N. Jb. Geol. Paläont. Abh.	178	2	147–166	Stuttgart, November 1989

Callovian dinoflagellate cysts from the Caucasus, U.S.S.R.

By

M. Smelror, Trondheim and **T. A. Lominadze,** Tbilisi

With 8 figures and 2 tables in the text

SMELROR, M., & LOMINADZE, T. A. (1989): Callovian dinoflagellate cysts from the Caucasus, U.S.S.R. – N. Jb. Geol. Paläont., Abh. **178**: 147-166; Stuttgart.

Abstract: Late Middle Jurassic assemblages of organic-walled microplankton have been recovered from several localities within the Caucasus region; U.S.S.R. Preservation and abundance of the marine palynomorphs are variable, the organic residues yielding 28 genera and 44 species of dinoflagellate cysts. The Middle Callovian assemblages are more diverse than those from the Lower Callovian. One species, *Reutlingia sekheladonensis*, is described as new. The stratigraphic distribution of the dinoflagellate cysts is related to the ammonite zonal scheme of the Caucasus region. The dinoflagellate cyst assemblages are compared with those described from contemporaneous strata in northwest Europe and the circum-Mediterranian region. Based on the presently available data it appears that the Caucasus assemblages show closer affinities to the dinoflagellate cyst floras described from Britain, West Germany and France, than to those known from Spain, Libya and Israel.

Zusammenfassung: Von verschiedenen Lokalitäten des Kaukasus werden spätmitteljurassische Vergesellschaftungen von Mikroplankton-Fossilien aus organischer Substanz beschrieben. Die Erhaltung und Häufigkeit der marinen Palynomorpha ist sehr variabel. Das Material läßt sich 28 Gattungen und 44 Arten zuordnen. Die Art *Reutlingia sekheladonensis* wird neu aufgestellt. Generell sind die Vergesellschaftungen des Mittel-Callovium diverser als die des Unter Callovium. Die stratigraphische Verteilung der Dinoflagellaten-Zysten wird mit der Ammoniten-Zonierung der Kaukasus-Region korreliert. Die Dinoflagellaten-Zysten-Vergesellschaftungen werden mit denen aus zeitgleichen Ablagerungen in NW Europa und im circum mediterranen Raum verglichen.

Introduction

The volume of published data on late Middle Jurassic dinoflagellate cysts has significantly increased in recent years, but few papers exist on areas outside Europe and the Arctic region. The utility of dinoflagelatte cysts in biostratigraphy both on local and regional scale has emerged as more refined zonation schemes are published. Based on the concept that the ranges of taxa of particular fossil groups should all be related to a single stratigraphic framework, several palynologists have consistently attempted to relate their zonation schemes based

0077-7749/89/0178-0147 $ 5.00

Dinoflagellate cyst assemblages from contemporaneous deposits in East Europe and the circum-Mediterranian areas are less well known, although some data have been made available through the studies of BEJU (1971) from Romania, GORKA (1970) from Poland, SMELROR & LEEREVELD (1989) from southern France and THUSU & VIGRAN (1985) from Libya.

England and West Germany:

In the earliest Callovian (Ccb/Cs Zone of WOOLLAM & RIDING 1983) of the British Jurassic ctenidodinioid dinoflagellate cysts often are abundant. *Ctenidodinium combazii* is generally restricted to southern England, while representatives of the *D. sellwoodii* group are characteristic of central and eastern England (RIDING et al., 1985). Overlying Callovian deposits (base of the Co/Ccn zone of WOOLLAM & RIDING 1983) contain local acmes of *Meiourogonyaulax caytonensis* group and *Cleistosphaeridium varispinosum*. In addition, *Ctenidodinium ornatum* and *C. continuum*, as well as *Sentusidium rioultii* and *Gonyaulacysta jurassic* may also be common within the Early - Middle Callovian.

Compared to the British Jurassic, *Ctenidodinium* spp., *Cleistosphaeridium varispinosum*, *Sentusidinium rioultii* and representatives of the genus *Meiourogonyaulax* are the prominent taxa within the Lower and Middle Callovian of the Caucasus. *Cleistosphaeridium varispinosum* is restricted to the Lower Callovian. *Ctenidodinium combazii* which is dominant in the open marine deposits of southern England has not been found in the Caucasus. The absence of this species may be due to the more restricted marine nature of the contemporaneous Caucasus deposits (i.e. more similar to those in eastern England).

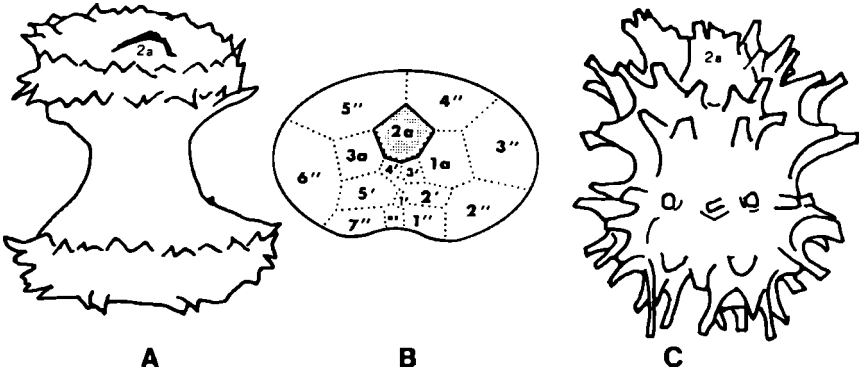


Fig. 4. A: *Reutlingia sekheladonensis* sp. nov. Schematic line-drawing of the holotype.

B: *Reutlingia* spp.. Apical view showing the archeopyle sutures and proposed paratubulation (From Below 1987).

C: *Reutlingia gochtii* DRUGG 1978. Schematic line-drawing.

In his study on Callovian dinoflagellate cysts from Kandern, West Germany, DIMTER (1988) found that the Early Callovian assemblages generally contained common *Meiourogonyaulax* spp. (mostly *M. callomonii*), *Sentusidinium rioultii* and *Mendicodinium groenlandicum*. *Gonyaulacysta jurassica* and *Sentusidinium* spp. were found to be common at several intervals, while representatives of the *Ctenidodinium sellwoodii* group show acmes in the uppermost Early Callovian and the Middle Callovian.

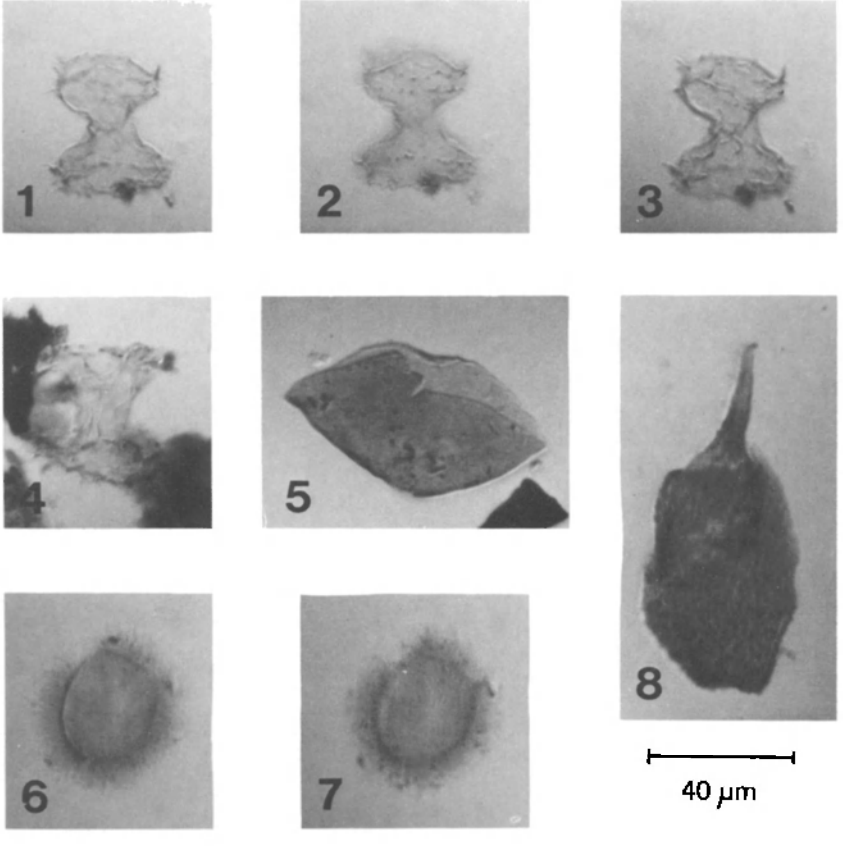


Fig. 5. Callovian dinoflagellate cysts from the Caucasus.

1-3: *Reutlingia sekheladonensis* n.sp., Sample 5, P24/2. Holotype.

4: *Reutlingia sekheladonensis* n. sp., Sample 5, S 24/3.

5: *Mendicodinium groenlandicum* (POCOCK & SARJEANT) DAVEY 1979. Sample 7, O30/4.

6-7: *Cometodinium* sp. Sample 4A, O28/0.

8: *Pareodinia prolongata* SARJEANT 1959. Sample 12, U32/0.

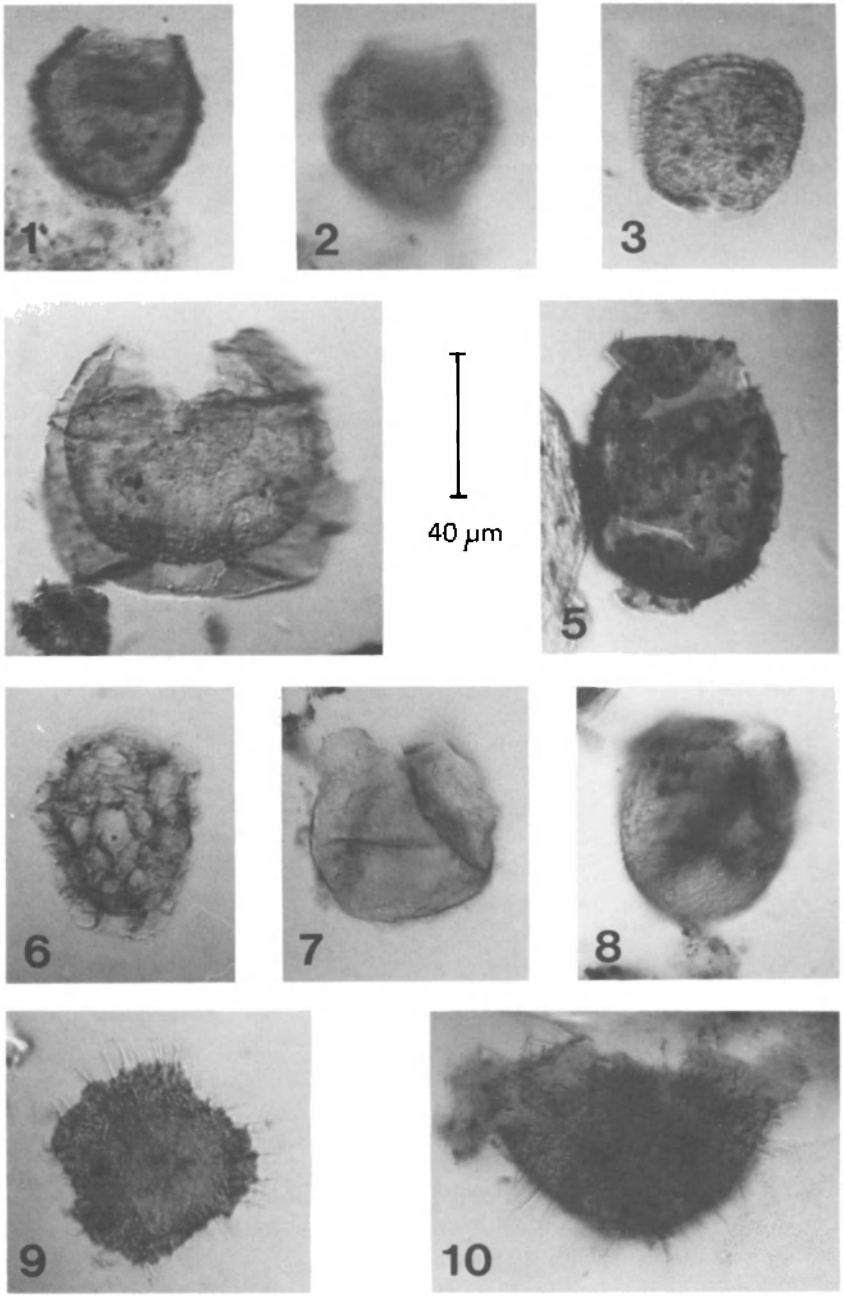


Fig. 6. Callovian dinoflagellate cysts from the Caucasus.
1,2: *Ellipsoidictyum* sp. Sample 3, X24/4.

East Greenland:

Although the majority of species recorded from the Early-Middle Callovian of Caucasus also have been reported from the contemporanous interval of East Greenland, other species than those dominating the assemblages of Caucasus (and Britain-W. Germany) are here most prominent. SMELROR (1988) reported peaks in the abundances of *Endoscrinium galeritum*, *Chlamydophorella ectotabulata* and *Chytroeisphaeridia grossa* within the Early Callovian of Jameson Land. Ctenidodinioid species appear not to be dominant within the Early-Middle Callovian of East Greenland, and *Cleistosphaeridium varispinosum* which is characteristic of the earliest Callovian of both Caucasus and Britian has not been reported from East Greenland.

Southern France:

Within the Late Bathonian - Early Callovian of Mt. Crussol, southern France SMELROR & LEEREVELD (1989) described a *Ctenidodinium combazii* - *Cleistosphaeridium varispinosum* association, characterized by common *Ctenidodinium combazii* and the occurrence of *Cleistosphaeridium varispinosum*. Other prominent spesies within this association are *Chytroeisphaeridia chytroeides*, *Escharisphaeridia* spp., *Sentusidinium rioultii* and occasionally *Adnatosphaeridium caulleryii* and *Rigaudella aemula*. (*Rigaudella aemula* is generally most frequent within the younger Late Callovian - Early Oxfordian interval). Most of the species recorded from the Early Callovian of Caucasus are also present within the Cc-Cv Association of Mt. Crussol, exceptions being *Cometodinium* sp., *Korystocysta* sp., and *Meiourogonyaulax reticulata*.

Libya, Spain and Israel:

Within the Late Bathonian - Early Callovian of northeast Libya, THUSU & VIGRAN (1985) found that *Systematophora penicillata*, *Adnatosphaeridium caulleryi*, *Sentusidinium echinatum*, *Escharisphaeridia pocockii*, *Tubotuberella dangeardii*, together with ctenidodinioid forms like *Korystocysta* cf. *gochtii*/

3: *Chlamydophorella* sp. Sample 1, G29/1.

4: *Sirmiodinium grossii* ALBERTI 1961. Sample 3, X24/3.

5: *Sentusidinium echinatum* (GITMEZ & SARJEANT) SARJEANT & STOVER 1978.

6: *Ellipsoidictyum cinctum* KLEMENT 1960. Sample 7, F25/2.

7: *Sentusidinium* sp. Sample 4A, Q43/3.

8: *Sentusidinium* sp. Sample 3, B35/3.

9: *Cleistosphaeridium varispinosum* (SARJEANT) WOOLLAM & RIDING 1983. Operculum. Sample 3, K36/1.

10: *Cleistosphaeridium varispinosum* (SARJEANT) WOOLLAM & RIDING 1983. Sample 3, O24/4.

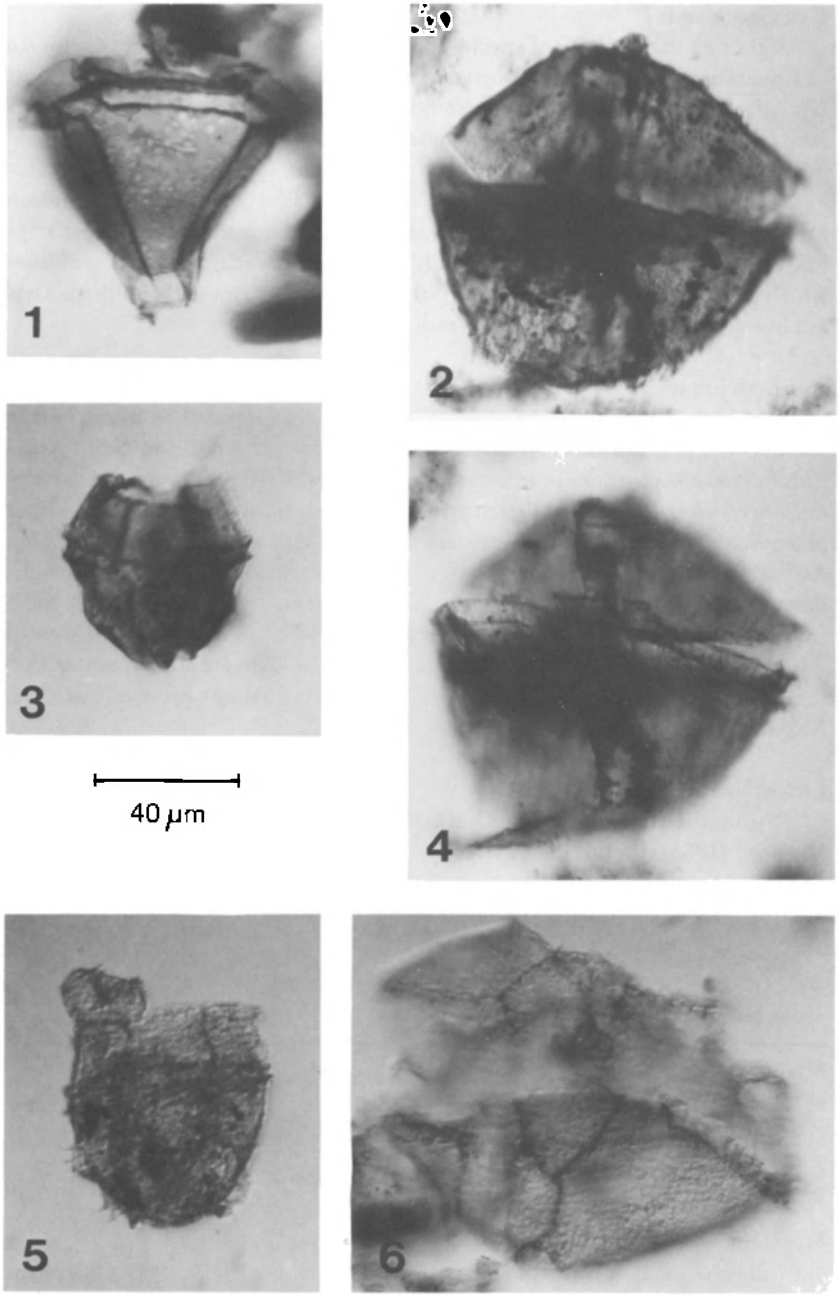


Fig. 7 (Legend see p. 161)

kettonensis, *Ctenidodinium* cf. *tenellum* and *Bradleyella* (*Dichadogonyaulax*) sp. were most prominent. Some similarities to the assemblages from Caucasus may be traced by the presence of *Ellipsoidictyum* spp., *Tubotuberella dangeardii*, *Korystocysta* sp., *Adnatosphaeridium caulleryii*, *Meiourogonyaulax callomonii*, and geographically widely distributed species as *Gonyaualcysta jurassica*, *Chytroeispaeridia chytroeides* and *Pareodinia ceratophora*.

Early-Middle Callovian dinoflagellate cysts assemblages from northeastern Spain, (Aquilón and Tosos) contain dominantly representatives of the *Dichadogonyaulax sellwoodii* group together with common species of the genus *Sentusidinium* (pers. obs.). Comparable to what is found in northeastern Libya, *Adnatosphaeridium caulleryi* and *Systematophora penicillata* are also prominent.

High abundances of *Dichadogonyaulax sellwoodii* and *Sentusidinium* spp. occur also in the Late Bathonian - Early Callovian of Israel, Mt. Hermon (pers. obs.). Species known from both Israel and Caucasus are *Compositosphaeridium polonicum*, *Cometodinium* sp., *Chytroeisphaeridia chytroeides*, *Ellipsoidictyum cinctum*, *Gonyaulacysta jurassica*, *Meiourogonyaulax callomonii* and *M. spongiosa*.

Conclusions

The Simpson Coefficient of microfloral similarity can be used to compare the dinoflagellate cyst assemblages of Caucasus with thouse previously described from: 1) East Greenland, 2) England and West Germany, 3) southern France, and 4) Libya, Spain and Israel; respectively. The Simpson Coefficient is expressed as C/N_1, C being the number of taxa common in two samples, and N_1 being the number of taxa in the sample having the smaller number. The coefficient is prefered among others because it is devised to minimize the effect of unequal size of the two assemblages being compared (FALLAW 1979). Using the taxalist given in Fig. 3 and the information found in the papers cited above, the Simpson Coefficients are determined as follow: 1) East Greenland: 0.66, 2) England and West Germany: 0.91, 3) southern France: 0.82, and 4) Libya, Israel and Spain: 0.73.

Based on the limited data presently available it is not possible to give any further detailed comparison of the Callovian dinoflagellate cysts assemblages from the Caucasus and those previously reported from northwest Europe and the circum-Mediterranium region. As a preliminary conclusion, it appears that the Caucasus assemblages show closest affinities to those described from Britain, West Germany and southern France.

Fig. 7. Callovian dinoflagellate cysts from the Caucasus.

1: *Meiourogonyaulax planoseptata* RIDING 1987. Sample 5, H37/3.

2, 4: *Korystocysta* sp. Sample 3, M22/1.

3: *Meiourogonyaulax* sp. Sample 12, W 38/3.

5: *Meiourogonyaulax reticulata* DODEKOWA 1975. Sample 15, C38/3.

6: *Ctenidodinium* sp. Sample 3, N25/0.

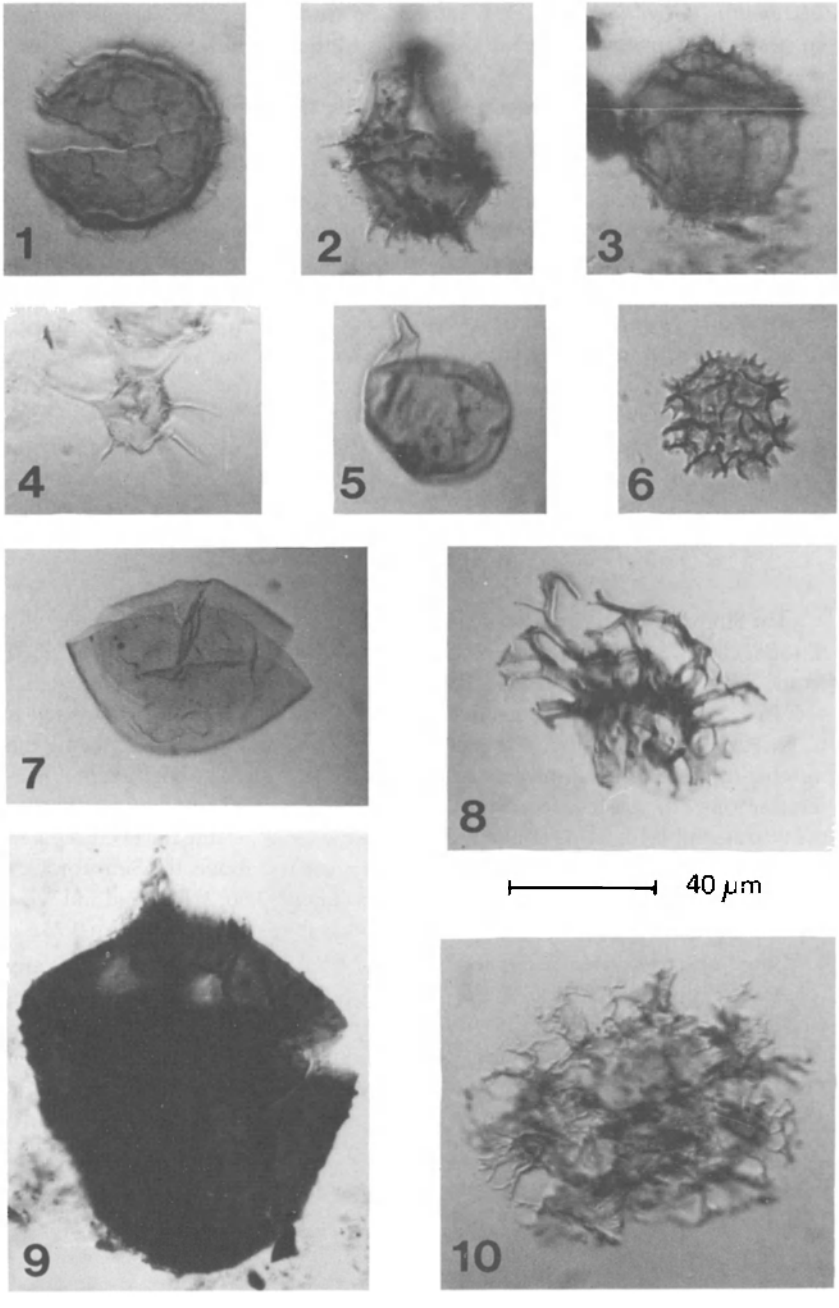


Fig. 8 (Legend see p. 163)

Taxonomy

Class Dinophyceae FRITSCH 1929
Order *Peridiniales* HAECKEL 1894
Genus *Chlamydophorella* COOKSON & EISENACK 1958
Type species: *Chlamydophorella nyei* COOKSON & EISENACK 1958.

Chlamydophorella spp.

Fig. 6,3

Remarks: Both specimens closely resembling *Chlamydophorella ectotabulata* SMELROR 1989 and *Chlamydophorella raritubula* DODEKOVA 1975 are here listed as *Chlamydophorella* spp.
Occurrence: Samples 2, 3, 4A, 5, 7, 9, 10 and 12, Early - Middle Callovian.

Genus *Cometodinium* DEFLANDRE & COURTEVILLE 1959
Type species: *Cometodinium obscurum* DEFLANDRE & COURTEVILLE 1959.

Cometodinium sp.

Fig. 5, 6 and 7

Remarks: *Cometodinium* sp. from the Callovian of Caucasus closely resembles the Early Cretaceous species *Cometodinium cometum Srivastava* 1984.
Occurrence: Samples 4A; Cherek Balkarski, *K. jason* Zone; 3; Tschegem, *M. macrocephalus* Zone; and 5; Sekheladon, Middle Callovian.

Genus *Ellipsoidictyum* KLEMENT 1960
Type species: *Ellipsoidictyum cinctum* KLEMENT 1960.

Ellipsoidictyum sp.

Fig. 6, 1 and 2

Remarks: *Ellipsoidictyum* sp. differs from *Ellipsoidictyum cinctum* KLEMENT 1960 and *Ellipsoidictyum reticulatum* (VALENSI) LENTIN & WILLIAMS 1977 in possessing a less well-developed reticulum on the autophragen.

Fig. 8. Callovian acritarchs and dinoflagellate cysts from the Caucasus.

1: *Cymatiosphaera* sp. Sample 3, W 36/2.

2: *Gonyaulacysta jurassica* (DEFLANDRE) NORRIS & SARJEANT 1965. Sample 1, P38/0.

3: *Gonyaulacysta pectinigera* (GOCHT) FENSOME 1979. Sample 7, P22/4.

4: *Micrhystridium* sp. Sample 4A, R25/4.

5: *Pareodinia ceratophora* DEFLANDRE 1947. Sample 1, K25/3.

6: *Reutlingia gochtii* DRUGG 1978. Sample 4A, R25/4.

7: *Mendicodinium greonlandicum* (POCOCK & SARJEANT) DAVEY 1979. Sample 7, N25/0.

8: *Adnatospaeridium caulleryi* (DEFLANDRE) WILLIAMS & DOWNIE 1969. Operculum. Sample 7, N39/3.

9: *Liesbergia* sp. Sample 7, Y41/4.

10: *Adnatosphaeridum caulleryi* (DEFLANDRE) WILLIAMS & DOWNIE 1969. Sample 10, T37/3.

This species appears comparable to the specimen illustrated as *E. gochtii* FENSOME 1979 from northwest Libya by THUSU & VIGRAN (1985, pl. 49, figs. 9 and 10), but is distinctly different from the holotype of *E. gochtii* by showing less well developed processes/ornaments.
Occurrence: Sample 3; Tschegen, *M. macrocephalus* Zone.

Genus *Korystocysta* WOOLLAM 1983
Type species: *Korystocysta gochtii* (SARJEANT) WOOLLAM 1983.

Korystocysta sp.
Fig. 7, 2 and 4

Remarks: The poorly expressed paratabular features make it difficult to assign (or compare) the single observed specimen to any of the described species of the genus *Korystocysta*.
Occurrence: Sample 3; Tschegem, *M. macrocephalus* Zone.

Genus *Liesbergia* BERGER 1986
Type species: *Liesbergia liesbergensis* BERGER 1986.

Liesbergia sp.
Fig. 9, 9

Remarks: This species is comparable to *Liesbergia liesbergensis* BERGER 1986 in possessing a well-developed characteristic apical horn formed by extensions of the ornamentation, and showing well expressed paratabular features, but differs in possessing coarser ornament.
Occurrence: Sample 7; Ardon, Middle Callovian.

Genus *Meiourogonyaulax* SARJEANT 1966
Type species: *Meiourogonyaulax valensii* SARJEANT 1966.

Meiourogonyaulax spp.
Fig. 7, 3

Remarks: Poorly preserved specimens assignable to the *Meiourogonyaulax caytonensis* (SARJEANT) SARJEANT 1969 group (see RIDING 1987, p. 262) and/or closely resembling *M. cantrellii* SARJEANT 1972 or *M. decapitata* (WETZEL) SARJEANT 1972 are here listed as *Meiourogonyaulax* spp.

Genus *Reutlingia* DRUGG 1978
Type species: *Reutlingia gochtii* DRUGG 1978.

Reutlingia sekheladonenesis n. sp.
Fig. 4. Fig. 5, 1-3 and 4.

Descriptions: Dinoflagellate cyst, elongated hour-glass shaped on outline, with a deeply incised paracingular area. Autophragm generally smooth, possessing small continous lines or short spines aligned in ?parasutural rows, and with well-developed denticles on the pre- and postcingular protuberances. Archeopyle intercalary (2a).
Dimensions: Overall lenth 35-45 μm, width of paracingular area 13-22 μm (6 specimens measured).
Holotype: Specimen shown on Fig. 5, 1 to 3. PMO number 120.722, England-finder coordinate P24/2.
Type locality and stratum: Near the river Sekheladon, Central North Caucasus; Sample 5; Middle Callovian.

Derivation of name: *Sekheladonensis*, named after the river Sekheladon in North Caucasus.
Occurrence: Sample 5, Sekheladon, Middle Callovian.
Remarks: This species was first described and illustrated by SMELROR (1987) (p. 232, Fig. 6H) from the Callovian of Franz Josef Land (Arctic Soviet). It was subsequently recorded from the Early Callovian on Jameson Land (East Greenland) (SMELROR 1988).

Reutlingia sekheladonensis n. sp. differs from *R. gochtii* DRUGG 1978 in being characteristically hour-glass shaped, and possessing short spines or denticulate ornamentation, whereas *R. gochtii* is more ovoidal to somewhat rectangular in outline and possesses more well developed broad based acuminate projections.

Acknowledgement

The authors thank Dr. R. BELOW, Bonn, and Dr. J. B. RIDING, Nottingham, for helpful comments on the submitted manuscript.

Literature

BEJU, D. (1971): Jurassic microplankton from the Carpatian Foreland of Roumania. – Annals Instituti Geologi Publici Hungarici, **54**: 275-302.

BELOW, R. (1987): Evolution und Systematik von Dinoflagellaten-Zysten aus der Ordnung Peridiniales. I. Allgemeine Grundlagen und Subfamilie Rhaetogonyaulacoideae (Familie Peridiniaceae). Palaeontographica, Abt. B., **205**: 1-164.

DIMTER, A. (1988): Palynostratigraphische Untersuchungen im Callovien von Kandern (Markgräflerland). – Diplomarbeit Univ. Tübingen, 74 pp. (Unpubl.).

GÓRKA, H. (1970): Dinoflagellate cysts from the Callovian of Luków (Poland). – Acta Palaeontologica Polonica, **15**: 479-505.

HERNGREN, G. F. W. & BOER, K, F. DE (1978): Dinoflagellate zonation of Upper Dogger and ?lowermost Malm in The Netherlands. – Palinologia, núm. extraord., **1**: 283-291.

HERNGREEN, G. F. W., BOER, K, F. DE, ROMEIN, B. J., LISSENBERG, TH. & WIJKER, N. C. (1983): Middle Callovian beds in the Achterhoek eastern Netherlands. – Meded. Rijks. Geol. Dienst, **37-3**: 96-123.

FALLAW, W. C. (1979): A test of the Simpson Coefficient and other binary coefficients of faunal similarity. – Journal of Paleontology, 53: 1029-1034.

FENSOME, R. A. (1979): Dinoflagellate cysts and acritarchs from the Middle and Upper Jurassic of Jameson Land, East Greenland. – Grønlands Geologiske Undersøgelse Bulletin, **132**: 98 pp.

LOMINADZE, T. A. (1982): Callovian ammonites of Caucasus, – Metsniereba, Tblisi, 272 pp. (In Russian).

LOMINADZE, T. A. (1987): Biostratigraphical scheme of the Callovian deposits of the Caucasus. – Abstr. 2nd. Internal. Symp. on Jurassic Stratigraphy, p. 75.

MUIR, M. D. & SARJEANT, W. A. S. (1978): The palynology of the Langdale Beds (Middle Jurassic) of Yorkshire and its stratigraphical implications. – Rev. Palaeobot. Palynol. **225**: 193-239.

RIDING, J. B. (1982): Jurassic dinocysts from the Warboys Borehole, Cambridgeshire, England. – J. micropaleont, **1**: 13-18.

on dinoflagellate cysts, to an ammonite orthochronology (e.g. SARJEANT 1979, RILEY & FENTON 1982, WOLLAM & RIDDING 1983, SMELROR 1988). Realizing the importance of interdisciplinary integration in biostratigraphy and paleobiogeography, this study was initiated in order to evaluate the use of dinoflagellate cysts in conjunction with ammonites in correlations of Callovian strata from the Caucasus with contemporaneous deposits from northwestern Europe. The Callovian ammonite faunas from Caucasus have been well documented by LOMINADZE (1982, 1987).

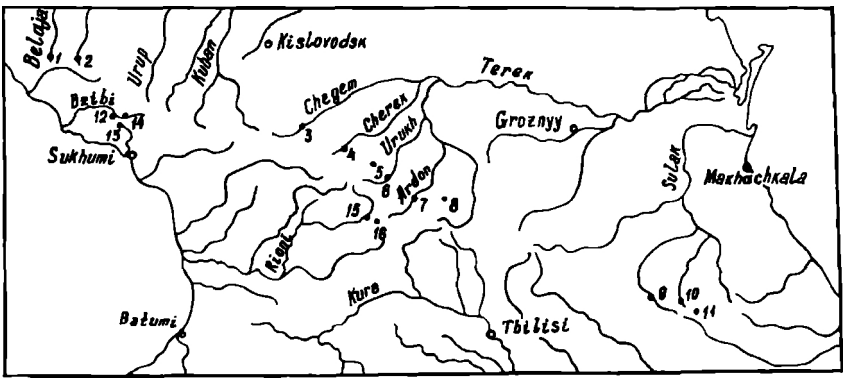


Fig. 1. Map of the Caucasus Region, showing locations of sampled sections refered to in Table 1.

Table 1. Localities and ages of samples included in the present study.

Sample no.	Locality	Age
1	Belaja (west in North Caucasus)	Early-Middle Callovian
2	Psebai (west in North Caucasus)	Middle Callovian
3	Tschegem (Kabardino-Balkaria)	*M. macrocephalus* Zone
4.A	Cherek Balkarski (Kabardino-Balkaria)	*K. jason* Zone
4.B	Cherek Balkarski (Kabardino-Balkaria)	*E. cororatum* Zone
4.C	Cherek Balkarski (Kabardino-Balkaria)	Late Callovian
5	Sekheladon (Central North Caucasus)	Middle Callovian
6	Urukh (Central North Caucasus)	Middle Callovian
7	Ardon (Central North Caucasus)	Middle Callovian
8	Fiag-don (Central North Caucasus)	Middle Callovian
9	Golotl (Daghestan, east Caucasus)	*K. jason* Zone
10	Ameterk-Makhi (Daghestan, east Caucasus)	*K. jason* Zone
11	Tsudakhar (Daghestan, east Caucasus)	*K. jason* Zone
12	Reschava (west Georgia, Abkhasia)	*M. macrocephalus* Zone
13	Adzaga (west Georgia, Abkhasia)	Early Callovian
14	Bzibi (west Georgia, Abkhasia)	Early Callovian
15	Tsessi (Georgi, southern Great Caucasus)	*M. macrocephalus* Zone
16	Korta (Georgia)	Early Oxfordian

RIDING, J. B. (1987): Dinoflagellate cyst stratigraphy of the Nettleton Bottom Borehole (Jurassic: Hettangian to Kimmeridgian), Lincolnshire, England. – Proceedings of the Yorkshire Geological Society, **46:** 231-266.

RIDING, J. B., PENN, I. E. & WOOLLAM, R. (1985): Dinoflagellate cysts from the type area of the Bathonian Stage (Middle Jurassic, Southwest England). Rev. Paleobot. Palynol., **45:** 149-169.

RILEY, L. A. & FENTON, J. P. G. (1982): A dinocyst zonation for the Callovian to Middle Oxfordian succession (Jurassic) of northwest Europe. – Palynology, **6:** 193-202.

SARJEANT, W. A. S. (1959): Microplankton from the Cornbrash of Yorkshire. – Geol. Mag., **96:** 329-346.

–,– (1961): Microplankton from the Kellaways Rock and Oxford Clay of Yorkshire. – Palaeontology, **4:** 90-118.

–,– (1965): Micorplankton form the Callovian (S. calloviense Zone) of Normandy. – Rev. Micropaléontol., **8:** 175-184.

–,– (1979): Middle and Upper Jurassic dinoflagellate cysts: the world excluding North America. – Contrib. Ser. Am. Assoc. Stratig. Palynol., **5:** 133-157.

SMELROR, M. (1987): Bathonian and Callovian (Middle Jurassic) dinoflagellate cysts and acritarchs from Franz Josef Land, Arctic Soviet. – Polar Research, **5:** 221-238.

–,– (1988): Late Bathonian to Early Oxfordian dinoflagellate cyst stratigraphy of Jameson Land and Milne Land, East Greenland. – Rapp. Grønlands Geol. Unders., **137:** 135-159.

SMELROR, M. & LEEREVELD, H. (1989): Dinoflagellate cyst and acritarch assemblages from the Late Bathonian - Early Oxfordian of Montagne Crussol, Rhône Valley (Southern France). – Palynology, **13:** (in press.).

THUSU, B. & VIGRAN, J. O. (1985): Middle-Late Jurassic) Late Bathonian-Tithonian) Palynomorphs. – J. Micropalaeontol., **4:** 113-130.

WOOLLAM, R. (1980): Jurassic dinocysts from shallow marine deposits of the East Midlands. – J. Univ. Sheffield Geol. Soc., **7:** 243-261.

WOOLLAM, R. & RIDING, J. B. (1983): Dinoflagellate cyst zonation of the English Jurassic. – Inst. Geol. Sci. Rep., **83/2:** 1-41.

Bei der Tübinger Schriftleitung eingegangen am 1. Dezember 1988.

Anschriften der Verfasser:

Dr. M. SMELROR, Continental Shelf and Petroleum Technology Research Institute A/S, P.O.Boox 1883, Jarlesletta, N-7002 Trondheim, Norwegen; D. T. A. LOMINADZE, Institute of Paleobiology, Academy of Science, Georgian SSR, Potočnaja 4a, Tbilisi 380004, UdSSR.

The samples included in the present study are from various areas in the Caucasus region. Sample locations and ages, based on ammonites of the studied samples are listed in Table 1. Litho- and biostratigraphic details of several sections sampled for this study are found in LOMINADZE (1982).

The samples were prepared for palynological analyses using standard preparation techniques (HCl, HF treatment, sieving of residues using a 15 μm sieve, mounting in glycerine – gelatin) at IKU, Trondheim. All figured material is stored in the collections of the Paleontological Museum in Oslo, Norway.

The Callovian deposits of the Caucasus: Ammonite biostratigraphical scheme

Ammonites are distributed irregularly over the Caucasus sections and throughout the area, due to different paleogeographical conditions developed during the Callovian Stage. The Callovian is most completely developed in the Northern Caucasus, herein it is subdivided into substages, zones and subzones by ammonites.

The Lower Callovian is traced in virtually all regions of the Caucasus, but it is only in Abkhazia, Zemo-Racha, the Southern Osetia and Mountainous Ingusheti that it can be subdivided into zones. The oldest Callovian strata are presented by the *M. macrocephalus* Zone, which is characterized by the occurrence of numerous Macrocephalitidae. Just above the *M. macrocephalus* Zone, the *K. gowerianus* Zone is developed. The Middle Callovian deposits unconformably overlap the Lover Callovian strata with a basal conglomerate. The most complete section of the Middle Callovian is found in Mountainous Daghestan in the *K. jason* Zone, where the most common ammonites are Kosmoceratinae and Perisphinctidae.

AGE		Ammonite zones	Ammonite sub-zones
CALLOVIAN	Upper	Quenstedtoceras lamberti	
		Peltoceras athleta	
	Middle	Erymnoceras coronatum	Kosmoceras pollux
			Erymnoceras coronatum
		Kosmoceras jason	
	Lower	Kepplerites gowerianus	
		Macrocephalites macrocephalus	

Fig. 2. Ammonite biostratigraphical scheme of the Caucasus region (From LOMINADZE 1982).

On the Southern Slope of the Caucasus, the Middle Callovian ammonite complex is composed of numerous Hecticoceratinae including *Putealiceras metomphalum*. Both the *E. coronatum* Zone, and the *K. jason* Zone, are best paleontogically represented within the Mountainous Daghestan. Herein the *E. coronatum* Zone is subdivided into two subzones (*E. coronatum* and *K. pollux*).

The Upper Callovian Substage is subdivided into two zones (*P. athleta* and *Q. lamberti*). The first one is found within the Upper Callovian deposits of Zemo-Racha, Kabardino-Balkaria and Daghestan. The deposits of the upper zone in Daghestan and Zemo-Racha have yielded *Quenstedtoceras, Vertumnicera, Eboraciceras,* and *Euaspidoceras*.

The Upper Callovian deposits are unconformably overlapped by Oxfordian sediments, the contact being rather abrupt.

Dinoflagellate cyst assemblages

Most of the studied samples yielded relatively low diversity assemblages of marine microplankton, with normally less than 17 species present. Highest diversity was found in the Middle Callovian sample 7 from Ardon in the Northern Caucasus, in which 22 species were indentified. The samples 4c, 8, 6 and 11 were barren of marine palynomorphs. A list of the encountered dinoflagellate cyst taxa is shown on Table 2.

Lower Callovian

The Lower Callovian dinoflagellate cyst assemblages are characterized by the presence of *Cleistosphaeridium varispinosum* and *Ctenidodinium* spp. which in some samples were fairly common. Other characteristic taxa were *Ellipsoidictyum cinctum, Pareodinia* spp., *Meiourogonyaulax* spp. and *Adnatosphaeridium caulleryi*. Most of the species recorded from the Early Callovian deposits occur also in the Middle Callovian, the only species restricted to the Early Callovian interval being *Caddasphaera halosa, C. varispinosum, Ellipsoidictyum* sp., *Korystocysta* sp., *Meiourogonyaulax callomonii, Lithodinia bathonia* and *Valensiella ovula*. *Caddasphaera halosa* and *Meiourogonyaulax callomonii* are known to range into younger Callovian strata elsewhere in NW Europe. A total of 28 species have been identified from the Early Callovian of the Caucasus.

In general terrestrial palynomorphs are more common than marine. The samples from the *M. macrocephalus* Zone of Tschegam (3) and Reschava (12) contain relatively abundant *Corollina(=Classopollis)* spp..

Middle Callovian

The Middle Callovian assemblages contain most of the species reported from the Lower Callovian. Species of the genus *Ctenidodinium* are still prominent. *Sentusidinium rioultii* is common in the samples from the *K. jason* Zone of Ameterk-Makli in the last Caucasus and from Cherek Balkarski. Species showing their earliest incoming within the Middle Callovian of Caucasus are *Chytroeis-*

phaeridia grossa, Nannoceratopsis pollucida, Lithodinia jurassica, Meiourogonyaulax planoseptata, Reutlingia gochtii, R. sekheladonensis sp. nov., *Liesbergia* sp., *Dingodinium harsveldtii, Meiourogonyaulax spongiosa, Mendicodinium groenlandicum* and *Aldorfia dictyota*. The Middle Callovian dinoflagellate cyst assemblages are more diverse than those from the Early Callovian, with a total of 36 taxa recognized.

Generally terrestrial palynomorphs are more abundant than marine, exceptions being the samples from Ardon (7) and Ameterk-Maklin (10), which contain more common dinoflagellate cysts and acritarchs. *Corollina(=Classopollis)* spp. is abundant and dominates the palynofloras in the samples from Cherek Balkarski (4A), Psebai (2) and Sekheladon (5).

Upper Callovian and Lower Oxfordian

Two samples were studied from the Late Callovian (4c) and Early Oxfordian (16) of the Caucasus. Sample 4c from the *P. athleta* ammonite Zone proved palynologically barren, while the only dinoflagellatte cysts found on the Early Oxfordian sample were *Ctenidodinium ornatum, Sentusidinium rioultii* and *Sentusidinium* sp. The organic residues in both these samples contained dominantly small angular dark brown to black woody and coaly fragments.

Palynostratigraphy

Too few data are available to propose a detailed palynostratigraphic scheme for the Callovian of the Caucasus. Presently only eigthteen samples, containing mostly low diversity assemblages have been examined. Dinoflagellate cyst zonation schemes covering the Callovian of England, have been published by Woollam & Riding (1983), of East Greenland by Smelror (1988) and of NW Europe by Riley & Fenton (1982). As no data are available from the Late Callovian of Caucasus, only comparison of the Early-Middle Callovian are here further discussed.

Woollam & Riding (1983) used the extinction of *Ctenidodinium combazii* and the disappearance of widespread *Ctenidodinium* dinoflagellate cyst floras to define the base of their *Ctenidodinium ornatum - Ctenidodinium continuum* dinoflagellate cyst Zone for the British Jurassic. The base of this Co/Ccn Zone was defined within the middle *M. macrocephalus* ammonite Zone. The top of the Zone was defined by the local incoming of *Wanaea thysanota*. The appearance of *Limbodinium absidatum* coincide with the the top of the *E. coronatum* ammonite Zone.

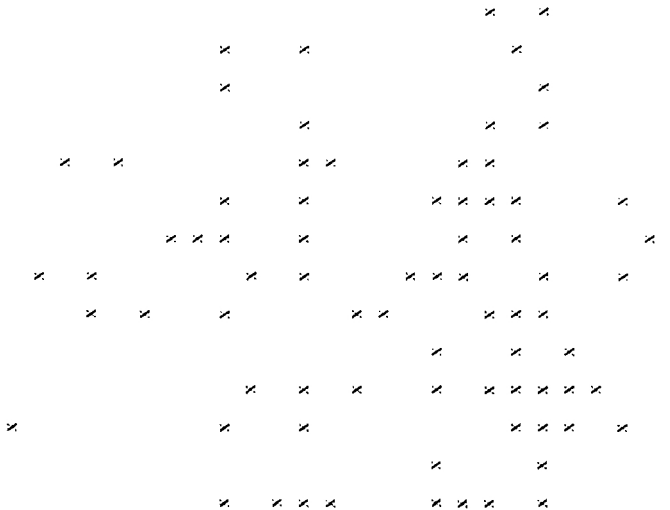
Riley & Fenton (1982) defined two dinoflagellate cyst zones and two subzones within the Lower and Middle Callovian of northwest Europe. Their oldest *Dichadogonyaulax gochtii* Zone, which is equivalent to the Early Callovian *M. macrocephalus* and partly the *S. calloviense* ammonite Zones, was defined as the interval from the first appearance of *Tubotuberella apatela* to the last

Table 2. List of recorded dinoflagellate cyst taxa (For details on sample numbers, see Table 1). Numbers in brackets refer to position in range chart Fig. 3.

List of recorded dinoflagellate cyst taxa:

	1	2	3	4A	4B	5	7	9	10	12	13	14	15	16
Aldorfia dictyota (Cookson & Eisenack) Davey 1982 (35)							x		x					
Adnatosphaeridium caulleryi (Deflandre) Williams & Downie 1969 (10)	x			x		x	x	x	x	x				
Caddasphaera halosa (Filatoff) Fenton et al. 1980 (1)										x				
Chlamydophorella spp. (14)	x	x	x	x		x	x	x	x	x				
Chytroeisphaeridia chytroeides (Sarjeant) Downie & Sarjeant 1965 (22)	x		x	x	x	x	x	x	x	x		x	x	
Chytroeisphaeridia grossa Smelror 1988 (39)	x													
Cleistosphaeridium ehrenbergii Davey et al. 1969 (12)	x		x				x		x					
Cleistosphaeridium varispinosum (Sarjeant) Woollam & Riding 1983 (6)			x	x						x	x	x	x	
Cometodinium sp. (13)			x	x		x								
Compositosphaeridium polonicum (Gorka) Erkmen & Sarjeant 1980 (8)								x	x				x	
Ctenidodinium continuum Gocht 1970 (11)	x			x		x	x	x	x			x		
Ctenidodinium ornatum (Eisenack) Deflandre 1938 (24)	x	x	x	x		x	x		x	x				x
Dingodinium harsveldtii Herngreen et al. 1984 (32)							x							
Ellipsoidictyum cinctum Klement 1960 (15)			x	x		x	x	x	x	x				
Ellipsoidictyum sp. (12)			x											
Escharisphaeridia pocockii (Sarjeant) Erkmen & Sarjeant 1980 (28)	x						x	x	x		x	x		
Gonyaulacysta jurassica (Deflandre) Norris & Sarjeant 1965 (16)	x		x			x	x	x	x					
Gonyaulacysta pectinigera (Gocht) Fensome 1979 (37)							x							

Korystocysta sp. (3)
Liesbergia sp. (38)
Lithodinia bathonica CONWAY 1985 (4)
Lithodinia jurassica EISENACK 1935 (40)
Meiourogonyaulax callomonii SARJEANT (1972 (5)
Meiourogonyaulax planoseptata RIDING 1987 (41)
Meiourogonyaulax reticulata DODEKOVA 1975 (27)
Meiourogonyaulax spongiosa SMELROR 1987 (30)
Meiourogonyaulax spp. (19)
Mendicodinium groenlandicum (POCOCK & SARJEANT) DAVEY 1979 (33)
Nannoceratopsis pellucida DEFLANDRE 1938 (42)
Pareodinia ceratophora DEFLANDRE 1947 (17)
Pareodinia prolongata SARJEANT 1959 (18)
Reutlingia gochtii DRUGG 1978 (34)
Reutlingia sekheladonensis sp. nov. (43)
Sentusidinium asymmetrum (FENTON et al.) LENTIN & WILLIAMS 1981 (44)
Sentusidinium echinatum (GITMEZ & SARJEANT) SARJEANT & STOVER 1978 (36)
Sentusidinium pilosum (EHRENBERG) SARJEANT & STOVER 1978 (20)
Sentusidinium rioultii (SARJEANT) SARJEANT & STOVER 1978 (25)
Sentusidinium villersense (SARJEANT) SARJEANT & STOVER 1978 (23)
Sentusidinium spp. (26)
Sirmiodinium grossii ALBERTI 1961 (9)
Stephanelytron caytonense SARJEANT 1961 (29)
Tubotuberella dangeardii (SARJEANT) STOVER & EVITT 1978 (29)
Tubotuberella eisenackii (DEFLANDRE) STOVER & EVITT 1978 (31)
Valensiella ovula (DEFLANDRE) EISENACK 1963 (7)



occurrence of *Nannoceratopsis spiculata*. The overlying Lower to Middle Callovian *Polystephanephorus paracalathus* Zone of RILY & FENTON (1982) was subdivided into the *Nannoceratopsis pellucida* Subzone, equivalent to the *S. calloviense* (pars) – *K. jason* ammonite Zones, and the *Kalyptea stegasta* Subzone, which was correlated with the *E. coronatum* ammonite Zone. The *Nannoceratopsis pellucida* Subzone was defined as the interval from the extinction of *N. spiculata* to the first appearance of *Wanaea digitata*. The *Kalyptea stegasta* Subzone was defined as the interval from the first appearance of *W. digitata* to the first appearance of *Atopodinium prostatum*.

None of the key species used in the zonation schemes of WOOLLAM & RIDING (1983) and RILEY & FENTON (1982) have been recognized from the contemporaneous deposits in the Caucasus. However, both WOOLLAM & RIDING (1983) and RILEY & FENTON (1982) found that common *Cleistosphaeridium varispinosum* are characteristic for the Early Callovian (although some rare specimens may also range into the Middle Callovian). This species also appears to be a reliable marker for the Early Callovian of Caucasus.

Lithodinia bathonica, found in the *M. macrocephalus* Zone of Caucasus, has previously only been reported from the Late Bathonian of Israel (CONWAY 1978) and southern France (TAUGOURDEAU - LANTZ & LACIIKAR 1984, SMELROR & Leereveld 1989). The extinction of this species might be of some stratigraphic significance. The earliest incoming of *Dingodinium harsveldtii*, *Reutlingia gochtii*, *Stephanelytron cayt onense*, *Mendicodinium groenlandicum* and *Meiourogonyaulax spongiosa* might possibly be used as markers for the Middle Callovian. *Stephanelytron* spp. show their earliest appearance in the *K. jason* Zone in the British Jurassic, which is comparable to their occurrence in the Caucasus. *Meiourogonyaulax planoseptata*, described from the *S. calloviense* ammonite Zone from the British Jurassic (RIDING 1987), also occurs in the Middle Callovian of Caucasus. The earliest incoming of *Reutlingia sekheladonensis* sp. nov. in the Middle Callovian is possibly of some biostratygraphic importance. In order to fully evaluate the biostratigraphic potential of dinoflagellate cysts within the Caucasus region and further to give more detailed palynostratigraphic correlations, significantly more data are, required.

Comparisons with Early-Middle Callovian dinoflagellate cyst assemblages from other European areas

Dinoflagellate cyst assemblages from the Early and Middle Callovian of northwest Europe are well documented, e.g. SARJEANT (1959, 1961), MUIR & SARJEANT (1978), WOOLLAM (1980), WOOLLAM & RIDING (1983) and RIDING 1982, 1987) from the British Jurassic; SARJEANT (1965) from North France; DIMTER (1988) from West Germany, HERNGREEN & DE BOER (1978) and HERNGREEN et al. (1983) from The Netherlands; and SARJEANT (1972), FENSOME (1979) and SMELROR (1988) from East Greenland.

AGE	Early Callovian		Middle Callovian			Late Callovian		Early Oxfordian
AMMONITE ZONES (NW EUROPE) / DINOFLAGELATE CYST TAXA	Macrocephalus		Jason		Coronatum		Athleta	
1 Caddasphaera halosa	•							
2 Ellipsoidictyum sp.	•							
3 Korystocysta sp.	•							
4 Lithodinia bathonica	•							
5 Meiourogonyaulax callomonii	•							
6 Cleistosphaeridium varispinosum	•	•						
7 Valensiella ovula	•	•						
8 Compositosphaeridium polonicum	•	—	•					
9 Sirmiodinium grossii	•	—	•					
10 Adnatosphaeridium caulleryi	•	—	•	•				
11 Ctenidodinium continuum	•	•	•	•				
12 Cleistosphaeridium eherenbergii	•	—	•	•				
13 Cometodinium sp.	•	—	•	•				
14 Chlamydophorella spp.	•	—	•	•				
15 Ellipsoidictyum cinctum	•	—	•	•				
16 Gonyaulacysta jurassica	•	—	•	•				
17 Pareodinia ceratophora	•	•	•	•				
18 Pareodinia prolongata	•	—	—	•				
19 Meiourogonyaulax spp.	•	•	•	•				
20 Sentusidinium pilosum	•	—	—	•				
21 Tubotuberella dangeardii	•	—	•	•				
22 Chytroeisphaeridia chytroeides	•	•	•	•	•			
23 Sentusidinum villersense	•	—	•	•	•			
24 Ctenidodinium ornatum	•	—	•	•	—	—	—	•
25 Sentusidinum rioultii	•	—	•	•	—	—	—	•
26 Sentusidinum spp.	•	•	•	•	—	—	—	•
27 Meiourogonyaulax reticulata	•	•						
28 Escharisphaeridia pocockii	•	•	•					
29 Stephanelytron caytonense			•					
30 Meiourogonyaulax spongiosa			•					
31 Tubotuberella eisenackii			•					
32 Dingodinium harsveldtii		•	•					
33 Mendicodinium groenlandicum		•	•					
34 Reutlingia gochtii		•	•					
35 Aldorfia dictyota		•	•					
36 Sentusidinium echinatum			•	•	•			
37 Gonyaulacysta pectinigera				•				
38 Liesbergia sp.				•				
39 Chytroeisphaeridia grossa				•				
40 Lithodina jurassica				•				
41 Meiourogonyaulax planoseptata				•				
42 Nannoceratopsis pellucida				•				
43 Reutlingia sekheladonensis				•				
44 Sentusidinium asymmetrum				•				

Fig. 3. Stratigraphic range of dinoflagellate cyst species from the Early Callovian - Early Oxfordian of the Caucasus region.