURSENKOINIDAE
Genus FURSENKOINA

Fursenkoina sp.A

Remarks: Pyritised internal moulds of this very rare species were only recorded from the Fillinges section.

Fursenkoina sp.B (Pl. 6, Figs. 10-11)

Remarks: This small form possesses highly compressed chambers. Very rare within the Bellevue section.

Order ROTALIIDA
Superfamily DISCORBACEA
Family EPONIDIDAE
Genus EPONIDES

?Eponides sp.A (Pl. 6, Figs. 12-13)

Remarks: This rare species possesses 6 chambers in the final whorl, a lobulate peripheral outline, thickened keel and a coarsely and densely perforated surface. The umbilical side is highly convex. Occurs rarely at Combes and Chauffemerande.

Family DISCORBIDAE
Genus DISCORBIS

Discorbis sp.A (Pl. 6, Figs. 14-15)

Remarks: Two small, rare specimens were found at the base of the Bellevue section. Possesses a few chambers in the final whorl, thick, flush sutures, and a smooth, perforate surface.

Family MISSISSIPPINIDAE
Genus STOMATORBINA

Stomatorbina sp.A

Remarks: One reworked specimen from Montauban was identified.

Superfamily DISCORBINELLACEA
Family PSEUDOPARRELLIDAE
Genus CIBICIDOIDES

Cibicidoides sp.A (Pl. 6, Figs. 16-17)

Remarks: This large species possesses numerous chambers, thick, curved sutures, a highly and densely perforated surface and a large calcitic umbilical plug. Sporadically distributed but relatively frequent throughout the studied area in comparison to other *Cibicidoides* species.

?Cibicidoides sp.B (Pl. 6, Figs. 18-19)

Remarks: The test is very coarsely perforated and particularly ornamented in the umbilical region. Possesses a large, fringed, thin keel and 8 chambers in the final whorl which are separated by distinctive thick, curved sutures. The spiral side is slightly convex. Occurs only within the upper part of the Dranse section.

Cibicidoides sp.C (Pl. 6, Figs. 20-21)

Remarks: Small biconvex test which displays thick, curved sutures and a thickened keel. The surface is smooth and finely perforated. Located within the Fiol section.

Superfamily PLANORBULINACEA
Family PLANULINIDAE
Genus PLANULINA

Planulina *ambigua* (Franzenau) (Pl. 6, Figs. 24-25)

1888 *Rotalia ambigua*, Franzenau, p. 174, pl. 2, figs. 9-11.
1996 *Planulina ambigua*; Cicha et al., pl. 63, figs. 14-16.

Remarks: Large test with a more lobulate outline and narrower periphery in comparison to *Planulina* sp.A. Possesses a thickened keel which thickens towards the umbilical side. Sutures are raised towards the umbilical region which is also ornamented. The surface displays distinctively large pores. This species represents a useful Oligocene marker from the Paratethys (Cicha et al. 1996). Two well preserved specimens were retrieved from the Bellevue section.

Planulina sp.A (Pl. 6, Figs. 22-23)

Remarks: Possesses thick, curved, raised sutures and a thickened periphery. The surface is smooth and finely perforated. A few specimens were recovered from, the base of the Marais and Combes, and top of the Dranse sections.

Family CIBICIDIDAE
Genus CIBICIDES

Cibicides sp.A (Pl. 6, Figs. 26-27)

Remarks: There is large morphological variation within this species regarding the size of the test and its calcite umbilical plug. Possesses numerous chambers and curved sutures. The most widely distributed of the *Cibicides* species. This species was recorded throughout the studied area usually in frequent proportions. Resembles *Cibicides umbonifer* (Parr 1938), a southern hemisphere species.

Cibicides sp.B (Pl. 6, Figs. 30-31)

Remarks: Possesses fewer chambers, thicker sutures and a higher spire in comparison to *Cibicides* sp.A. Recovered rarely from Dranse, Fillinges, Chauffemerande, Saxel, Nantbellet and Marais.

Cibicides sp.C (Pl. 6, Figs. 28-29)

Remarks: This rare form possesses about 8 chambers in the final whorl, a thickened peripheral keel, and straight to slightly curved, thick, flush sutures. Recorded within Fiol and Combes.

Cibicides sp.D (Pl. 6, Figs. 32-33)

Remarks: Test plano-convex to concavo-convex and lobulate in outline. Possesses thin, curved, depressed sutures. Its shape varies considerably probably as a result of the different substrates that provided attachment areas for the shell. Rarely recovered from Bellevue and Combes. It is probably synonymous with *Cibicides lobatulus* (Walker & Jacob 1798).

? *Cibicides* sp.E (Pl. 6, Figs. 34-35)

Remarks: This species possesses 5-6 chambers in the final whorl, straight, very depressed sutures, thin keel and a small interior marginal aperture. The spiral side is slightly convex and is tightly coiled displaying numerous small chambers. Only 2 pyritised internal moulds were observed within the Fillinges section.

Superfamily ASTERIGERINACEA
Family EPISTOMARRIDAE
Genus NUTTALLIDES

Nuttallides truempyi (Nuttall) (Pl. 6, Figs. 36-37)

1930 *Eponides truempyi* Nuttall, p. 287, pl. 24, figs. 9, 13-14.
1983 *Nuttallides truempyi*; Tjalsma & Lohmann, p. 17, pl. 17, figs. 4a-5b, pl. 21, figs. 1a-4c.
1986 *Nuttallides truempyi*; Van Morkhoven et al., p. 288, pl. 96A, figs. 1-4.
1992 *Nuttallides truempyi*; Milner, p. 81, pl. 4, figs. 1-2.

A few rare, moderately well preserved specimens were observed from Bons, Nantbellet, Fillinges, Signal Voirons B, the upper most parts of the Fiol and Dranse, and the lower most part of the Combes and Chauffemerande sections. This well described species is thought to possess an upper depth limit of 500m, although it more commonly occurs within lower bathyal-abyssal facies (Berggren & Aubert 1976). It is restricted to late Cretaceous-late Eocene, deep marine sediments (Van Morkhoven et al. 1986).

Superfamily NONIONACEA
Family NONIONIDAE
Genus NONION

Nonion cf. *boueanum* (d'Orbigny) (Pl. 6, Figs. 38-39)

1846 *Nonionina boueana* d'Orbigny, p. 108, pl. 5, figs. 11-12.
1958 *Nonion boueanum*; Batjes, p. 143, pl. 7, fig. 7.

Remarks: Observed throughout the upper part of the lower shaly interval of the Calcaires plaquetés at Marais and also within the Bellevue section. Originally described from the Miocene of the Vienna basin but ranges from the Oligocene through to modern environments (Butt 1966).

Genus NONIONELLA

Nonionella liebusi Hagn (Pl. 6, Fig. 40, Pl. 7, Fig. 1)

1952 *Nonionella liebusi* Hagn, p. 161, pl. 2, figs. 10a-c.
1982 *Nonionella liebusi*; Sztrakos, pl. 22, fig. 5.
1996 *Nonionella liebusi*; Cicha et al., pl. 66, figs. 7-9.

Remarks: Possesses a more rounder peripheral outline in comparison to *Nonionella* sp.A. Final chambers may vary in size and often possess a flap-like structure which partially covers the

umbilical region. Sztrakos (1982) recorded this species from the late Eocene and Reiser (1987) and Cicha et al. (1996) from the Oligocene to early Miocene. Retrieved from one sample within the upper part of the Bellevue section and from within the lowermost beds of the Fillinges section.

Nonionella sp.A (Pl. 7, Figs. 2-3)

Remarks: Possesses an angulate periphery, 5-7 chambers in the final whorl and a highly perforated wall texture. Occurs as small, pyritised internal moulds at the top of the lower shaly interval and within the upper interval of the Bellevue section and the lowermost part of the Fillinges section. A specimen which may belong to this species was also retrieved from the Calcaires plaquetés at Marais.

Nonionella sp.B (Pl. 7, Figs. 4-5)

Remarks: Relatively large and consists of 6 chambers in the final whorl. Characterised by a large open umbilical region and a subangular peripheral outline in cross section. Smooth test which is very finely perforated. Observed frequently at Sage.

Nonionella sp.C (Pl. 7, Figs. 6-7)

Remarks: Chambers rapidly increase in size and are more globular in comparison to the other studied *Nonionella* species. Occurs rarely at the base of the Bellevue section and relatively frequently at Sage and at the base of Fillinges.

Nonionella sp.D

Remarks: This rare, small species has a large basal aperture, highly depressed sutures and a lobulate periphery. Possesses 8 chambers in the final whorl. Located within one sample of the lower shaly horizon at Bellevue and from one sample within Fiol.

Genus PULLENIA

Pullenia quinqueloba (Reuss) (Pl. 7, Figs. 8-9)

1851 *Nonionina quinqueloba* Reuss, p. 71, pl. 5, figs. 31a-b.
1989 *Pullenia quinqueloba*; Hulsbos et al., pl. 3, fig. 8.

Remarks: A few well preserved individuals of this well established shelf species (Pflum & Frerichs 1976), were retrieved from the lowermost part of Montauban, uppermost part of Combes, Nantbellet, Fiol and Signal Voirons B. Poorly preserved specimens were identified from Fillinges, Bellevue and Venay indicating possible shelf to slope transport.

Pullenia cf. *bulloides* (d'Orbigny) (Pl. 7, Figs. 10-11)

1846 *Nonionoides bulloides* d'Orbigny, p. 107, pl. 5, figs. 9-10.
1994 *Pullenia bulloides*; Huber, p. 82, pl. 10, figs. 12-13.

Remarks: A few specimens were observed from the uppermost part of the Signal Voirons B section.

Genus MELONIS

Melonis sp.A (Pl. 7, Figs. 12-13)

Remarks: Possesses 5-6 inflated chambers, highly depressed umbilici, a smooth surface and a subrounded peripheral outline. Frequent within the Calcaires plaquetés of the Marais section.

Melonis sp. indet.

Remarks: Poorly preserved specimens were encountered within the Combes, Nantbellet, Vacherie and Fayaux B sections.

Superfamily CHILOSTOMELLACEA
Family CHILOSTOMELLIDAE
Genus CHILOSTOMELLA

Chilostomella cf. *chilostomelloides* Vasicek (Pl. 7, Figs. 14-17)

1947 *Chilostomella chilostomelloides* Vasicek, p. 248, pl. 2, fig. 16.
1949 *Chilostomella chilostomelloides*; Cushman & Todd, p. 87, pl. 15, fig. 7.

Remarks: The types were derived from late Eocene-early Oligocene flysch deposits. Occurs frequently throughout Fiol, commonly at the base of Fillinges and sparsely within Dranse, suggesting a late Eocene stratigraphic distribution. The aperture forms a half circle and has a lip which is detached from the final chamber. Reiser (1987), Sztrakos (1993) and Cicha et al. (1996) recorded *Chilostomelloides oviformis*, which possesses a more rounded aperture, within middle Eocene to early Oligocene sediments.

Chilostomella cylindroides Reuss (Pl. 7, Figs. 18-19)

1851 *Chilostomella cylindroides* Reuss, p. 80, pl. 6, fig. 43.
1958 *Chilostomella cylindroides*; Batjes, pl. 6, figs. 13a-c.

Remarks: The most widely distributed *Chilostomella* species and occurs frequently within middle Eocene-Oligocene sections in the Voiron Massif and the Thônes syncline. Abundant populations occur at the top of the Bellevue and at the base of the Fillinges sections. This species represents a useful indicator of dysaerobic bathyal environments. The types come from the Oligocene of Germany, however it is frequently recorded in middle Eocene-Oligocene Paratethyan deposits (e.g. Sztrakos 1982 and 1987). *Chilostomella cylindroides* Reuss var. *tenuis* Bornemann described also from Oligocene deposits in Germany, and observed also frequently from within middle-late Eocene sediments in Hungary (Sztrakos 1987), is more slender and possesses parallel sides. Forms which approach this variation in this study have been included within the range of *Chilostomella cylindroides*. Represents a geographically widespread species of late Eocene intermediate water depths (Kaiho 1992).

Chilostomella czizeki Reuss (Pl. 7, Figs. 20-21)

1850 *Chilostomella czizeki* Reuss, p. 80, pl. 6, fig. 43.
1987 *Chilostomella czizeki*; Wenger, p. 302, pl. 14, figs. 9-10.

Remarks: The final chambers possess more tapering ends in comparison to *Chilostomella ovoidea*. Specimens are often preserved as pyritised internal moulds. Rare occurrences within Bellevue, Fiol, Fillinges and Dranse suggesting a late Eocene-Oligocene stratigraphic distribution. Dohmann (1991) Wenger (1987) and Reiser (1987) recorded this species from the early and late Oligocene respectively.

Chilostomella ovoidea Reuss (Pl. 7, Figs. 22-23)

1850 *Chilostomella ovoidea* Reuss, p. 380, pl. 48, fig. 12.
1987 *Chilostomella ovoidea*; Wenger, p. 302, pl. 14, figs. 7-8.

Remarks: This species occurs commonly at the base of the Fillinges and top of the Bellevue sections. Specimens are often preserved as pyritised internal moulds. Sztrakos (1982, 1987) and Mathelin & Sztrakos (1993) observed *Chilostomella* aff. *ovoidea* in middle-late Eocene sediments. Cicha et al. (1996), Wenger (1987) and Reiser (1987) recorded this species from the Oligocene.

Genus ALLOMORPHINA

Allomorphina trigona Reuss (Pl. 7, Figs. 24-25)

1850 *Allomorphina trigona* Reuss, p.380, pl. 148, fig. 14.
1996 *Allomorphina trigona*; Cicha et al., pl. 67, figs. 11-14.

Remarks: Specimens are often preserved as pyritised internal moulds. Rare, sporadic occurrences within Bellevue and frequent at the base of Fillinges. Common within Paratethyan deposits beginning in the middle Eocene (e.g. Sztrakos 1987, 1993 and Cicha et al. 1996). Berggren & Aubert (1976) noted its presence in bathyal to abyssal deposits from the Labrador Sea.

Family ALABAMINIDAE
Genus ALABAMINA

Alabamina sp.A (Pl. 7, Figs. 26-27)

Remarks: The biconvex test shows a very smooth surface, 5-6 chambers in the final whorl and a large triangular shaped aperture. The test is more angulate in outline and sutures are more flush in comparison to the specimen of *Alabamina abtrusa* Franzenau, illustrated by Cicha et al. (1996). A few rare specimens were retrieved from the Fillinges and lowermost parts of the Bons and Combes sections.

Family OSANGULARIIDAE
Genus OSANGULARIA

Osangularia cf. *mexicana* (Cole) (Pl. 7, Figs. 28-29)

1927 *Pulvinulinella culter* (Parker & Jones) var. *mexicana* Cole, p. 31, pl. 1, figs 15-16.
1987 *Osangularia mexicana*; Miller & Katz, pl. 5, figs. 3a-b.

Remarks: Retrieved rarely from Fiol. This well described Eocene to early Oligocene species occupied depths between 1000-3000m (Tjalsma & Lohmann 1983).

?*Osangularia* sp.A (Pl. 7, Figs. 30-31)

Remarks: Its biconvex test displays a distinctive thickened keel and a large triangular interiomarginal aperture. Retrieved from the upper part of the Dranse section.

Osangularia spp. indet.

Remarks: Several poorly preserved specimens pertaining to this genus were observed from Bellevue, Bons, Marais, Nantbellet and Fiol.

Family HETEROLEPIDAE
Genus HETEROLEPA

Heterolepa dutemplei (d'Orbigny) (Pl. 7, Figs. 32-33)

1846 *Rotalina dutemplei* d'Orbigny, figs. 19-21.
1986 *Cibicidoides dutemplei*; Van Morkhoven et al., p. 112, pl. 35, figs. 1-2.
1996 *Heterolepa dutemplei*; Cicha et al., pl. 71, figs. 19-21.

Remarks: Occurs frequently within Sage, lowermost parts of Dessy and Nantbellet, Vacherie and throughout Combes. This well described species has generally been observed from early Miocene-Pliocene, outer neritic to bathyal deposits (Van Morkhoven et al. 1986). Sztrakos (1982) and Cicha et al. (1996) observed this species beginning from the early Oligocene in the central Paratethys. Represents a geographically widespread species of late Eocene intermediate water depths (Kaiho 1992).

Heterolepa sp.A (Pl. 7, Figs. 34-35)

Remarks: This species is relatively smaller and possesses fewer chambers in comparison to *Heterolepa dutemplei*. Sutures are thin, flush and curved. The surface of its biconvex test is very smooth and finely perforated. Occurs frequently throughout the Fiol section.

Heterolepa sp.B (Pl. 7, Figs. 36-37)

Remarks: Possesses thick, curved, depressed sutures, 5-7 chambers in the final whorl and a lobulate peripheral outline. The surface is smooth and densely perforated. Its periphery is much more angulate in comparison to the other *Heterolepa* species. Retrieved frequently from Venay and Vacherie. Rare occurrences from the top of the Dranse and throughout the Nantbellet and Combes sections.

Genus ANOMALINOIDES

Anomalinoides cf. *affinis* (Hantken) (Pl. 7, Figs. 38-39)

1875 *Pulvinulina affinis* Hantken, p. 68, pl. 10, fig. 6.
1993 *Anomalinoides affinis*; Mathelin & Sztrakos, pl. 20, fig. 8.

Remarks: Occurs frequently and very widely distributed throughout the studied area. Possesses thick, curved sutures, a rounded periphery, well perforated surface and often a small, shallow umbilicus.

Anomalinoides granosus (Hantken) (Pl. 8, Figs. 1-2)

1875 *Truncatulina granosa* Hantken, p. 74, pl. 10, fig. 2.
1996 *Anomalinoides granosus*; Cicha et al., pl. 69, figs. 14-18.

Remarks: This species is also well represented throughout the field areas. The test is usually slightly lobulate, inflated and subrounded in cross section and varies in size between 350-850µm. Its smooth surface possesses very large pores. Occurs within late Eocene to late Oligocene sediments from the central Paratethys (Cicha et al. 1996).

Anomalinoides sp.A (Pl. 8, Figs. 3-4)

Remarks: This species possesses numerous chambers in the final whorl and is slightly lobulate in outline. The test is more compressed and possesses a smoother surface in comparison to *Anomalinoides* sp.A. Observed within Sage, Dessy, Bellevue and Combes.

Family GAVELINELLIDAE
Genus GYROIDINOIDES*Gyroidinoides soldanii* (d'Orbigny) (Pl. 8, Figs. 5-6)

1826 *Rotalina soldanii* d'Orbigny, p. 155, pl. 8, figs 10-12.
1985 *Gyroidinoides soldanii*; Grunig, p. 275, pl. 10, figs. 12-14.

Remarks: This well described species is frequent and widely distributed throughout the studied sections. Some specimens resemble *Gyroidinoides girardanus* (Mathelin & Sztrakos 1993) but may in effect be a result of deformation which seems apparent in some samples (e.g. Fiol section).

Gyroidinoides sp.A (Pl. 8, Figs. 7-8)

Remarks: Approximately 10 chambers in the final whorl. Umbilical side is highly convex. Central area of chambers in peripheral view is depressed. Aperture extends from periphery to a deep, rounded central umbilicus. This very rare species was retrieved from the Fiol section.

Genus ESCORNEBOVINA

Escornebovina cuvillieri Poignant (Pl. 8, Figs. 9-10)

1965 *Rotalia cuvillieri* Poignant, p. 103, pl. 1, figs 1-2, 5-6.
1966 *Escornebovina cuvillieri*; Butt, p. 56, pl. 3, figs 8-11.

Remarks: A rare specimen was recorded within the Bellevue section. Sztrakos (1982) and Mathelin & Sztrakos (1993) recorded this species in middle Eocene to Oligocene sediments. A complete morphological description is found in Butt (1966).

Genus GAVELINELLA

Gavelinella acuta (Pl. 8, Figs. 11-12)

1926 *Anomalina ammonoides* (Reuss) var. *acuta* Plummer, pl. 10, figs. 2a-c
1987 *Gavelinella acuta*; Sztrakos, pl. 13, figs. 12-13

Remarks: This species is characterised by its inflated convex spiral side which displays raised sutures towards the central portion of the test. Subangular in cross section. Occurs frequently within Eocene deposits in the Thônes syncline at Combes, Nantbellet and Marais. Also observed rarely to frequently at Vacherie and within the lower part of the Chauffemerande section.

Gavelinella sp.A (Pl. 8, Figs. 13-14)

Remarks: Characterised by raised, elongate ornamentations which occur parallel and slightly oblique to the sutures on the umbilical side. Rare to frequent within Signal Voirons B, rare and sporadic within Fillinges and rare from the top of the Combes sections.

Gavelinella sp.B (Pl. 8, Figs. 15-16)

Remarks: This poorly preserved species possesses a distinctive large, deep umbilicus, few chambers in the final whorl and a highly perforated surface. Rare individuals were located within Nantbellet and Combes.

Genus HANZAWAIA

Hanzawaia ammophila (Gümbel) (Pl. 8, Figs. 17-18)

1868 *Rotalia ammophila* Gümbel, p. 652, pl. 2, figs. 90a-b.
1986 *Hanzawaia ammophila*; Morkhoven et al., p. 168, pl. 56, figs. 1a-3c.

Remarks: Test trochospiral, planoconvex with numerous chambers in the final whorl. Very large, may be depressed on both sides, though spiral side is usually inflated with a clear central boss. Sutures thickened and strongly curved back at the periphery. Possesses a keeled periphery and an aperture which extends from the periphery to the umbilicus under its umbilical flaps. Observed frequently within Combes, Venay and Vacherie. This species has a known stratigraphic range from the latest Paleocene (zone P6a) through to the middle Miocene (zone N11) and is most common in outer neritic to upper bathyal environments (Van Morkhoven et al. 1986).

Superfamily ROTALIACEA
Family ROTALIIDAE
Genus PARAROTALIA*Pararotalia* spp. indet.

Remarks: Usually poorly preserved indicating that specimens were probably reworked from shallow to deeper sites. Occurs frequently at the top of the Dranse and base of the Chauffemerande sections. Rare and sporadic within Bellevue, Bons and Nantbellet.

Superfamily NUMMULITACEA
Family NUMMULITIDAE
Genus NUMMULITES

Nummulites spp. indet.

Remarks: Very abundant, relatively well preserved specimens were found at the base of the Nantbellet section. A few rare, probably reworked specimens were retrieved from Dranse and Combes.

Superfamily OPEN
Family PATELLINIDAE
Genus PATELLINA

Patellina sp.A (Pl. 8, Figs. 19-20)

Remarks: This species is frequent throughout the Bellevue section and also occurs rarely at Sage, the top of the Montauban, Dranse and Combes, and base of the Chauffemerande and Dessy sections.

Superfamily OPEN
Family CARTERINIDAE
Genus CARTERINA

Carterina sp.A (Pl. 8, Figs. 21-22)

Remarks: Well preserved specimens were retrieved from Sage and at the base of Chauffemerande. Specimens pertaining to this genus were observed from the late Eocene and Holocene (Loeblich & Tappan 1988).

Order GLOBIGERINIDA
Superfamily HETEROHELICACEA
Family CHILOGUEMBELINIDAE
Genus CHILOGUEMBELINA

Chiloguembelina cf. *cubensis* (Palmer) (Pl. 8, Figs. 23-24)

Remarks: A very rare species which was recovered from Bellevue and Bons. Dubious specimens were retrieved from Marais and Dranse. Some specimens were probably reworked from Paleocene sediments. Sztrakos (1979) and Reiser (1987) noted this species from Oligocene sediments.

Superfamily ROTALIPORACEA
Family ROTALIPORIDAE
Genus ROTALIPORA

Rotalipora sp. indet.

Remarks: A few poorly preserved specimens were recovered from one sample within the Signal Voiron B section indicating reworking of Cretaceous material.

Superfamily GLOBOTRUNCANACEA
Family GLOBOTRUNCANIDAE
Genus GLOBOTRUNCANA

Globotruncana spp. indet.

Remarks: Sporadic occurrences of poorly preserved *Globotruncana* specimens were recorded from Bellevue, Dranse, Signal Voiron B, Bons, Marais, Nantbellet, Chauffemerande and Fillinges indicating reworked Cretaceous sediments.

Superfamily GLOBOROTALIACEA
Family GLOBOROTALIIDAE
Genus GLOBOROTALIA

Globorotalia increbescens (Bandy) (Pl. 8, Figs. 25-26)

Remarks: Observed within late Eocene deposits at Dranse, Fiol, Montauban, Combes, Saxel and Chauffemerande and early Oligocene sediments at Bellevue, Sage, Venay and Vacherie.

Globorotalia munda Jenkins (Pl. 8, Figs. 27-28)

Remarks: *Globorotalia permicra* seems closely related to this species which occurs in the early Oligocene deposits at Dessy, Venay and Vacherie. Cicha et al. (1996) observed this species which they refer to as *Tenuitella*, according to wall texture, within early to middle Oligocene sediments.

Globorotalia opima nana Bolli (Pl. 8, Figs. 29-30)

Remarks: Specimens belonging to this species rarely occur at Fillinges, Fiol, Montauban, Bellevue, Venay and Dranse. Recorded from the late Eocene to early Miocene (Reiser 1987, Dohmann 1991 and Cicha et al. 1996).

Globorotalia cf. *opima opima* Bolli (Pl. 8, Figs. 31-32)

Remarks: A few rare forms were observed within sediments from Sage and Venay. Recovered from the middle Oligocene (Cicha et al. 1996).

Genus PLANOROTALITES

Planorotalites compressa (Plummer) (Pl. 8, Figs. 33-34)

Remarks: Well preserved individuals were retrieved from the Signal Voiron B section. Some reworked specimens were noted from Bellevue.

Planorotalites palmerae (Cushman & Bermudez)

Remarks: Reworked specimens were recorded from the Bellevue section.

Planorotalites renzi (Bolli) (Pl. 8, Figs. 35-36)

Remarks: A few well preserved specimens were observed from within the Nantbellet outcrop.

Genus TURBOROTALIA

Turborotalia cerroazulensis cf. *frontosa* (Subbotina)

Remarks: Specimens belonging to this species were recorded from Bellevue and Montauban. Some dubious forms were also recorded from Nantbellet. All of the specimens found, most likely indicate reworking of middle Eocene sediments.

Turborotalia cerroazulensis cerroazulensis (Cole) (Pl. 8, Figs. 37-38)

Remarks: This species occurs within sections from the Thônes syncline and Voiron massif. Abundant populations occur within the Fiol, Dranse and Combes sections. Rarer occurrences were observed within Bellevue, Marais, Montauban, Nantbellet and Chauffemerande.

Turborotalia cerroazulensis cocoaensis (Cushman) (Pl. 8, Fig. 39, Pl. 9, Fig. 1)

Remarks: Can be considered as a latest Eocene marker as the presence of *Turborotalia cerroazulensis cunialensis* is rare within north alpine sediments due to poor test preservation. Retrieved from the top of the Fiol and Dranse sections.

Turborotalia cerroazulensis pomeroli (Tourmakine & Bolli) (Pl. 9, Figs. 2-3)

Remarks: Rare occurrences from Combes, Fiol and Montauban. Dubious identifications were also noted from Dranse, Nantbellet and Saxel.

Family TRUNCOROTALOIDIDAE
Genus ACARININA

Acarinina broedermanni (Cushman & Bermudez) (Pl. 9, Figs. 4-5)

Remarks: Mainly represented by sporadic occurrences of reworked forms from Bellevue, Montauban and Chauffemerande. Some well preserved specimens were retrieved from within the Nantbellet section.

Acarinina bullbrooki (Bolli) (Pl. 9, Figs. 6-7)

Remarks: Common occurrences of well preserved forms were noted from Marais and Nantbellet in the Thônes syncline. Rare forms within Dranse, Fiol and Montauban were probably reworked.

Acarinina mckannai (White)

Remarks: A few reworked specimens were recovered from the Bons and Montauban outcrops.

Acarinina nitida (Martin)

Remarks: Poorly preserved, reworked specimens were retrieved from Bellevue.

Acarinina pentacamerata (Subbotina) (Pl. 9, Figs. 8-9)

Remarks: A few well preserved specimens were observed from Nantbellet.

Acarinina cf. pentacamerata (Pl. 9, Figs. 10-11)

Remarks: Specimens retrieved from Bons possibly represent intermediate forms between *Acarinina aspensis* and *Acarinina pentacamerata* as illustrated by Hillebrandt (1976).

Acarinina primitiva (Finlay)

Remarks: Reworked forms were identified within Bons, Marais and Montauban.

Acarinina pseudotopilensis Subbotina (Pl. 9, Figs. 12-13)

Remarks: A few well preserved forms were derived from Nantbellet.

Acarinina rotundimarginata Subbotina (Pl. 9, Figs. 14-15)

1971 *Acarinina rotundimarginata* Subbotina, pl. 25, figs 1a-3c.

Remarks: Occurs frequently within isolated horizons within the Dranse and Supersaxel sediments. Indicative of low oxygenated conditions in the Russian Carpathians (Luterbacher pers. comm. 1996).

Acarinina soldadoensis (Brönnimann)

Remarks: Rare, poorly preserved, possibly reworked, forms were observed from within the Montauban and Nantbellet sections.

Acarinina spinuloinflata (Bandy)

Remarks: A few rare, reworked specimens were noted from Bellevue and Chauffemerande.

Acarinina spp. indet.

Remarks: Sporadic, rare to common occurrences of reworked *Acarinina* species were observed from Bellevue, Bons, Dranse, Fillinges, Montauban, Chauffemerande, Saxel and Supersaxel.

Genus MOROZOVELLA

Morozovella aequa (Cushman & Renz)

Remarks: A few reworked specimens from Bellevue, Bons, Fillinges and Nantbellet were recorded.

Morozovella angulata (White)

Remarks: Rare internal moulds, probably belonging to this species, were recovered from Fillinges.

Morozovella aragonensis (Nuttall) (Pl. 9, Figs. 16-17)

Remarks: A few reworked specimens were derived from the upper part of the Montauban section. Relatively well preserved specimens were recorded throughout the Nantbellet section.

Morozovella conicotruncata (Subbotina)

Remarks: A few poorly preserved, probably reworked forms, were found within the Bons section.

Morozovella formosa gracilis (Bolli)

Remarks: A well preserved, reworked specimen was located within the Bons section.

Morozovella inconstans (Subbotina) (Pl. 9, Figs. 18-19)

Remarks: Very rare, well preserved, autochthonous specimens were retrieved from the Signal Voiron B outcrop.

Morozovella pseudobulloides (Plummer) (Pl. 9, Figs. 20-21)

Remarks: Reworked specimens were retrieved from one sample within the Bellevue section. This species is very common throughout the Signal Voiron B outcrop.

Morozovella subbotinae (Morozova) (Pl. 9, Figs. 22-23)

Remarks: Well preserved specimens, though possibly reworked, were frequently observed within the Bons section. Sediments from Bellevue also contained some poorly preserved specimens.

Morozovella trinidadensis (Bolli) (Pl. 9, Figs. 24-25)

Remarks: A few rare, well preserved specimens were recovered from the top of the Signal Voiron B section.

Morozovella sp. indet.

Remarks: A few poorly preserved *Morozovella* forms were located at the base of the Fillinges section.

Genus TRUNCOROTALOIDES

Truncorotaloides rohri Brönnimann & Bermudez (Pl. 9, Figs. 26-27)

Remarks: A few moderately, well preserved forms were recorded from the Nantbellet and the lower and upper parts of the Montauban section.

Family CATAPSYDRACIDAE
Genus CATAPSYDRAX

Catapsydrax dissimilis (Cushman & Bermudez) (Pl. 9, Figs. 28-29)

Remarks: Frequent occurrences within Combes, Dranse, Chauffemerande, Fiol, Sage and Marais. The bulla is thin and flattened, covering the umbilical region and 2 apertures occur in a horizontal position.

Catapsydrax cf. globiformis (Blow & Banner) (Pl. 9, Figs. 30-31)

1962 *Globigerinita globiformis* Blow & Banner p. 108, pl. 14, figs. s-u.
1979 *Globigerinita globiformis* Blow, pl. 197, figs. 7-9.

Remarks: This rare species, recovered from Fillinges and Venay, represents a useful late Eocene to early Oligocene marker. Blow & Banner (1962) observed this species within late Eocene sediments.

Catapsydrax pera (Todd) (Pl. 9, Figs. 32-33)

1957 *Globigerinita pera* Todd, p. 301, pl. 70, figs. 10-11.
1962 *Globigerinita pera*; Blow & Banner, p. 112, pl. 14, figs. e-h.

Remarks: The most common of the *Catapsydrax* species, frequenting most of the studied outcrops containing calcareous assemblages within the Voirons massif, Thônes syncline and Subalpine chains. Forms considered as *Catapsydrax dissimilis* (Tourmakine & Luterbacher 1985) are included as *Catapsydrax pera* in this study.

Catapsydrax unicava primitiva (Blow & Banner) (Pl. 9, Figs. 34-35)

1957 *Catapsydrax unicavus* Bolli, p. 166, pl. 37, figs. 7a-b.
1962 *Globigerinita unicava primitiva*, Blow & Banner, p. 114, pl. 14, figs. j-l

Remarks: Also frequently observed in the Voirons massif, Thônes syncline and Subalpine chains. The bulla is usually smaller in comparison to *Catapsydrax pera* and occurs in a more extraumbilical position.

Genus GLOBOROTALOIDES

Globorotaloides carcoselleensis Tourmakine & Bolli (Pl. 9, Figs. 36-37)

Remarks: This very rare species is a reliable middle to late Eocene marker and was recorded from Dranse. This species is extremely rare north of the Alps (Rögl, pers. comm. 1995).

Globorotaloides suteri Bolli (Pl. 9, Fig. 38, Pl. 10, Fig. 1)

Remarks: Specimens studied often possess a bulla as noted by Bolli & Saunders (1985). Found within late Eocene to early Oligocene sediments at Dessy, Bellevue, Chauffemerande, Dranse, Fiol, Supersaxel, Saxel and Venay.

Superfamily HANTKENINACEA
Family GLOBANOMALINIDAE
Genus PSEUDOHASTIGERINA

Pseudohastigerina micra (Cole) (Pl. 10, Figs. 2-3)

Remarks: Sporadic occurrences are represented from within Combes, Fiol, Bellevue and Nantbellet. Recorded from the late Eocene to early Oligocene (Dohmann 1991) and within the Oligocene (Reiser 1987).

Pseudohastigerina cf. nagewichiensis (Myatliuk)

Remarks: One poorly preserved specimen was observed within the Bellevue section. Occurs within late Eocene to early Oligocene sediments from the central Paratethys (Cicha et al. 1996).

Pseudohastigerina wilcoxensis (Cushman & Ponton)

Remarks: A few, probably reworked, specimens were observed within Fillinges and Nantbellet.

Family HANTKENINIDAE
Genus HANTKENINA

Hantkenina alabamensis Cushman (Pl. 10, Figs. 4-5)

Remarks: A few rare specimens occurred only within the Fiol and Marais sections. *Hantkenina* is very rarely found during the late Eocene within and north of the Alps as waters were probably too cold.

Family CASSIGERINELLIDAE
Genus CASSIGERINELLA

Cassigerinella cf. chipolensis (Cushman & Ponton) (Pl. 10, Figs. 6-7)

Remarks: A few well preserved specimens were retrieved from Bellevue, Dessy and Sage. Individuals from Dessy seem to possess slightly less inflated chambers. The abundance of this small species was probably affected by the cool water temperatures during the Oligocene.

Superfamily GLOBIGERINACEA
Family GLOBIGERINIDAE
Genus GLOBIGERINA

Globigerina ampliapertura Bolli (Pl. 10, Figs. 8-9)

Remarks: Rare within Bellevue, Venay, Vacherie, Fiol and Dessy. Also occurs rarely within the upper part of the Montauban and Dranse sections. Retrieved from the late Eocene to early Oligocene (Reiser 1987, Dohmann 1990) and from the early Oligocene (Cicha et al. 1996).

Globigerina cf. ampliapertura (Pl. 10, Figs. 10-11)

Remarks: Specimens were recovered from the Dranse and Fiol sections.

Globigerina angiporoides Hornibrook (Pl. 10, Figs. 12-13)

1965 *Globigerina angiporoides* Hornibrook, p. 835, figs. 1-2.
1985 *Globigerina angiporoides*; Jenkins, p. 274, figs. 6.3-5.

Remarks: Rare within Combes and Fiol, and rare to frequent at Sage and Vacherie. Also occurs at the base of the Bellevue section. Represents a late Eocene to late Oligocene marker (Reiser 1987, Dohmann 1991 and Cicha et al. 1996).

Globigerina ciproensis anguliofficialis (Blow) (Pl. 10, Figs. 14-15)

Remarks: Occurs rarely within the Bellevue section. Observed from Oligocene to early Miocene deposits (Reiser 1987, Dohmann 1991, Rögl 1994, Cicha et al. 1996).

Globigerina ciproensis angustiumbilitata Bolli (Pl. 10, Figs. 16-17)

Remarks: Rare abundances were derived from late Eocene sediments at Fiol and within the upper part of the Dranse section. Rare specimens were also located at the base of the Bellevue section and at Dessy, Venay and Vacherie. Appears in the early Oligocene and extends to the middle Miocene in the central Paratethys, under the generic assignment of *Tenuitellinata* (Cicha et al. 1996).

Globigerina ciproensis ciproensis Bolli (Pl. 10, Figs. 18-19)

Remarks: This very rare species was observed within the upper part of the Bellevue section and the Meletta shales at Dessy. Its occurrence may be associated with dysaerobic conditions during the Oligocene. Dohmann (1990) and Cicha et al. (1996) record this species within Oligocene sediments, however, Reiser (1987) traces this form already from the latest Eocene. Rögl (1994) recorded this species beginning from the P19 planktonic foraminiferal zone.

Globigerina cf. *ciproensis fariasi* (Bermudez)

Remarks: This small species possesses a high spire and could belong to this species. However, it was always observed as internal moulds from Fillinges.

Globigerina corpulenta Subbotina (Pl. 10, Figs. 20-21)

Remarks: Occurs rarely in sediments from Bellevue, Fiol, Montauban and Venay. Frequent in the uppermost part of the Dranse section.

Globigerina eocaena Guembel (Pl. 10, Figs. 22-23)

Remarks: Rare within Bellevue, Dranse, Fillinges and Fiol. Frequent to common at Marais and throughout the Combes section.

Globigerina euapertura Jenkins (Pl. 10, Figs. 24-25)

Remarks: Rare forms were observed from within the uppermost sample of the Dranse section. Appears in the Oligocene (Cicha et al. 1996) and in the latest Eocene to early Oligocene (Dohmann 1991).

Globigerina gortanii (Borsetti) (Pl. 10, Figs. 26-27)

Remarks: Recorded rarely within sediments from Bellevue and Venay. Observed within late Eocene to late Oligocene deposits (Cicha et al. 1996).

Globigerina hagni (Gohrbrandt) (Pl. 10, Figs. 28-29)

Remarks: Rare to frequent within a few samples belonging to the Bons section.

Globigerina linaperta Finlay (Pl. 10, Figs. 30-31)

Remarks: Possesses a distinct lip and narrow aperture. Varies in size. This species is widely distributed throughout the field areas. Found rarely within Chauffemerande, Fiol, Fillinges,

Bellevue, Dranse, Montauban and Sage. Frequent to common within the Marnes plaquetés at Marais and throughout the Nantbellet, Combes and Bons sections.

Globigerina officinalis Subbotina (Pl. 10, Figs. 32-33)

1953 *Globigerina officinalis* Subbotina, p. 78, pl. 11, figs. 1a-c. 2a-c. 6a-7c.
1962 *Globigerina officinalis*; Blow & Banner, p. 88, pl. 9, figs. a-c.

Remarks: This species is widely distributed throughout the studied areas. Rarely observed from Supersaxel, Chauffemerande and Montauban. Frequent to common at Bellevue, Dessy, Sage, Venay and Vacherie. Extends from the latest Eocene to late Oligocene (Dohmann 1991 and Cicha et al. 1996).

Globigerina ouachitaensis gnaucki Blow & Banner (Pl. 10, Figs. 34-35)

Remarks: Well preserved specimens were recorded throughout the Bellevue section and sporadically from the Dessy, Fillinges and Fiol sections.

Globigerina ouachitaensis ouachitaensis (Howe & Wallace) (Pl. 10, Figs. 36-37)

Remarks: Occurs rarely and sporadically within Fiol, Sage, Venay, Vacherie, Dessy, Fillinges, Dranse and throughout Bellevue. Dohmann (1991) and Cicha et al. (1996) observe *Globigerina* gr. *ouachitaensis* from the latest Eocene to late Oligocene.

Globigerina praebuloides praebuloides Blow (Pl. 11, Figs. 3-4)

Remarks: Rare specimens were encountered from within the Fiol, Sage, Bellevue and Dessy sections. Specimens comparable with this species were also recovered from Fillinges and Montauban. A few forms from Montauban possess a coarser wall texture and approach *Globigerina praebuloides occlusa*. Frequent in the uppermost part of the Dranse section.

Globigerina praebuloides leroyi Blow & Banner (Pl. 11, Figs. 5-6)

Remarks: Found rarely from Fiol, Chauffemerande and Bellevue. Specimens comparable with this species were also recovered from Fillinges and Montauban. More frequent occurrences from the upper part of the Dranse and the lower part of the Saxel sections.

Globigerina cf. *praeturritilina* Blow & Banner (Pl. 10, Figs. 38-39)

Remarks: Occurs rarely within the Fiol and Montauban outcrops. Individuals from the upper part of the Fiol section approach *Globigerina gortanii*. Occurs in the late Eocene but is more frequent in early to late Oligocene sediments (Dohmann 1991, Cicha et al. 1996).

Globigerina pseudoampliapertura Blow & Banner (Pl. 10, Figs. 40-41)

Remarks: This species was determined in samples from Fillinges, Fiol, Marais, Bons and Dranse.

Globigerina cf. *pseudoampliapertura* Blow & Banner (Pl. 10, Figs. 42-43)

Remarks: This species was observed from middle Eocene sediments at Marais and Bons. Haggag & Luterbacher (1995) demonstrated that the *G. Pseudoampliapertura* lineage occurred from the P13 *Orbulinoides beckmanni* zone.

Globigerina pseudovenezuelana Blow & Banner (Pl. 11, Figs. 1-2)

Remarks: Occurs within the uppermost part of the Dranse section.

Globigerina cf. *sellii* (Borsetti)

Remarks: Some dubious specimens recovered sporadically from the Bons section.

Globigerina cf. senilis (Bandy) (Pl. 11, Figs. 7-8)

Remarks: Recorded at the base of the Bellevue section. Specimens are smaller than the forms illustrated by Blow (1979). A few rare specimens from Sage are also comparable to this species.

Globigerina cf. senni (Beckmann) (Pl. 11, Figs. 9-10)

Remarks: Rare individuals derived from the base of the Chauffemerande section are comparable to this species.

Globigerina tapuriensis (Blow & Banner) (Pl. 11, Figs. 11-12)

Remarks: Specimens probably pertaining to this species were recorded rarely from the upper parts of the Bellevue and Dranse sections, Montauban and more frequently from Sage. Recorded within late Eocene to early Oligocene sediments (Dohmann and Cicha et al. 1996).

Globigerina triloculinoides Plummer (Pl. 11, Figs. 13-14)

Remarks: Well preserved and frequent to common throughout the Signal Voirons B section.

Globigerina tripartita (Koch) (Pl. 11, Figs. 15-16)

Remarks: Rare throughout the Bellevue and Fiol sections. Also occurs rarely at the top of the Dranse and Montauban sections. Specimens possibly belonging to this species occur rarely at Nantbellet and Chauffemerande and frequently at Bons.

Globigerina utilisindex Jenkins & Orr (Pl. 11, Figs. 17-18)

1972 *Globigerina utilisindex*, Jenkins & Orr, p. 133-135, pl. 1, figs. 1-6, pl. 2, figs. 1-9, pl. 3, figs. 1-3.
1980 *Globigerina utilisindex*; pl. 5, figs. 3-5.

Remarks: This rare species occurs frequently within the Vacherie section and rarely towards the top of the Montauban section. Occurring in late Eocene to early Oligocene sediments (Reiser 1987, Dohmann 1991 and Cicha et al. 1996).

Globigerina velascoensis Cushman (Pl. 11, Figs. 19-20)

Remarks: Sporadically frequent within Bons and rare throughout the Combes section.

Globigerina venezuelana Hedberg (Pl. 11, Figs. 21-22)

Remarks: Widely distributed but rare in occurrence within Bellevue, Bons, Dranse, Fiol, Nantbellet and Montauban. More frequent from the Calcaires plaquetés at Marais and from the Oligocene Meletta shales at Venay.

Globigerina wagneri Rögl (Pl. 11, Figs. 23-24)

1994 *Globigerina wagneri* Rögl, p. 140, pl. 2, figs. 7-12, pl. 3, figs. 1-6, pl. 4, figs. 4-5.
1994 "*Globigerina ciperensis*", Ujetz & Wernli, p. 200 pl. 1, figs. 1-3, 5, pl. 2, figs. 1-3.

Remarks: This species is frequent, particularly within Oligocene sediments from the upper part of the Bellevue section and was described by Ujetz & Wernli (1994) as giant "*Globigerina ciperensis*". Rögl (1994) also described and named this species which he observed in Oligocene sediments (P18-P22 planktonic foraminiferal zones) from the central Paratethys.

Globigerina yeguaensis Weinzierl & Applin (Pl. 11, Figs. 25-26)

Remarks: Observed at Fiol and dubious forms within Nantbellet were also recorded.

Globigerina spp. indet.

Remarks: A number of poorly preserved specimens belonging to *Globigerina* were recorded frequently from all of the studied calcareous planktonic foraminiferal bearing deposits.

Genus GLOBIGERINATHEKA

Globigerinatheka index index (Finlay) (Pl. 11, Figs. 27-28)

Remarks: Frequent to common throughout the Combes section.

?*Globigerinatheka cf. index rubriformis* (Subbotina) (Pl. 11, Figs. 29-30)

Remarks: One well preserved specimen was retrieved from the upper part of the Dranse section. The surface of the test is more sparsely perforated with large pores in comparison to typical *Globigerinatheka index rubriformis* specimens. The size of the test is also much smaller.

Globigerinatheka index tropicalis (Blow & Banner) (Pl. 11, Figs. 31-32)

Remarks: Rare to frequent within Combes and Dranse.

Globigerinatheka cf. mexicana mexicana (Cushman)

Remarks: Some poorly preserved forms were recorded from Bons, Fillinges and Montauban.

Globigerinatheka cf. semiinvoluta (Keijzer) (Pl. 11, Figs. 33-37)

Remarks: Frequent within the upper part of the Dranse section and rare from the lower part of the Saxel section.

Globigerinatheka subconglobata luterbacheri (Bolli) (Pl. 11, Fig. 38)

Remarks: Rare to frequent within Combes.

Globigerinatheka cf. subconglobata subconglobata (Shutskaya) (Pl. 11, Figs. 39-40)

Remarks: Rare poorly preserved, reworked forms were retrieved from Supersaxel, Bons, Dranse and Chauffemerande.

Globigerinatheka spp. indet.

Remarks: Forms belonging to this group were identified within Fiol, Fillinges, Dranse and Supersaxel.

Genus HASTIGERINA

Hastigerina cf. bolivariana Petters (Pl. 11, Figs. 41-42)

Remarks: The test is evolute, more compressed and possesses more chambers in the final whorl in comparison to typical *Hastigerina bolivariana* specimens. This form is also similar to *Globanomalina sharkriverensis* from middle Eocene sediments of New Jersey (Berggren, Olsson & Reymont 1967). A few rare specimens were retrieved from the Bons section.

7. CONCLUSIONS

* The occurrence of rich early-middle Paleocene hyaline calcareous-dominated foraminiferal assemblages were observed in the Voirons massif and attain similarities with Atlantic-Tethyan faunas.

* The late Paleocene is represented by the cosmopolitan-defined, bathyal-abyssal DWAF and occurs most prominently within the Gurnigel flysch of the Romand Prealps and are typical of North sea faunas. DWAF were also recorded in the Voirons massif and front of the Chablais Prealps.

* Dysaerobic, bathyal, middle Eocene assemblages were observed within the front of the Chablais Prealps, resembling faunas from the Caucasus, whereas diverse, aerobic, predominantly outer neritic assemblages were observed from the Thônes syncline and Voirons massif, similar to subtropical, mediterranean faunas.

* Diverse, aerobic, outer neritic, late Eocene assemblages were observed from both the Thônes syncline, Voirons massif and Prealpine front of the Chablais Prealps, and show affinities to southern provinces. Evidence of bathyal, fluctuating dysaerobic/aerobic late Eocene assemblages were also observed from Voirons massif.

* Dysaerobic, bathyal, and aerobic, outer neritic, early Oligocene assemblages were observed from the Voirons massif and Subalpine chains. A connection with northern European and Paratethyan basins probably occurred.

* The standard planktonic foraminiferal tropical/subtropical biozonations are applicable to Paleogene deposits in the region. Special attention is required during the late Eocene-early Oligocene due to the rarity of some planktonic index species and low abundance of individuals in some areas. Benthic foraminifers provide a useful, complementary biostratigraphic tool.

* Late Eocene and early Oligocene mixed microfossil assemblages may be explained by the occurrence of freshwater sedimentary plumes.

* Due to the rarity of faunal studies from the Haute-Savoie, deep water, Paleogene sediments have been often misinterpreted. Multidisciplinary biostratigraphic studies, employing several and different microfossil groups, are essential for the interpretation of these deposits. A systematic revision of flysch and deep water related deposits is necessary for further paleogeographic reconstruction.

* Foraminifers represent an important tool in biostratigraphy related to deep water deposits, providing in some cases the most refined results. They are also a useful means of recognizing paleoecological trends, especially related to the bathymetry and oxygen levels of depositional environments.

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












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ANNEXE 1: Legend for figures

LITHOLOGY			
	Shale		Thinly bedded sandstone (<1cm)
	Sandstone		Alternation of sandstone and shale (sandstone beds <15cm)
	Conglomerate		
SEDIMENTARY STRUCTURES			
	Convoluted bedding	TC	Traction carpets
	Cross bedding		Mud pebbles
	Graded bedding		Slump
	Laminated bedding		Channel
A	Amalgamated bed		Thickening up
Ta-Te	Bouma sequence	W	Bioturbation
	Flute cast	C	Coal

ANNEXE 2: Sections & samples studied

Voirons massif

UB1-UB72, An3s9, An3s9b, An3s9c
 UCB1-UCB26
 UCH1-UCH6
 UFL1-UFL25
 UFIOL1-UFIOL8, An3s140/IV/bis/ter
 UJ1-UJ2
 UM1-UM33
 URS1-URS15
 USV1-USV9
 USVB1-USVB9
 USS1-USS3

Bellevue
 Bons
 Chauffemerande
 Fillinges
 Fiol
 Juffly
 Montauban
 Saxel
 Signal Voirons A
 Signal Voirons B
 Supersaxel

Subalpine chains

UBR1-UBR22
 UDS1-UDS31
 USL1-USL2
 UV1-UV2
 UVA1-UVA2

Brison
 Dessy
 Sage
 Venay
 Vacherie

Romand Prealpine front

UCC1-UCC8
 UFAYA1-UFAYA19
 UFAYB1-UFAYB8

Cucloz
 Fayaux A
 Fayaux B

Chablais Prealpine front

UDR1-UDR18
 UGD1-UGD5

Dranse
 St. Gingolph

Thônes syncline

UCO1-UCO9, Combes 1-Combes 5
 UMC1-UMC4, KS44
 UNB1-UNB9
 KS8, KS54

Combes
 Marais
 Nantbellet
 Nantbellet road

PLATE 1

(l=lateral view, a=apertural view, p=peripheral view, u=umbilical view, s=spiral view)

1. *Bathysiphon* sp.A, l, UFL8, 2200 μ m
2. *Bathysiphon* sp.A, a, UFL8, 980 μ m
3. *Bathysiphon eocaenica*, l, UFIOL5, 1175 μ m
4. *Bathysiphon eocaenica*, a, UFIOL5, 520 μ m
5. *Nothia latissima*, An3s9b, 1075 μ m
6. *Nothia latissima*, An3s9b, 475 μ m
7. *Rhabdammina discreta*, a, UFAYB1, 225 μ m
8. *Rhabdammina discreta*, l, UFAYB1, 1300 μ m
9. *Rhabdammina* cf. *robusta*, a, UFL9, 770 μ m
10. *Rhabdammina* cf. *robusta*, l, UFL9, 800 μ m
11. *Rhabdammina* sp.A, l, UB12, 1300 μ m
12. *Rhabdammina* sp.A, a, UB12, 140 μ m
13. *Saccamina placenta*, l, UFAYA3, 715 μ m
14. *Saccamina placenta*, a, UFAYA3, 610 μ m
15. *Ammodiscus cretaceus*, l, UFL7, 935 μ m
16. *Ammodiscus cretaceus*, a, UFL7, 935 μ m
17. *Glomospira charoides*, l, UFL4, 340 μ m
18. *Glomospira gordialis*, l, UFL5, 1080 μ m
19. *Glomospira gordialis*, a, UFL5, 500 μ m
20. *Glomospira irregularis*, l, UFAYA14, 1070 μ m
21. *Rzehakina epigona*, l, UFL7, 900 μ m
22. *Rzehakina epigona*, l, UFL7, 770 μ m
23. *Kalamopsis grzybowski*, a, UFL7, 345 μ m
24. *Kalamopsis grzybowski*, a, UFL7, 345 μ m
25. *Reophax* cf. *duplex*, l, UFAYB8, 810 μ m
26. *Reophax* cf. *duplex*, a, UFAYB8, 640 μ m
27. *Reophax* cf. *pilulifera*, l, An3s140IV, 900 μ m
28. *Reophax* cf. *pilulifera*, a, An3s140IV, 555 μ m
29. *Reophax* sp.A, l, An3s140ter, 1100 μ m
30. *Reophax* sp.A, a, An3s140ter, 385 μ m
31. *Subreophax pseudoscalaris*, l, UFAYB1, 1800 μ m
32. *Subreophax pseudoscalaris*, a, UFAYB1, 870 μ m
33. *Haplophragmoides* cf. *stomatus*, l, UFL1, 765 μ m
34. *Haplophragmoides* cf. *stomatus*, p, UFL1, 765 μ m
35. *Haplophragmoides walteri*, l, URS3, 640 μ m
36. *Haplophragmoides walteri*, p, URS3, 500 μ m
37. *Haplophragmoides* sp.A, p, UFIOL5, 450 μ m
38. *Haplophragmoides* sp.A, l, UFIOL5, 450 μ m
39. *Haplophragmoides* sp.B, p, An3s140ter, 1020 μ m
40. *Haplophragmoides* sp.B, l, An3s140ter, 1020 μ m
41. *Haplophragmoides* sp.C, l, COMBES1, 1020 μ m
42. *Haplophragmoides* sp.C, p, COMBES1, 1020 μ m
43. *Haplophragmoides* sp.D, p, UFAYB1, 345 μ m



PLATE 2

(l=lateral view, a=apertural view, p=peripheral view, u=umbilical view, s=spiral view)

1. *Haplophragmoides* sp.D, l, UFAYB1, 345 μ m
2. *Labrospira scitula*, l, UDS1, 680 μ m
3. *Labrospira scitula*, p, UDS1, 680 μ m
4. *Lituotuba* cf. *lituiformis*, l, UDR13, 915 μ m
5. *Lituotuba* cf. *lituiformis*, a, UDR13, 630 μ m
6. *Lituotuba* sp.A, l, KS8, 610 μ m
7. *Lituotuba* sp.A, l, KS8, 190 μ m
8. *Trochamminoides irregularis*, p, UFL7, 815 μ m
9. *Trochamminoides irregularis*, l, UFL7, 815 μ m
10. *Trochamminoides proteus*, p, UFAYA3, 1050 μ m
11. *Trochamminoides proteus*, l, UFAYA3, 1050 μ m
12. *Trochamminoides* cf. *variolarius*, l, UFAYB8, 820 μ m
13. *Trochamminoides* cf. *variolarius*, p, UFAYB8, 770 μ m
14. *Recurvoides* sp.A, l, UFAYB1, 445 μ m
15. *Recurvoides* sp.A, p, UFAYB1, 430 μ m
16. *Reticulophragmium amplexens*, l, UFIOL5, 1175 μ m
17. *Reticulophragmium amplexens*, p, UFIOL5, 975 μ m
18. *Spiroplectammina spectabilis*, l, UFL1, 685 μ m
19. *Spiroplectammina spectabilis*, a, UFL1, 340 μ m
20. *Spiroplectammina* sp.A, l, UDR14, 600 μ m
21. *Spiroplectammina* sp.A, a, UDR14, 285 μ m
22. *Vulvulina haeringensis*, l, UDS1, 920 μ m
23. *Vulvulina haeringensis*, a, UDS1, 660 μ m
24. *Vulvulina spinosa*, l, UFIOL3, 560 μ m
25. *Vulvulina spinosa*, a, UFIOL3, 510 μ m
26. *Trochammina* cf. *deformis*, l, UFIOL3, 920 μ m
27. *Trochammina* cf. *deformis*, p, UFIOL3, 920 μ m
28. *Tritaxis* sp.A, p, UB7, 250 μ m
29. *Tritaxis* sp.A, l, UB7, 250 μ m
30. *Eggerella trochoides*, l, UFIOL3, 305 μ m
31. *Eggerella trochoides*, a, UFIOL3, 305 μ m
32. *Gaudryina* sp.A, l, UFIOL2, 935 μ m
33. *Gaudryina* sp.A, a, UFIOL2, 465 μ m
34. *Tritaxia szaboi*, l, UV2, 1150 μ m
35. *Tritaxia szaboi*, a, UV2, 640 μ m
36. *Ataxophragmium* sp.A, l, UFL10, 350 μ m
37. *Ataxophragmium* sp.A, a, UFL10, 350 μ m
38. *Arenobulimina* sp.A, l, UFL23, 370 μ m
39. *Dorothia retusa*, l, UFL23, 520 μ m
40. *Dorothia retusa*, a, UFL23, 390 μ m

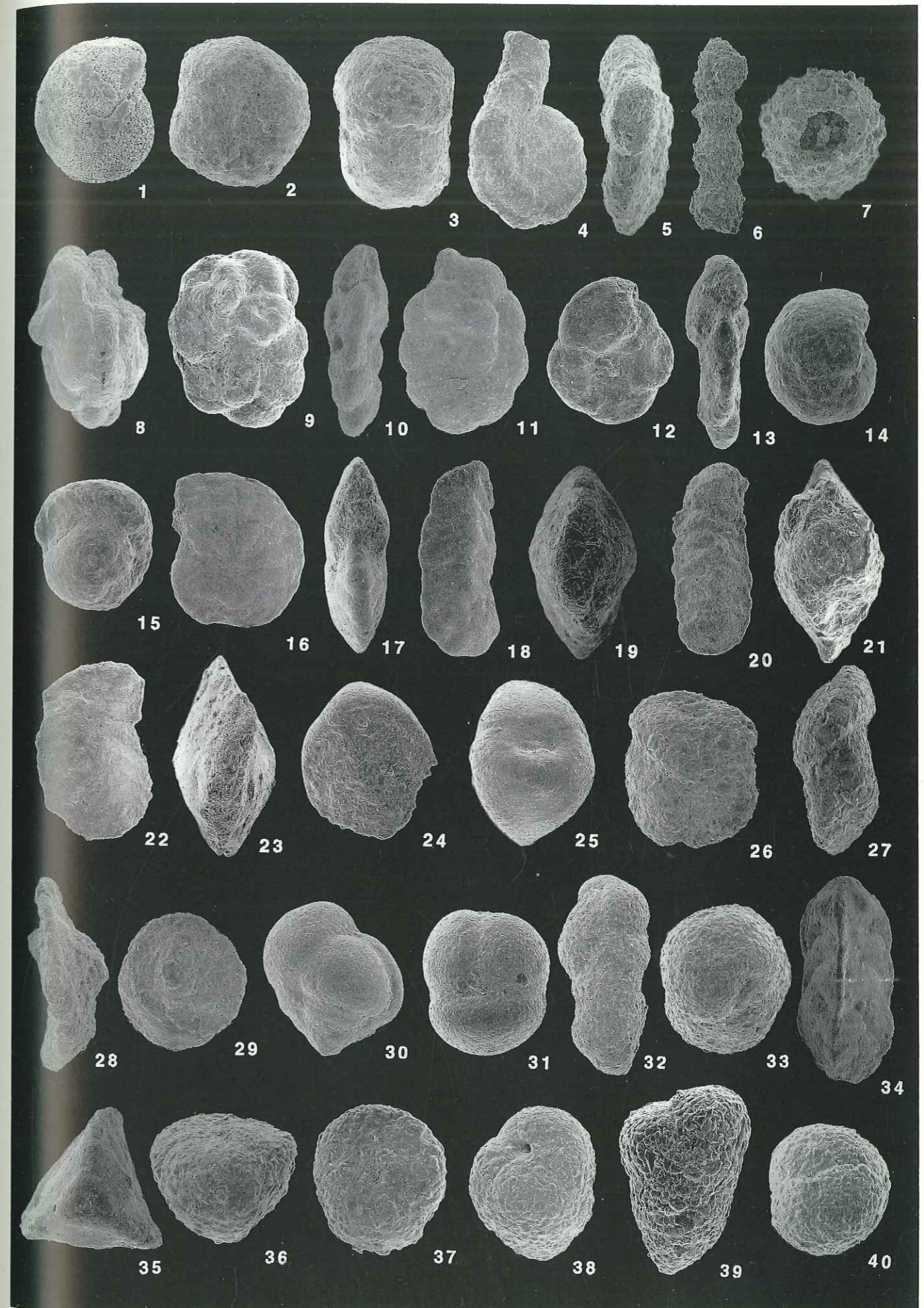


PLATE 3

(l=lateral view, a=apertural view, p=peripheral view, u=umbilical view, s=spiral view)

1. *Marsonella oxycona*, l, USVB6, 480µm
2. *Marsonella oxycona*, a, USVB6, 390µm
3. *Dorothia pupa*, l, UFIOL1, 825µm
4. *Dorothia pupa*, a, UFIOL1, 570µm
5. *Karrieriella chilostoma*, l, UFIOL1, 925µm
6. *Karrieriella chilostoma*, a, UFIOL1, 300µm
7. *Textularia* sp.A, a, UB14, 415µm
8. *Textularia* sp.A, l, UB14, 510µm
9. *Triloculina* sp.A, l, An3s140ter, 255µm
10. *Triloculina* sp.A, a, An3s140ter, 310µm
11. *Nodosaria* cf. *dacrydium*, l, An3s140ter, 450µm
12. *Nodosaria* cf. *dacrydium*, a, An3s140ter, 355µm
13. *Nodosaria* cf. *pyrula*, a, KS44, 170µm
14. *Nodosaria* cf. *pyrula*, l, KS44, 635µm
15. *Nodosaria* sp.A, l, UFL4, 900µm
16. *Nodosaria* sp.A, a, UFL4, 270µm
17. *Nodosaria* sp.B, l, KS44, 670µm
18. *Nodosaria* sp.B, a, KS44, 225µm
19. *Nodosaria* sp.C, l, UDR14, 1000µm
20. *Nodosaria* sp.C, a, UDR14, 290µm
21. *Pseudonodosaria hantkeni*, l, UDR14, 570µm
22. *Pseudonodosaria hantkeni*, a, UDR14, 375µm
23. *Pseudonodosaria* cf. *radicula*, l, UDR14, 780µm
24. *Pseudonodosaria* cf. *radicula*, a, UDR14, 460µm
25. *Pyramidulina* sp.A, l, UDR14, 1730µm
26. *Pyramidulina* sp.A, a, UDR14, 465µm
27. *Dentalina* cf. *acuta*, l, UB9, 720µm
28. *Dentalina* cf. *acuta*, l, UB9, 170µm
29. *Dentalina* sp.A, l, UFIOL5, 640µm
30. *Dentalina* sp.A, a, UFIOL5, 370µm
31. *Laevidentalina* cf. *communis*, l, An3s140ter, 1660µm
32. *Laevidentalina* cf. *communis*, a, An3s140ter, 275µm
33. *Chrysalogonium longiscatum*, l, UFIOL4, 830µm
34. *Grigelis* sp.A, a, UB7, 150µm
35. *Grigelis* sp.A, l, UB7, 300µm
36. *Lenticulina* sp.A, l, ULS2, 935µm
37. *Lenticulina* sp.A, p, ULS2, 935µm
38. *Saracenaria propinqua*, l, An3s140, 740µm
39. *Saracenaria propinqua*, p, An3s140, 740µm
40. *Amphicoryna badenensis*, l, An3s9, 415µm
41. *Amphicoryna badenensis*, a, An3s9, 170µm
42. *Astacolus* sp.A, l, UCO8, 345µm

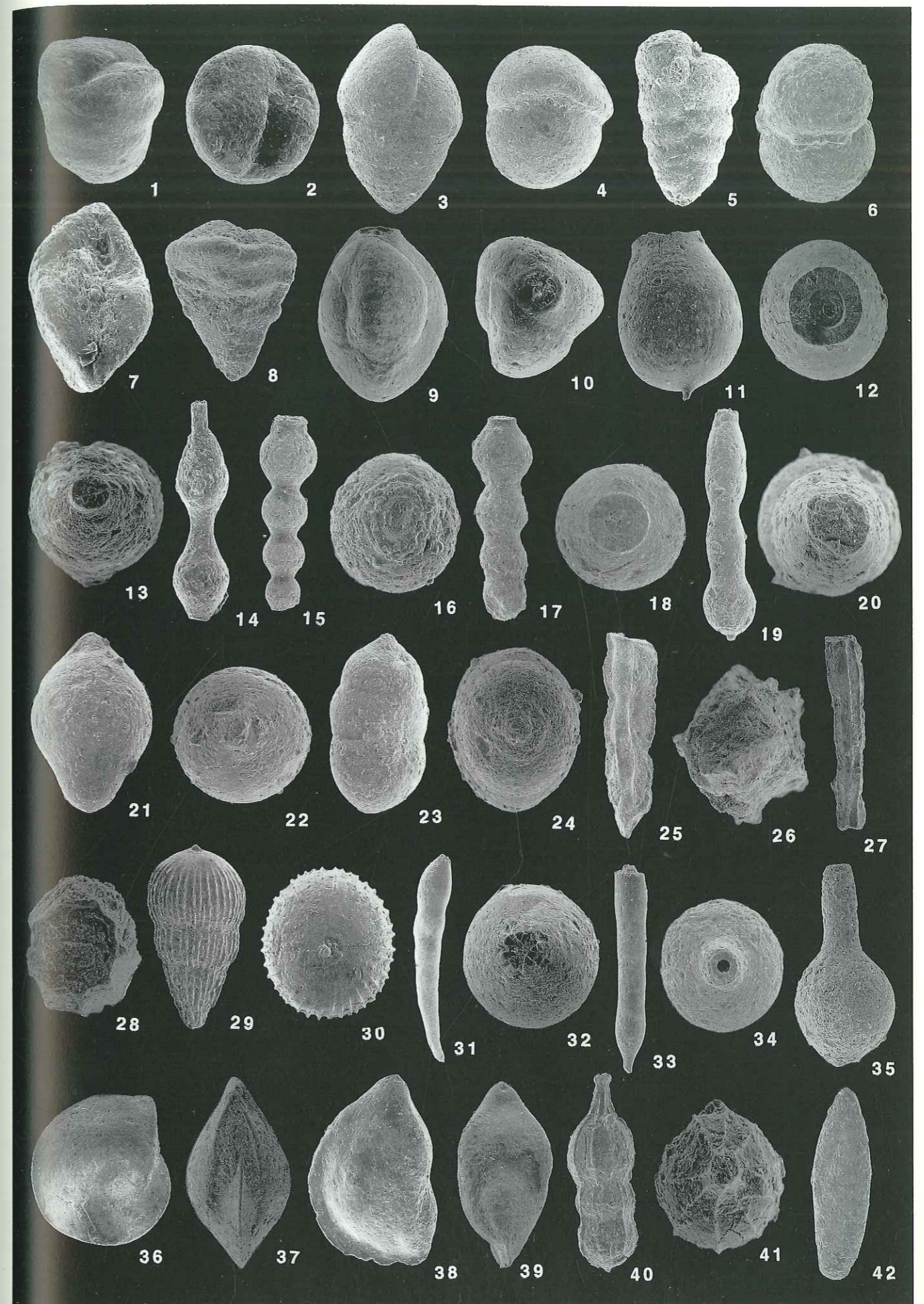


PLATE 4

(l=lateral view, a=apertural view, p=peripheral view, u=umbilical view, s=spiral view)

1. *Astacolus* sp.A, a, UCO8, 345 μ m
2. *Vaginulinopsis cumulicostata*, l, UDR14, 1515 μ m
3. *Vaginulinopsis cumulicostata*, a, UDR14, 720 μ m
4. *Lagena* cf. *gracilicosta*, l, UB4, 330 μ m
5. *Lagena* cf. *gracilicosta*, a, UB4, 200 μ m
6. *Favulina hexagona*, l, An3s140bis, 240 μ m
7. *Favulina hexagona*, a, An3s140bis, 180 μ m
8. *Lagena* cf. *tenius*, l, An3s140ter, 365 μ m
9. *Lagena* cf. *tenius*, a, An3s140ter, 135 μ m
10. *Lagena* sp.A, l, An3s140ter, 400 μ m
11. *Lagena* sp.A, a, An3s140ter, 270 μ m
12. *Lagena* sp.B, l, COMBES1, 590 μ m
13. *Lagena* sp.B, a, COMBES1, 590 μ m
14. *Falsoguttulina* sp.A, a, USVB6, 240 μ m
15. *Falsoguttulina* sp.A, l, USVB6, 310 μ m
16. *Polymorphina* sp.A, a, UFL8, 255 μ m
17. *Polymorphina* sp.A, l, UFL8, 515 μ m
18. *Guttulina irregularis*, l, USVB6, 260 μ m
19. *Guttulina irregularis*, a, USVB6, 250 μ m
20. *Parafissurina* cf. *laevigata*, a, UB3, 175 μ m
21. *Parafissurina* cf. *laevigata*, l, UB3, 175 μ m
22. *Parafissurina* sp.A, a, UFIOL5, 300 μ m
23. *Parafissurina* sp.A, l, UFIOL5, 330 μ m
24. *Paliolatella* sp.A, l, USVB6, 490 μ m
25. *Paliolatella* sp.A, a, USVB6, 380 μ m
26. *Buchnerina* sp.A, l, UDR13, 465 μ m
27. *Buchnerina* sp.A, a, UDR13, 370 μ m
28. *Pleurostomella alternans*, l, KS44, 1090 μ m
29. *Pleurostomella alternans*, a, KS44, 325 μ m
30. *Pleurostomella bellardi*, l, UDR14, 970 μ m
31. *Pleurostomella bellardi*, a, UDR14, 320 μ m
32. *Pleurostomella* sp.A, l, UCB21, 410 μ m
33. *Pleurostomella* sp.A, a, UCB21, 280 μ m
34. *Stilostomella* cf. *aldophina*, l, UFIOL5, 965 μ m
35. *Stilostomella* cf. *aldophina*, a, UFIOL5, 195 μ m
36. *Stilostomella* cf. *conspurcata*, l, UFIOL3, 620 μ m
37. *Stilostomella* cf. *conspurcata*, a, UFIOL3, 240 μ m
38. *Stilostomella* sp.A, l, UB8, 450 μ m
39. *Stilostomella* sp.A, a, UB8, 85 μ m

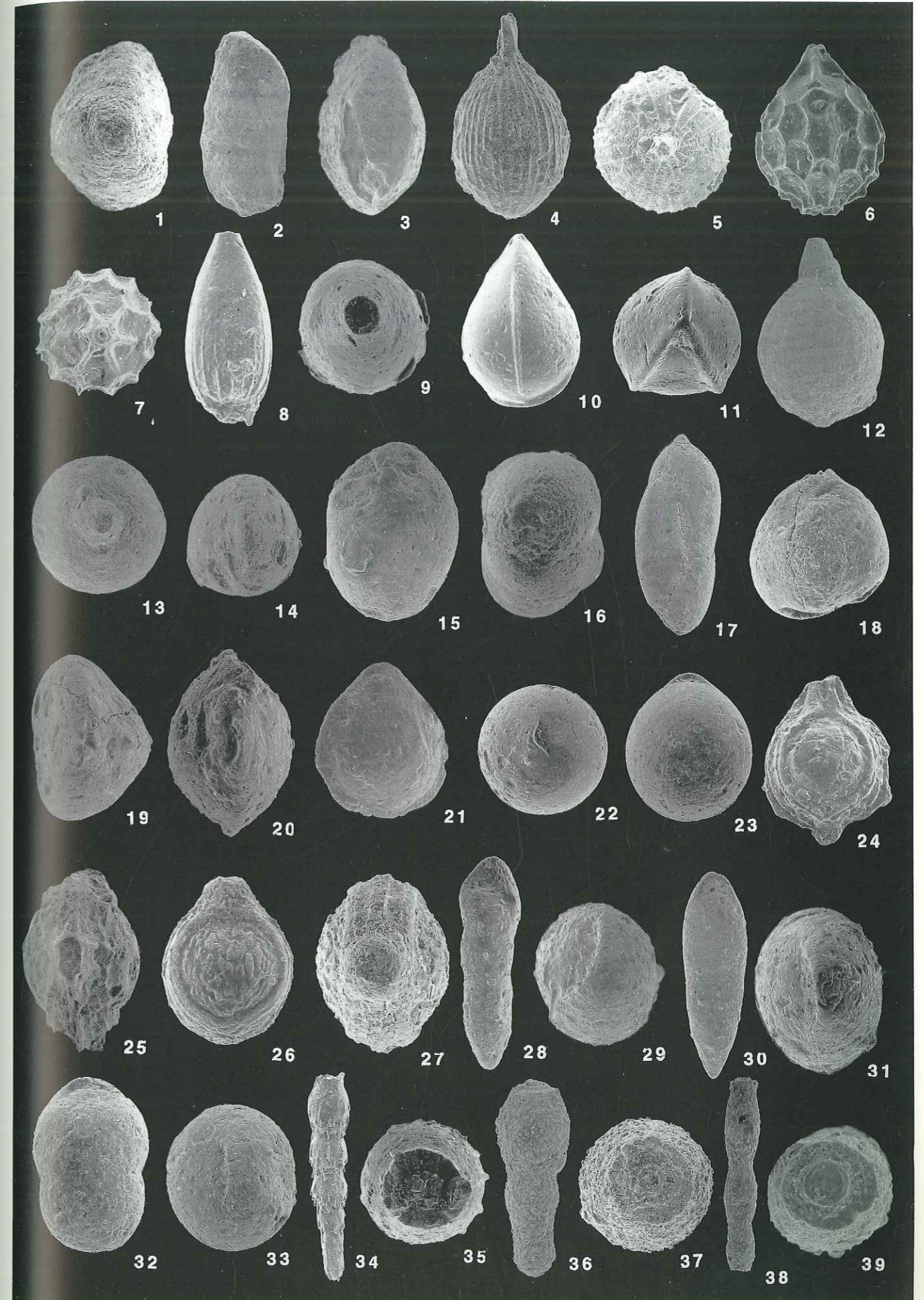


PLATE 5

(l=lateral view, a=apertural view, p=peripheral view, u=umbilical view, s=spiral view)

1. *Hoeglundina elegans*, l, UCO2, 580 μ m
2. *Hoeglundina elegans*, p, UCO2, 580 μ m
3. *Bolivina* cf. *beyrichi*, l, UB15, 595 μ m
4. *Bolivina* cf. *beyrichi*, a, UB15, 180 μ m
5. *Bolivina* sp.A, l, UB13, 520 μ m
6. *Bolivina* sp.A, a, UB13, 175 μ m
7. *Bolivina* sp.B, l, An3s9, 285 μ m
8. *Bolivina* sp.B, a, An3s9, 170 μ m
9. *Bolivina vacekibavarica*, l, ULS2, 440 μ m
10. *Bolivina vacekibavarica*, a, ULS2, 210 μ m
11. *Aragonia velascoensis*, l, USVB1, 455 μ m
12. *Aragonia velascoensis*, a, USVB1, 270 μ m
13. *Cassidulina laevigata*, l, An3s9, 330 μ m
14. *Cassidulina laevigata*, p, An3s9, 330 μ m
15. *Globocassidulina globosa*, l, ULS1, 215 μ m
16. *Globocassidulina globosa*, a, ULS1, 195 μ m
17. *Pyramidina rudita*, l, USVB6, 715 μ m
18. *Pyramidina rudita*, a, USVB6, 530 μ m
19. *Bulimina elongata*, l, UB50, 530 μ m
20. *Bulimina elongata*, a, UB50, 120 μ m
21. *Bulimina jarvisi*, l, UFIOL1, 770 μ m
22. *Bulimina jarvisi*, a, UFIOL1, 335 μ m
23. *Bulimina subtruncana*, l, ULS1, 465 μ m
24. *Bulimina subtruncana*, a, ULS1, 250 μ m
25. *Bulimina trinitatensis*, l, USVB6, 370 μ m
26. *Bulimina trinitatensis*, a, USVB6, 275 μ m
27. *Bulimina* sp.A, a, An3s9b, 200 μ m
28. *Bulimina* sp.A, l, An3s9b, 260 μ m
29. *Praeglobobulimina bathyalis*, l, UFL8, 370 μ m
30. *Praeglobobulimina bathyalis*, a, UFL8, 335 μ m
31. *Praeglobobulimina pupoides*, l, UB50, 350 μ m
32. *Praeglobobulimina pupoides*, a, UB50, 230 μ m
33. *Praeglobobulimina pyrula*, l, UB50, 260 μ m
34. *Praeglobobulimina pyrula*, a, UB50, 200 μ m
35. *Caucasina coprolithoides*, l, UB1, 340 μ m
36. *Caucasina coprolithoides*, a, UB1, 190 μ m
37. *Uvigerina eocaena*, l, ULS1, 505 μ m
38. *Uvigerina eocaena*, a, ULS1, 380 μ m
39. *Uvigerina moravia*, l, ULS2, 465 μ m

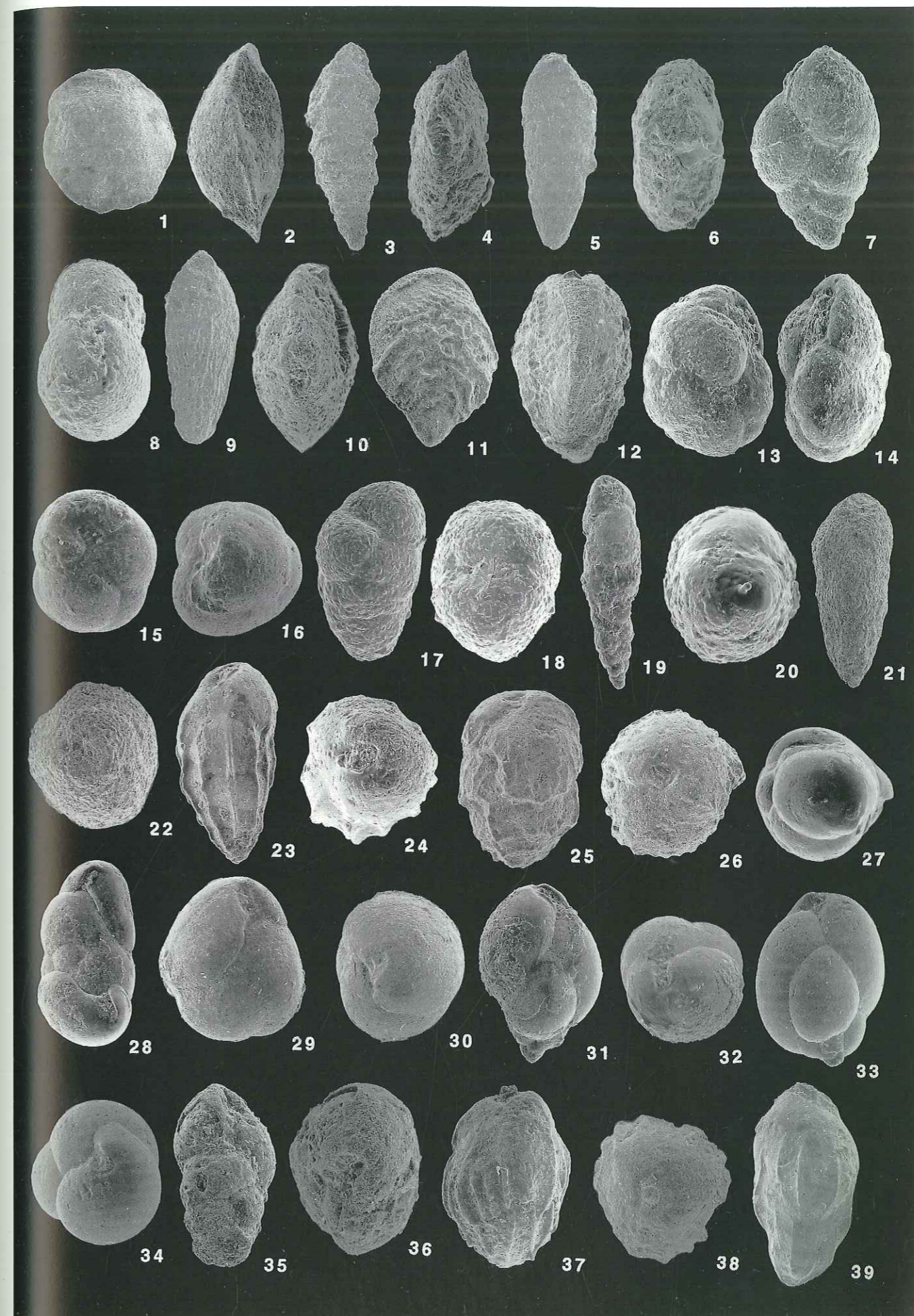


PLATE 6

(l=lateral view, a=apertural view, p=peripheral view, u=umbilical view, s=spiral view)

1. *Uvigerina moravia*, a, ULS2, 355µm
2. *Uvigerina tenuistriata*, l, UB15, 415µm
3. *Uvigerina tenuistriata*, a, UB15, 415µm
4. *Uvigerina* sp.A, l, KS8, 320µm
5. *Uvigerina* sp.A, a, KS8, 320µm
6. *Angulogerina globosa*, a, UB10, 200µm
7. *Angulogerina globosa*, l, UB10, 560µm
8. *Trifarina* sp.A, l, KS8, 460µm
9. *Trifarina* sp.A, a, KS8, 235µm
10. *Fursenkoina* sp.B, l, UB5, 385µm
11. *Fursenkoina* sp.B, a, UB5, 170µm
12. ?*Eponides* sp.A, u, UCO8, 740µm
13. ?*Eponides* sp.A, p, UCO8, 740µm
14. *Discorbis* sp.A, u, UB3, 180µm
15. *Discorbis* sp.A, p, UB3, 180µm
16. *Cibicidoides* sp.A, u, COMBES5, 1050µm
17. *Cibicidoides* sp.A, p, COMBES5, 1050µm
18. ?*Cibicidoides* sp.B, u, UDR14, 615µm
19. ?*Cibicidoides* sp.B, p, UDR14, 615µm
20. *Cibicidoides* sp.C, p, UFIOL2, 385µm
21. *Cibicidoides* sp.C, u, UFIOL2, 385µm
22. *Planulina ambigua*, l, UDR14, 470µm
23. *Planulina ambigua*, p, UDR14, 470µm
24. *Planulina* sp.B, l, UB3, 480µm
25. *Planulina* sp.B, p, UB3, 480µm
26. *Cibicides* sp.A, u, UCH6, 230µm
27. *Cibicides* sp.A, p, UCH6, 230µm
28. *Cibicides* sp.C, u, An3s140IV, 345µm
29. *Cibicides* sp.C, p, An3s140IV, 345µm
30. *Cibicides* sp.B, u, UFL25, 285µm
31. *Cibicides* sp.B, p, UFL25, 285µm
32. *Cibicides* sp.D, u, UB15, 405µm
33. *Cibicides* sp.D, p, UB15, 405µm
34. ?*Cibicides* sp.E, u, UFL4, 280µm
35. ?*Cibicides* sp.E, p, UFL4, 265µm
36. *Nuttallides truempyi*, u, UCH6, 280µm
37. *Nuttallides truempyi*, p, UCH6, 280µm
38. *Nonion* cf. *boueanum*, l, UB15, 240µm
39. *Nonion* cf. *boueanum*, p, UB15, 240µm
40. *Nonionella liebusi*, u, An3s9b, 255µm

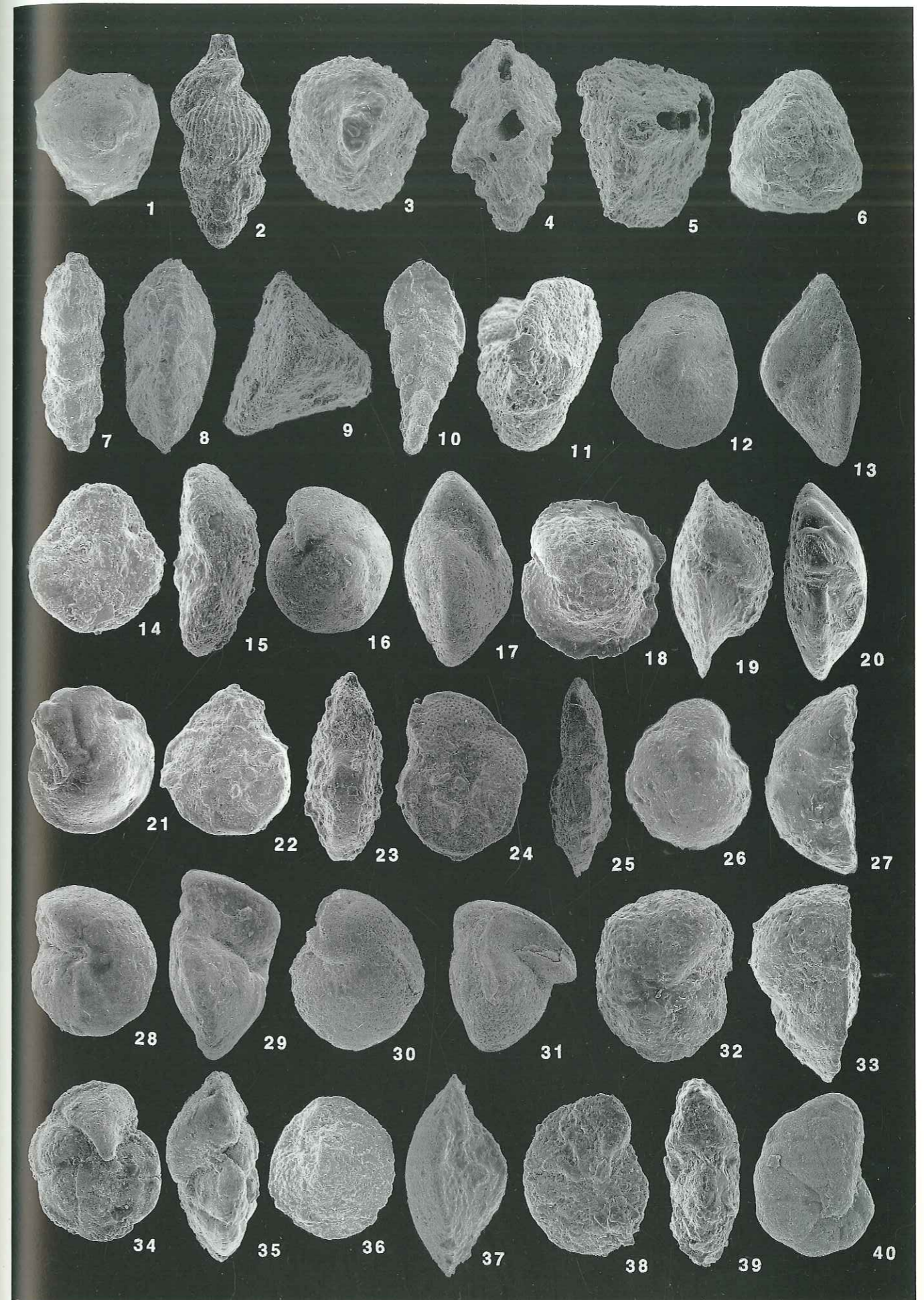


PLATE 7

(l=lateral view, a=apertural view, p=peripheral view, u=umbilical view, s=spiral view)

1. *Nonionella liebusi*, p, An3s9b, 255µm
2. *Nonionella* sp.A, u, UB15, 215µm
3. *Nonionella* sp.A, p, UB15, 215µm
4. *Nonionella* sp.B, u, ULS1, 450µm
5. *Nonionella* sp.B, p, ULS1, 450µm
6. *Nonionella* sp.C, u, UB4, 390µm
7. *Nonionella* sp.C, p, UB4, 390µm
8. *Pullenia quinqueloba*, l, UCO8, 270µm
9. *Pullenia quinqueloba*, p, UCO8, 270µm
10. *Pullenia* cf. *bulloides*, p, USV6, 300µm
11. *Pullenia* cf. *bulloides*, l, USV6, 300µm
12. *Melonis* sp.A, l, KS44, 480µm
13. *Melonis* sp.A, p, KS44, 480µm
14. *Chilostomella* cf. *chilostomelloides*, l, An3s140IV, 840µm
15. *Chilostomella* cf. *chilostomelloides*, a, An3s140IV, 700µm
16. *Chilostomella* cf. *chilostomelloides*, l, UFIOL4, 845µm
17. *Chilostomella* cf. *chilostomelloides*, a, UFIOL4, 500µm
18. *Chilostomella cylindroides*, l, UFL8a, 560µm
19. *Chilostomella cylindroides*, a, UFL8a, 355µm
20. *Chilostomella czizeki*, l, UFL8a, 685µm
21. *Chilostomella czizeki*, a, UFL8a, 470µm
22. *Chilostomella ovoidea*, l, UFL8a, 525µm
23. *Chilostomella ovoidea*, a, UFL8a, 360µm
24. *Allomorphina trigona*, l, UFL8a, 275µm
25. *Allomorphina trigona*, a, UFL8a, 245µm
26. *Alabamina* sp.A, u, Combes1, 620µm
27. *Alabamina* sp.A, p, Combes1, 620µm
28. *Osangularia* cf. *mexicana*, u, UFIOL7, 405µm
29. *Osangularia* cf. *mexicana*, p, UFIOL7, 405µm
30. ?*Osangularia* sp.A, u, UDR14, 500µm
31. ?*Osangularia* sp.A, p, UDR14, 500µm
32. *Heterolepa dutemplei*, u, ULS2, 720µm
33. *Heterolepa dutemplei*, p, ULS2, 720µm
34. *Heterolepa* sp.A, u, An3s140ter, 420µm
35. *Heterolepa* sp.A, p, An3s140ter, 420µm
36. *Heterolepa* sp.B, u, UV2, 455µm
37. *Heterolepa* sp.B, p, UV2, 455µm
38. *Anomalinoides* cf. *affinis*, u, UDR14, 400µm
39. *Anomalinoides* cf. *affinis*, p, UDR14, 400µm

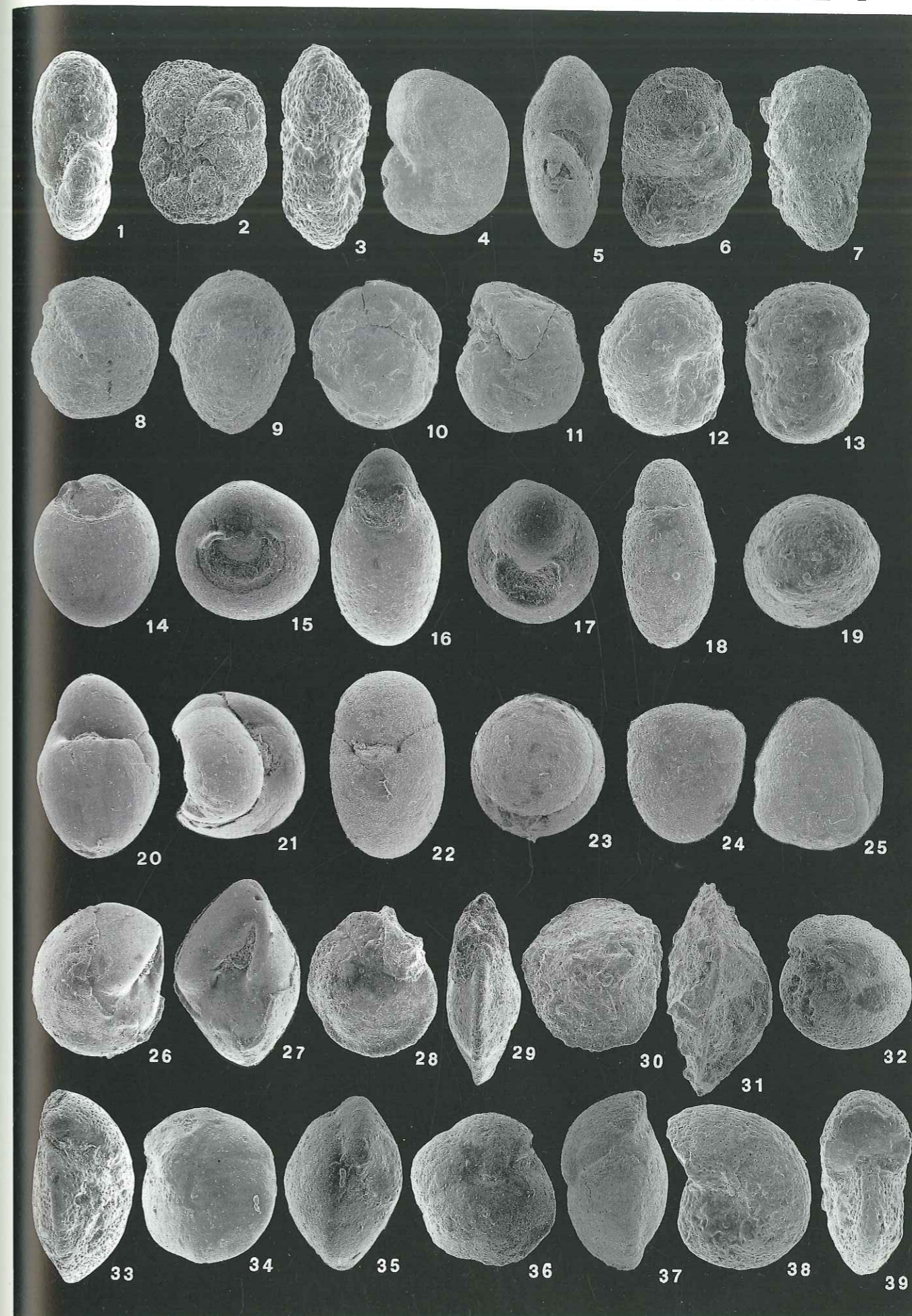


PLATE 8

(l=lateral view, a=apertural view, p=peripheral view, u=umbilical view, s=spiral view)

1. *Anomalinoides granosus*, u, ULS2, 725 μ m
2. *Anomalinoides granosus*, p, ULS2, 725 μ m
3. *Anomalinoides* sp.A, p, UDS1, 470 μ m
4. *Anomalinoides* sp.A, u, UDS1, 470 μ m
5. *Gyroidinoides soldanii*, u, UFIOL5, 475 μ m
6. *Gyroidinoides soldanii*, p, UFIOL5, 475 μ m
7. *Gyroidinoides* sp.A, p, UFIOL3, 490 μ m
8. *Gyroidinoides* sp.A, u, UFIOL3, 490 μ m
9. *Escornebovina cuvillieri*, u, UB6, 230 μ m
10. *Escornebovina cuvillieri*, p, UB6, 230 μ m
11. *Gavelinella acuta*, u, UCO9, 490 μ m
12. *Gavelinella acuta*, p, UCO9, 490 μ m
13. *Gavelinella* sp.A, p, KS8, 480 μ m
14. *Gavelinella* sp.A, u, KS8, 480 μ m
15. *Gavelinella* sp.B, p, USVB1, 465 μ m
16. *Gavelinella* sp.B, u, USVB1, 465 μ m
17. *Hanzawaia ammophila*, u, UV2, 690 μ m
18. *Hanzawaia ammophila*, p, UV2, 690 μ m
19. *Patellina* sp.A, s, An3s9, 260 μ m
20. *Patellina* sp.A, p, An3s9, 260 μ m
21. *Carterina* sp.A, s, ULS1, 455 μ m
22. *Carterina* sp.A, p, ULS1, 455 μ m
23. *Chiloguembelina* cf. *cubensis*, l, UCB12a, 295 μ m
24. *Chiloguembelina* cf. *cubensis*, a, UCB12a, 195 μ m
25. *Globorotalia increbescens*, u, UFIOL8, 350 μ m
26. *Globorotalia increbescens*, p, UFIOL8, 350 μ m
27. *Globorotalia munda*, u, UV2, 290 μ m
28. *Globorotalia munda*, p, UV2, 290 μ m
29. *Globorotalia opima nana*, u, UB50, 320 μ m
30. *Globorotalia opima nana*, p, UB50, 320 μ m
31. *Globorotalia* cf. *opima opima*, u, ULS1, 400 μ m
32. *Globorotalia* cf. *opima opima*, p, ULS1, 400 μ m
33. *Planorotalites compressa*, p, USVB1, 280 μ m
34. *Planorotalites compressa*, u, USVB1, 280 μ m
35. *Planorotalites renzi*, u, KS54, 290 μ m
36. *Planorotalites renzi*, p, KS54, 290 μ m
37. *Turborotalia cerroazulensis cerroazulensis*, p, UDR14, 330 μ m
38. *Turborotalia cerroazulensis cerroazulensis*, u, UDR14, 330 μ m
39. *Turborotalia cerroazulensis cocoaensis*, u, COMBES1, 360 μ m

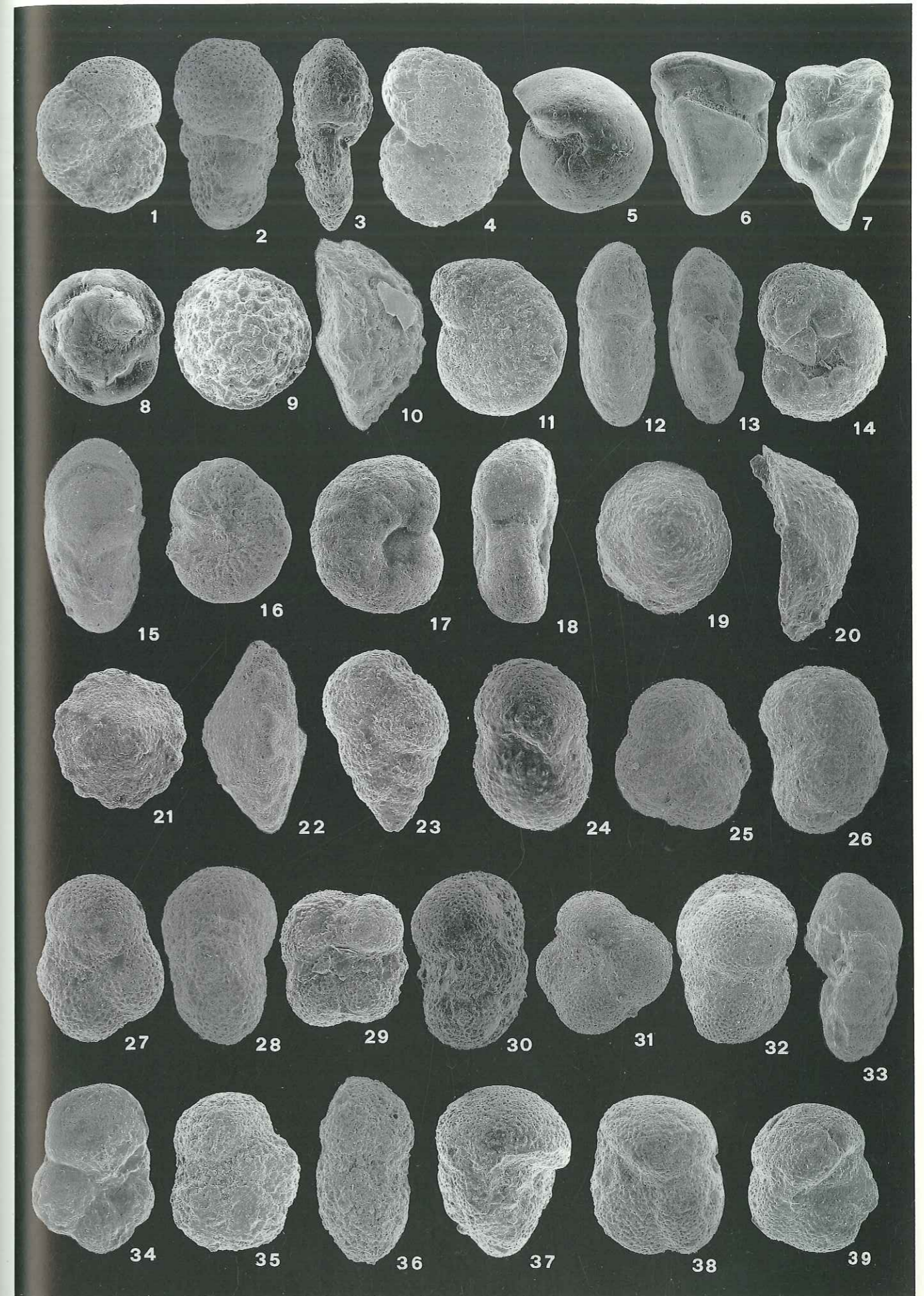


PLATE 9

(l=lateral view, a=apertural view, p=peripheral view, u=umbilical view, s=spiral view)

1. *Turborotalia cerroazulensis cocoaensis*, p, COMBES1, 360µm
2. *Turborotalia cerroazulensis pomeroli*, u, UFIOL1, 600µm
3. *Turborotalia cerroazulensis pomeroli*, p, UFIOL1, 600µm
4. *Acarinina broedermanni*, u, UM23, 290µm
5. *Acarinina broedermanni*, p, UM23, 290µm
6. *Acarinina bullbrooki*, u, KS44, 440µm
7. *Acarinina bullbrooki*, p, KS44, 440µm
8. *Acarinina pentacamerata*, u, KS8, 250µm
9. *Acarinina pentacamerata*, p, KS8, 250µm
10. *Acarinina* cf. *pentacamerata*, u, UCB3, 300µm
11. *Acarinina* cf. *pentacamerata*, p, UCB3, 300µm
12. *Acarinina pseudotopilensis*, u, KS54, 310µm
13. *Acarinina pseudotopilensis*, p, KS54, 310µm
14. *Acarinina rotundimarginata*, u, UDR4, 220µm
15. *Acarinina rotundimarginata*, p, UDR4, 220µm
16. *Morozovella aragonensis*, u, KS54, 550µm
17. *Morozovella aragonensis*, p, KS54, 550µm
18. *Morozovella inconstans*, u, USVB6, 350µm
19. *Morozovella inconstans*, p, USVB6, 350µm
20. *Morozovella pseudobulloides*, p, USVB6, 440µm
21. *Morozovella pseudobulloides*, u, USVB6, 440µm
22. *Morozovella subbotinae*, u, UCB12a, 500µm
23. *Morozovella subbotinae*, p, UCB12a, 500µm
24. *Morozovella trinidadensis*, u, USVB6, 320µm
25. *Morozovella trinidadensis*, p, USVB6, 320µm
26. *Truncorotaloides rohri*, u, UM24, 260µm
27. *Truncorotaloides rohri*, p, UM24, 260µm
28. *Catapsydrax dissimilis*, p, UCO3, 610µm
29. *Catapsydrax dissimilis*, u, UCO3, 610µm
30. *Catapsydrax* cf. *globiformis*, u, UFL5, 300µm
31. *Catapsydrax* cf. *globiformis*, p, UFL5, 300µm
32. *Catapsydrax pera*, u, An3s140ter, 470µm
33. *Catapsydrax pera*, p, An3s140ter, 470µm
34. *Catapsydrax unicava primitiva*, u, UDR14, 305µm
35. *Catapsydrax unicava primitiva*, p, UDR14, 305µm
36. *Globorotaloides carcoselleensis*, u, UDR12, 230µm
37. *Globorotaloides carcoselleensis*, p, UDR12, 230µm
38. *Globorotaloides suteri*, u, UFIOL4, 250µm

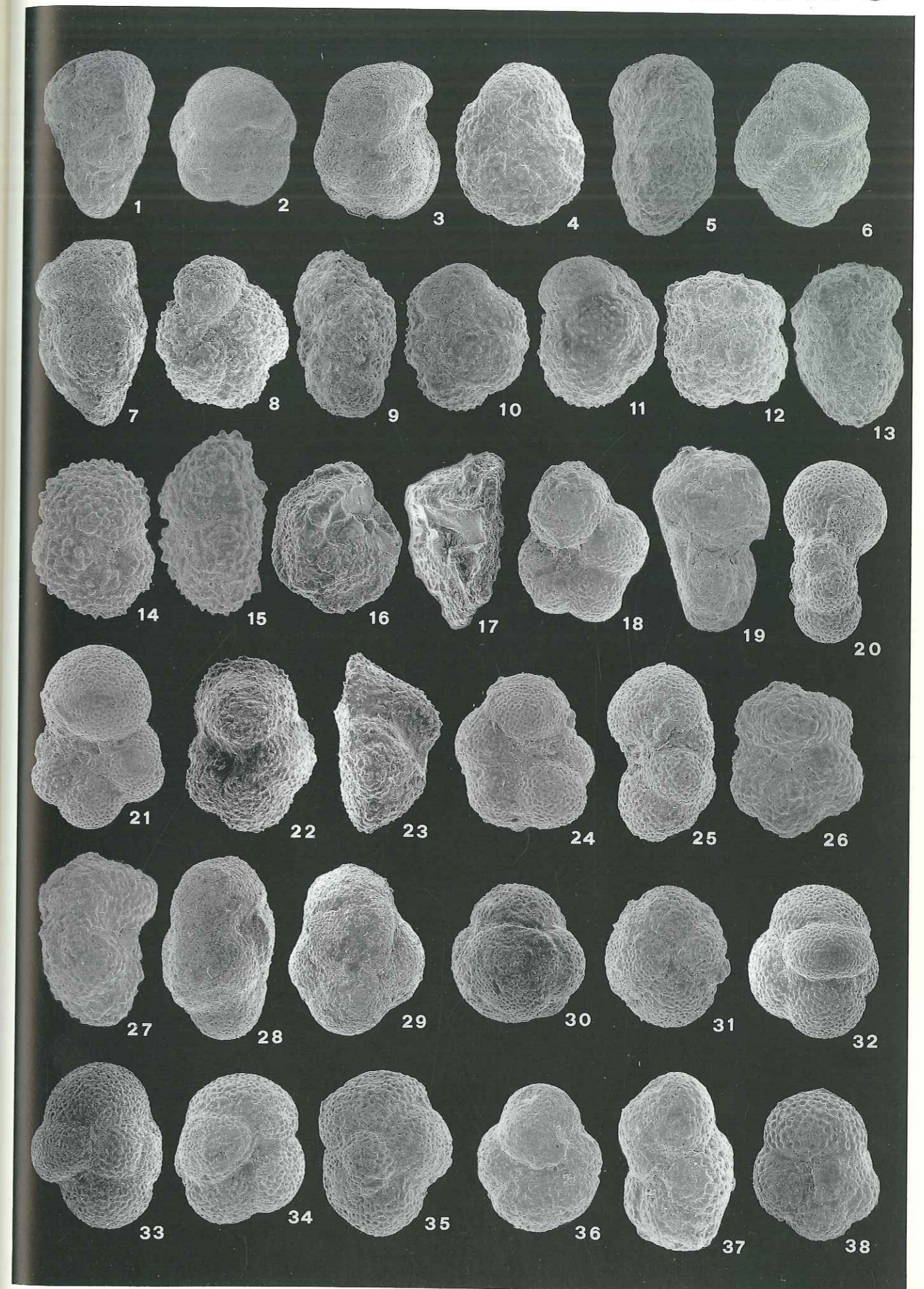


PLATE 10

(l=lateral view, a=apertural view, p=peripheral view, u=umbilical view, s=spiral view)

1. *Globorotaloides suteri*, p, UFIOL4, 250 μ m
2. *Pseudohastigerina micra*, u, An3s140bis, 280 μ m
3. *Pseudohastigerina micra*, p, An3s140bis, 280 μ m
4. *Hantkenina alabamensis*, l, An3s140ter, 600 μ m
5. *Hantkenina alabamensis*, p, An3s140ter, 600 μ m
6. *Cassigerinella* cf. *chipolensis*, l, ULS1, 170 μ m
7. *Cassigerinella* cf. *chipolensis*, p, ULS1, 170 μ m
8. *Globigerina ampliapertura*, u, UV2, 350 μ m
9. *Globigerina ampliapertura*, p, UV2, 350 μ m
10. *Globigerina* cf. *ampliapertura*, u, UB14, 270 μ m
11. *Globigerina* cf. *ampliapertura*, p, UB14, 270 μ m
12. *Globigerina angiporoides*, u, UFIOL8, 330 μ m
13. *Globigerina angiporoides*, p, UFIOL8, 330 μ m
14. *Globigerina ciperoensis anguliofficialis*, u, UB50, 230 μ m
15. *Globigerina ciperoensis anguliofficialis*, p, UB50, 230 μ m
16. *Globigerina ciperoensis angustiumbilitata*, u, UDS1, 260 μ m
17. *Globigerina ciperoensis angustiumbilitata*, p, UDS1, 260 μ m
18. *Globigerina ciperoensis ciperoensis*, u, An3s9b, 285 μ m
19. *Globigerina ciperoensis ciperoensis*, p, An3s9b, 285 μ m
20. *Globigerina corpulenta*, p, UFIOL4, 620 μ m
21. *Globigerina corpulenta*, u, UFIOL4, 620 μ m
22. *Globigerina eocaena*, p, UFIOL6, 470 μ m
23. *Globigerina eocaena*, u, UFIOL6, 470 μ m
24. *Globigerina euapertura*, u, UDR14, 315 μ m
25. *Globigerina euapertura*, p, UDR14, 315 μ m
26. *Globigerina gortanii*, u, An3s9, 465 μ m
27. *Globigerina gortanii*, p, An3s9, 465 μ m
28. *Globigerina hagni*, u, UCB3, 455 μ m
29. *Globigerina hagni*, p, UCB3, 455 μ m
30. *Globigerina linaperta*, u, UCB12a, 245 μ m
31. *Globigerina linaperta*, p, UCB12a, 245 μ m
32. *Globigerina officinalis*, u, UB6, 250 μ m
33. *Globigerina officinalis*, p, UB6, 250 μ m
34. *Globigerina ouachitaensis gnaucki*, p, An3s9c, 255 μ m
35. *Globigerina ouachitaensis gnaucki*, u, An3s9c, 255 μ m
36. *Globigerina ouachitaensis ouachitaensis*, u, UB15, 285 μ m
37. *Globigerina ouachitaensis ouachitaensis*, p, UB15, 285 μ m
38. *Globigerina* cf. *praeturritilina*, u, An3s140ter, 540 μ m
39. *Globigerina* cf. *praeturritilina*, p, An3s140ter, 540 μ m
40. *Globigerina pseudoampliapertura*, u, An3s140ter, 350 μ m
41. *Globigerina pseudoampliapertura*, p, An3s140ter, 350 μ m
42. *Globigerina* cf. *pseudoampliapertura*, p, UCB12a, 320 μ m
43. *Globigerina* cf. *pseudoampliapertura*, u, UCB12a, 320 μ m

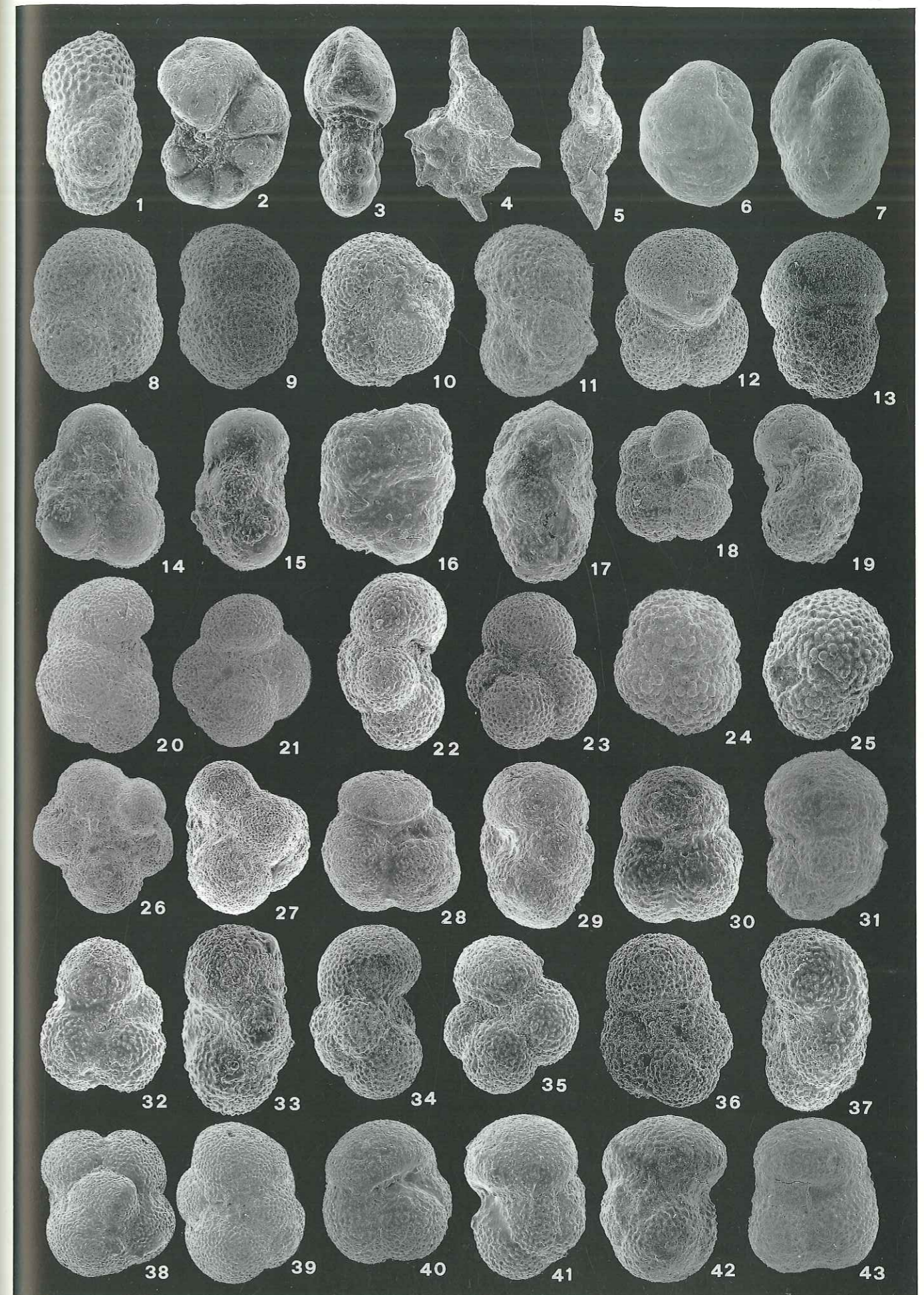


PLATE 11

(l=lateral view, a=apertural view, p=peripheral view, u=umbilical view, s=spiral view)

1. *Globigerina pseudovenezuelana*, u, UDR14, 320µm
2. *Globigerina pseudovenezuelana*, p, UDR14, 320µm
3. *Globigerina praebulloides praebulloides*, u, An3s9c, 280µm
4. *Globigerina praebulloides praebulloides*, p, An3s9c, 280µm
5. *Globigerina praebulloides leroyi*, u, UDR12, 210µm
6. *Globigerina praebulloides leroyi*, p, UDR12, 210µm
7. *Globigerina* cf. *senilis*, u, UB1, 235µm
8. *Globigerina* cf. *senilis*, p, UB1, 235µm
9. *Globigerina* cf. *senni*, p, UCB3, 275µm
10. *Globigerina* cf. *senni*, p, UCB3, 275µm
11. *Globigerina tapuriensis*, u, UM23, 460µm
12. *Globigerina tapuriensis*, p, UM23, 460µm
13. *Globigerina triloculinoides*, u, USVB6, 265µm
14. *Globigerina triloculinoides*, p, USVB6, 265µm
15. *Globigerina tripartita*, u, UFIOL6, 320µm
16. *Globigerina tripartita*, p, UFIOL6, 320µm
17. *Globigerina utilisindex*, u, UVA2, 400µm
18. *Globigerina utilisindex*, p, UVA2, 400µm
19. *Globigerina velascoensis*, u, UCB12a, 310µm
20. *Globigerina velascoensis*, p, UCB12a, 310µm
21. *Globigerina venezuelana*, p, UB5, 320µm
22. *Globigerina venezuelana*, u, UB5, 320µm
23. *Globigerina wagneri*, u, UB15, 460µm
24. *Globigerina wagneri*, p, UB15, 460µm
25. *Globigerina yeguaensis*, u, An3s140bis, 440µm
26. *Globigerina yeguaensis*, p, An3s140bis, 440µm
27. *Globigerinatheka index index*, l, UCO3, 550µm
28. *Globigerinatheka index index*, p, UCO3, 550µm
29. ?*Globigerinatheka* cf. *index rubriformis*, p, UDR12, 215µm
30. ?*Globigerinatheka* cf. *index rubriformis*, l, UDR12, 215µm
31. *Globigerinatheka index tropicalis*, l, COMBES1, 390µm
32. *Globigerinatheka index tropicalis*, p, COMBES1, 390µm
33. *Globigerinatheka* cf. *semiinvoluta*, s, UDR14, 375µm
34. *Globigerinatheka* cf. *semiinvoluta*, u, UDR14, 375µm
35. *Globigerinatheka* cf. *semiinvoluta*, p, UDR14, 375µm
36. *Globigerinatheka* cf. *semiinvoluta*, u, UCO6, 455µm
37. *Globigerinatheka* cf. *semiinvoluta*, p, UCO6, 455µm
38. *Globigerinatheka subconglobata luterbacheri*, l, COMBES5, 520µm
39. *Globigerinatheka* cf. *subconglobata subconglobata*, u, UCH6, 340µm
40. *Globigerinatheka* cf. *subconglobata subconglobata*, u, UCH6, 340µm
41. *Hastigerina* cf. *bolivariana*, p, UCB12a, 365µm
42. *Hastigerina* cf. *bolivariana*, l, UCB12a, 365µm

