Advances in the study on genus *Tianzhushania* of Neoproterozoic Doushantuo formation in Weng'an, Guizhou province, South China

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The genus *Tianzhushania* Yin and Li, 1978, was first found at Tianzhushan Mountain near Changyang County and was considered one of the most distinctive acanthomorphic acritarchs in the Doushantuo Stage of Sinian or any other Neoproterozoic formation. It is characterized by large diameter (350–1000 μm) and processes that penetrate a multilamellate wall layer to support an external multilamellate membrane. Previous palaeontological research on the genus has been based mainly on petrographic thin sections made from chert nodules or bandings in the Doushantuo Formation at the Yangtze Gorges, Hubei Province, and Weng'an, Guizhou province. So far, two morphospecies of *Tianzhushania* have been reported, both from cherty intercalations in the Doushantuo Formation. The type species, *T. spinosa* (Yin and Li, 1978) was first found in the Yangtze Gorges area and later in the Weng'an area. The other species is *T. tuberifera* Yin, Gao and Xing, 2001, found in the same horizon in the Doushantuo phosphorites of the Weng'an area. This species differs from the ones described as *T. spinosa* in having a distinct dense and robust middle wall with clearly demarcated tubercles or arches.

Comparative study of microfossils from two kinds of sediments: chert intercalations (studied in thin section) and phosphorite/phosphatic carbonate (in thin section and maceration), from the upper Neoproterozoic Doushantuo phosphorites in the Weng'an area, Guizhou Province, South China, shows that the phosphatized *Megasphaera ornata* Xiao and Knoll, 2000, and the chert-preserved *Tianzhushania tuberifera* Yin, Gao and Xing, 2001, should be regarded as representing the same taxon preserved by different mineralization processes. In phosphatized specimens the outer wall is often peeled off, exposing the ornamented middle wall. Some phosphatized specimens isolated from the rock matrix and specimens seen in thin sections of phosphorites show a partly preserved outer wall with spines, which can be compared to the thin-sectioned specimens from the chert beds. The small pits usually seen on the surface of the ornamented middle wall of phosphatized specimens correspond to the attachment spots of the spines in the outer wall. The presence of a spiny outer wall is a characteristic of *Tianzhushania* Yin and Li, 1978. So, *Tianzhushania ornata* (Xiao and Knoll) Yin, Bengtson and Yue should be a valid name for the species (Yin, Bengtson and Yue, 2004). The proposed resting-egg nature of *T. ornata*, mainly based on the ornament type of the middle wall, cannot be excluded. The presence of a spiny outer wall, however, suggests that it is a pelagic rather than a benthic form.

Morphological and taphonomic studies of permineralizated fossils in cherts and phosphorites of the Doushantuo phosphorites in the Weng'an area, South China indicate that specimens assigned to *Megasphaera ornata* Xiao and Knoll, 2000, are preservational variants of *Tianzhushania tuberifera* Yin, Gao and Xing, 2001. The discovery of *Tianzhushania* both in the Weng'an area and in the Yangtze Gorges provides not only new data for studying spheroidal microfossils in phosphorite but also a way to correlate the silicified assemblages with phosphatized ones. The fossiliferous horizons at Weng'an and in the Yangtze Gorges are coeval.

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LOWER PALAEOZOIC PALYNOLOGY/CIMP SYMPOSIUM

On the biological affinities of galeate acritarchs: morphological and biogeochemical data

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Per definition, the Acritarcha are organic-walled microfossils for which the biological affinities are unknown (Evitt, 1963) The list of possible biological groups to which the acritarchs could belong to is long and includes the dinoflagellates, prasinophyceaean, chlorophycean and zygnemaphyceaen algae, arthropod (copepod) egg cases, exoskeletal elements of other invertebrates and of vertebrates and remains of higher plants (e.g. spores).

Up to know, mostly morphological criteria are used to elucidate the biological assignment of acritarchs. However, over the last years the analysis of biomarkers, and more recently palynomorph wall-polymers have emerged as additional tools to characterise algae and they have also been applied to elucidate the biological affinities, though with different success. Nevertheless, clear differences are found in polymer structure amongst recent algal groups like Dinophyta and Chlorophyta and also within these groups polymer structure appears to vary significantly. As such, there remains considerable potential for these chemical techniques to elucidate acritarch biological affinities.

The Late Cambrian-Ordovician galeate acritarchs strongly resemble the cysts of dinoflagellates from a morphological point of view: the large "apical" opening may correspond to the archeopyle of the dinoflagellates, while the polygonal fields observed on some galeate vesicles may correspond to a paratabulation. In addition, the morphology of the processes and their variability strongly resembles those of some dinoflagellate cysts. The palaeoecological and palaeogeographical distribution of the galeate acrtitarchs also corresponds to that of modern and fossil dinoflagellates.

In this lecture, we present the results of the first study on the chemical structure of galeates wall polymers. The results will be discussed in relation to our current understanding of the composition of recent and fossil palynomorph polymers.

Late Cambrian acritarchs from the "Túnel Ordovícico del Fabar", Cantabrian Zone, N Spain

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The excavation of the El Fabar Tunnel of the Cantabrian superhighway provided the opportunity for detailed investigation of the Cambrian-Ordovician successions of the Laviana and Rioseco nappes, eastern Cantabrian Zone of the Iberian Massif (GUTIÉRREZ-MARCO *et al.* 2003).

The Middle? to Upper Cambrian La Matosa Member of the Barrios Formation consists mainly of quartz sandstones and comprises a thick fossiliferous intercalation of dark shales ("El Fabar beds"). These shales yielded olenid trilobites and filocarid crustaceans and one sample provided an acritarch association of Late Cambrian age.

The palynoflora is well preserved and quite rich but not highly diverse. The most common genera are *Cristallinium*, *?Retisphaeridium*, *Timofeevia*, *Cymatiogalea*, *Acanthodiacrodium* and *Stelliferidium*.

Lusatia dendroidea BURMANN 1970, reported for the first time from Spain, is a very characteristic element of this association. In the material at hand, *Lusatia dendroidea* exhibits a great morphological variability and occurs in high number, mostly as completely preserved specimens.

Some taxa, represented by numerous specimens, are of problematic generic assignment and their taxonomical interpretation requires further investigations and comparisons with other areas where similar associations occur.

BURMANN, G. 1970. Weitere organische Mikrofossilien aus dem unteren Ordovizium. **Paläontologische Abhandlungen**, Abt.B, 3(3-4): 289-332.

GUTIÉRREZ-MARCO, J.C., BERNÁRDEZ, E., RÁBANO, I., SARMIENTO G.N., SENDINO, M.C., ALBANI, R. & BAGNOLI, G. 2003. Ordovician on the move: geology and paleontology of the "Túnel Ordovícico del Fabar" (Cantabrian free highway A-8, N Spain). In: ALBANESI G.L., BERESI, M.S. & PERALTA S.H. (eds). **Ordovician from the Andes. INSUGEO, Serie Correlación Geológica**, 17: 71-77.

Veryhachium dumontii: a diacrodian or a veryhachid acritarch?

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After the definition of the unformal group Acritarcha by Evitt (1963), several authors proposed the distinction of different acritarch "subgroups" (e.g. Downie et al., 1963). These subgroups were commoly used in the 1960s and 1970s by acritarch workers, but subsequently they were abandoned. Marry intermediates exist between the different subgroups and the parataxonomical scheme of subgroups did not correspond to any biological classification.

Diacrodian acritarchs (formerly classified as the subgroups "Diacromophitae") show a bipolar morphology of the central body with ornaments and/or processes concentrated at the two poles of the vesicle. Although present at many geological periods, this group of acritarchs are especially abundant and extremely variable in Upper Cambrian and lowermost Ordovician palynological assemblages.

Polygonomorph acritarchs (formely classief as the subgroup "Polygonomorphitae") have a pronouncedly polygonal central body. Acritarch morphotypes of this type wih few processes were generally attributed to the genus Veryhachium Deunff, 1954, referred here to "veryhachid" acritarchs.

A particular acritarch species from the Upper Cambrian, Veryhachium dumontii was attributed to the polygonomorph acritarchs and the genus Veryhachium, although this morphotype is found within diacrodian assemblages and has strong relationships with diacrodian taxa, such as, for example, the species Dasydiacrodium caudatum and the genus Nellia.

In the present study we try to find out to which entity may belong V. dumontii. Our investigation is based on a reinvestigation of previously published material and of new analyses of assemblages from other localities. It appears that the species is clearly belonging to the diacrodians, but to none of the previously described genera. The species should thus be placed here in a new diacrodian genus. The species cannot be maintained in the genus *Veryhachium*. This latter genus was never described to have a bipolar central body. In addition, the first *Veryhachium* morphotypes only appear in the lalest Treamdocian, i.e. about 10 MA years later than the occurrence of dumontii.

EVITT, W.R. 1963. A discussion and proposals concerning fossil dinoflagellates, hystrichospheres, and acritarch. Procedings of the National Academy of Sciences, 49 (1): 158-164; 49 (II): 298-302.

DOWNIE, Ch, EVITT, W.R. & W.A.S. 1963. Dinoflagellates, hystrichospheres ans the classification of the acritarch. Stanford Univ. Publ. Geological Sciences. VII (3): 3-16.

Turnover of acritarch and chitinozoan species, endemism and sequence stratigraphy in the Lower Palaeozoic of Oman

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The Late Cambrian to Early Silurian succession in the subsurface of north Oman comprises braid delta and shore-face facies intercalated with mudstone deposited during a series of marine flooding events. The major marine events form the basis of a genetic sequence stratigraphy. Each of the major flooding events is characterized by a unique assemblage of marine palynomorphs, mainly acritarchs but also including chitinozoans in the upper part of the succession. The unique character of each assemblage means that the marine rocks of each genetic sequence can be fingerprinted, so that the palynology of these rocks constitutes a powerful and effective means of correlation. It also means, however, that species turnover between successive marine flooding events is high.

In addition, assemblages are characterized by a high degree of endemism, particularly in the Lower and Middle Ordovician, and although more cosmopolitan taxa are present, there are some notable omissions. As a consequence, the marine palynomorph assemblages from the Lower Palaeozoic of Oman, particularly those of Early and Middle Ordovician age, constitute a series of distinctive planktonic biofacies on the Early Palaeozoic margin of Gondwana.

The character of these assemblages may be related to their position on the margin of Gondwana, which is inferred to be more cratonic than contemporaneous terranes of, for example, Iran and Pakistan. This in turn raises questions concerning the relationship between planktonic organisms and genetic depositional sequences on the margin of Gondwana, between lithofacies and plantktonic biofacies, and between microfloral and microfaunal species turnover, biostratigraphy and sequence stratigraphy.

Enviromental significance of the Ordovician acritarchs from Tarim Basin, NW China

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Located in the Xinjiang, NW China, Tarim has been considered one of the major three blocks of China during Ordovician. The Ordovician, especially the early and middle Ordovician, was a period of relative stability for the Tarim Block, the Mid-Tianshan Massif and the Tarim Platform formed a single unit without tectonic activity. Ordovician acritarchs and cryptosprores from Tarim have been investitated.The present paper will divide the Middle-Late Ordovician acritarchs from Tarim into four assmeblages and disscuss the stratigraphical and environmental significance of these assamblages.

Acritarch Assemblage 1 (*Peteinosphaeridium-Baltisphaeridium* Assemblage)□This assemblage occured in the lower part of Tumuxiuke Formation. Charateristic representatives of the assemblage are as following: *Peteinosphaeridium trifurcatum breviradiatum* (Eisenack) Eisenack, *Baltisphaeridium breviciliatum* (Staplin), *B. microspinosum* (Eisenack), *Leiosphaeridia tenuissima* Eisenack, ect. Late Llanvirnian conodont *Eoplacognathus suecicus* has been discovered in the lower part of the Tumuxiuke Formation. That indicated the Late Llanvirn age for the Assemblage 1.

Acritarch Assemblage 2 (*Baltisphaerosum-Dichotisphaera* Assemblage)□Acritarchs of this assemblage have been reported from the lower part of the Qilang Formation, Daxikumu Formation and the upper part of the Tumuxiuke Formation. The dominating spicies are *Baltisphaerosum dispar* Turner, *B. bystrentos* (Loeblich and Tappan) Turner, *B. onniense* Turner, *Dichotisphaera caracocensis* Turner. Other taxa occurred are *Excultibracium okigocladatum* Turner, *Baltisphaeridium granosum* Kjellstrom, *B. hirsutoides* (Eisenack), *Goniospaheridium connectum* Kjellstrom, *Leiosphaeridia granulata* (Eisenack). The Assemblage 2 is early-middle Caradoc in age.

Acritarch Assemblage 3 (*Navifusa-Ordovicidium* Assemblage)□In the Tarim Basin, this assemblage occurred in upper part of Qilang Formation, middle to upper part of the Daxikumu Formation, upper part of the Charchaq Group. It includes mainly *Ordovicidium asperrum* (Kjellstrom), *O. nudum* (Eisenack), *Navifusa indianensis* Loeblich and Tappan, *N. punctata* Loeblich, with the association of *Veryhachium stelligerum* Deunff, *Dactulofusa cabottii* (Cramer), According to the acritarchs and other fossil data, the age of this assemblage was dated as late Caradocian.

Acritarch Assemblage 4 (*Dactylofusa-Leiosphaeridia* Assemblage)□This assemblage is set up by the matearials from the upper part of the Charchaq Group, the lower part of the Kalpintake Formation. Acritarchs in this assemblage is very rare, with abundent *Dactylofusa cabottii* and some *Leiosphaeridia laevigata* .Well preserved cryptospores like *Tetrahedraletes medinensis*, *Velatitetras laevigata* Burgess, *Dyadospora murusattenuata*, *Pseudodyadospora laevigata* Johnson and *Segestreapora rugosa* (Johnson). Accordiong to the associated trilobites, conodonts and chitinozoas, this assamblage is dated as Ashgillian.

Palaeoenvironment: Ordovician acritarchs from Tarim are the Sphaeromorphs, Herkomorph, Polygonomorphs and Netromorph. The most rich are the Acnthomorphs, represented by *Baltispahaeridium*, *Baltisphaerosum*, *Micrhystridium*, *Multiplicisphaeridium*, *Ordovicidium*, *Peteinosphaeridium*, *Tylotopalla*, *Excultibrachium*, *Gorgonisphaeridium*, *Pheoclosterium*. The acritarch assemblages 1, 2 and 3, the composition of the acritarchs aredominated by acanthomorphs. The Assemblage 4, however, only yields sphaeromorphs and *Dactylofusa cabottii*, and cryptospores, without any acanthomorphs occurrence. Gray and Boucot argued that

Dactylofusa cabottii may be euglenoid which s fresh-water algae, and the cryptospores have been thought to be terrestrial plant origin. Combined with the sedimentory dada, the assemblages 1, 2, and 3 are the shelf to slope facies, while the assemblage 4 is littoral facies or terrestrial facied enviroment.

Chitinozoan biostratigraphy and paleogeography of the Lower Paleozoic strata in Kuh-e-Boghou, Southwest of Kashmar city, Central Iran

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The Lower Paleozoic strata (Ordovician-Silurian) are well-exposed in Kuh-e-Boghou southwest of Kashmar city. The Lower Paleozoic sequence is 2200 m. thick and in ascending stratigraphical order, it has been divided into the Shirgesht (700m.), Ghelli (500m.) and Niur (1000m.) formations.

The Ordovician sediments consist of the Shirgesht (Tremodoc-Arenig) and Ghelli (Llanvirnian-Ashgillian) formations, but the Niur Formation is related to the Silurian. 150 surface samples were selected from the uppermost part of Ghelli Formation and the whole Niur Formation in order to identify the Chitinozoan taxa. Extensive transmitted and electron microscopic examination were carried out on the productive samples. A total of 30 Chitinozoan taxa were identified in this study, consisting of Plectochitina paraguayensis, Plectochitina pseudoagglutinans, Plectochitina saharica, Plectochitina aff nodifera, Plectochitina raphli, Angochitina longicollis, Cyathochitina campanulaeformis, Ancyrochitina convexa, Ancyrochitina vikiensis, Cyathochitina kuckersiana, Conochitina alargata, Angochitina macclarei, Acanthochitina barbata, Tanuchitina ontariensis, Tanuchitina fistulosa, Spinachitina bulmani, Ancyrochitina merga, Ancyrochitina persica, Plectochitina sylvanica, Sphaerochitina baltica, Jenkinochitina lepta, Calpichitina lenticularis, Armorichitina iranica, Armorichitina nigerica and Desmochitina minor.

The critical chitinozoan species of the uppermost Ghelli Formation consist of Plectochitina sylvanica, Armoricochitina nigerica and Ancyrochitina merga, suggesting the Late Ordovician for this part of Ghelli Formation. On the other hand, the dominant and diagnostic chitinozoan taxa of Niur Formation are Spinachitina fragilis,Plectochitina pseudoagglutinans, Conochitina alargata,Plectochitina saharica,Plectochitina nodifera, Angochitina macclarei and Angochitina longicollis, indicating the Early Silurian for this formation. The encountered Ordovician and Silurian chitinozoan taxa of the Niur and Ghelli formations were compared with those of other parts of the world. This comparison reveals broad similarity with those of Algeria, Libya, Morocco, Spain, Florida as well as southern and northern Iran. This similarity suggests that all parts of Iranian platform have formed a union continent, relating to the North Gondwana domain.

Palaeophytogeography of Ordovician beds by palynological studies through North Iran

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Regarding to appearance and aboundance of palaeophytogeographycal index Phytoplankton such as: *Vulcanisphara, Saharidia, Goniosphaeridium, Straitoteca, Corphydium, Arbuscludium*, that could be observed in most of 15 Ordovician section (7 section studied by auther) in North Iran, this area is belonged to Gondwana(or pri-Gondwana) in high latitude and pri-glatial regions in southern hemisphere at that time.

It seems that upper Ordovican to Carboniferous from east toward west were eroded by tectonic phases.

Diversity patterns of Ordovician microphytoplankton in the light of Self Organized Criticality

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In this paper I present an updated Ordovician acritarch diversity curve, including rates of originations and extinctions, for the peri-Gondwana palaeobioprovince, and discuss its palaeobiological meaning. The diversity curve is plotted on the recently proposed Ordovician Chronostratigraphic Chart by the IGCP 410 clade teams, and is tightly correlated to the standard chitinozoan north Gondwana biozonation. It results principally from the direct investigation of more than 500 samples from numerous „northern Gondwanan" localities, and secondarily from a thorough and critical literature survey.

Standard, classic interpretations of Proterozoic to Palaeozoic marine microphytoplankton diversity patterns emphasize the role of external causes on patterns of originations/extinctions, and tend to find „ad hoc" explanations in search for cause-effect relationships. For example, the Llanvirn diversity peak is often causally associated with an increase in continental shelf environment, putatively more favourable to increased microphytoplankton diversity. Marine transgressions are generally believed to promote diversity increase among the acritarchs, and the opposite is assumed for regressions. Glaciations are also often associated to extinction events. However, such 'regular' relationships are not as evident as it is normally considered. Catastrophic causes such as bolide impacts, have been invoked to explain inferred – but not adequately documented – mass extinction events among the acritarchs at the Ordovician – Silurian transition (Colbath, 1986). The role of changing oceanographic conditions on acritarch diversity is equally difficult to evaluate because of the highly hypothetical available models of Ordovician oceanography.

I test the hypothesis that patterns of Ordovician acritarch diversity may be explained in terms of complex dynamics and that the fossil record of marine microphytoplankton reflect the evolution of a highly connected natural system which has reached a state of Self-Organized Criticality (SOC). In this way, diversity fluctuations reflect mainly a spontaneous generation of patterns with little or no external control. The quasi-linear power-law distributions of extintion/origination events and of species life-spans of Ordovician acritarchs found in the present study appear as supportive of such an hypothesis.

Although still highly speculative, the SOC hypothesis would explain some peculiarities which characterize the fossil record of aritarchs, such as the decoupling between acritarch and marine invertebrate Phanerozoic diversity records (Strother, 1996), the „insensitivity" of the acritarchs to widespread mass extinction events (e.g., end-Ordovician, end-Devonian, end-Permian), and the up to now enigmatic „Carboniferous phytoplankton blackout" for which no satisfactory cause has ever been found.

COLBATH, G.K. 1986. Abrupt terminal Ordovician extinction in phytoplankton associations, southern Appalachians. **Geology** 14: 943-946.

STROTHER, P.K., MACRAE, R.A., FRICKER, A., FENSOME, R.A. & WILLIAMS, G.L. 1996. Phanerozoic phytoplankton diversity is decoupled from marine invertebrate diversity. **Ninth International Palynological Congress Program and Abstracts**, Houston, Texas, p. 152.

New evidence for the nature of the earliest land plants

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Until recently the earliest generally accepted evidence for land plants was dispersed spore assemblages that are first reported from the Llanvirn (Mid Ordovician). It is not until some 40 million years later, from the Wenlock (Late Silurian), that the earliest land plant megafossils occur. Evidence that the Mid Ordovician-Early Silurian spores derive from land plants are: (i) morphological similarities with the spores of land plants, particularly the similarity between the envelope-enclosed permanent tetrads and spores of certain extant liverworts; (ii) the distribution of the spores, that occur in terrestrial deposits, and when found in marine deposits, tend to diminish in abundance offshore; (iii) wall ultrastructure in certain of the spore morphologies that resembles that in extant liverworts; (iv) the occurrence of some of the spore morphologies *in situ* in Late Silurian-Early Devonian plants that have bryophytic characteristics.

However, the Mid Ordovician-Early Silurian spores provide little information regarding the nature of their producers. Phylogenetic analysis of extant land plants suggests that either the liverworts or hornworts are the earliest divergent land plants, with a moss + vascular plant clade appearing sometime later. Thus we might expect the earliest land plants to exhibit liverwort and/or hornwort characteristics. Indeed, the fossil spores do provide some evidence that they have liverwort affinities (see above).

Recently (Wellman *et al.* 2003) top sieving during routine palynological processing of Caradoc (Ordovician) deposits from Oman has produced relatively large fragments of the plants that produced the early spores. These consist of spore masses and fragments of sporangia, and provide the first tantalizing evidence for the nature of the producers. The fossils confirm that the early dispersed spores, that are reputed to derive from land plants, did indeed form in vast numbers in sporangia. The fossil sporangia are miniscule, but are of similar dimensions to those produced by extant bryophytes, and we may envisage a flora consisting of diminutive bryophyte-like plants. TEM analysis of wall ultrastructure in spores contained within the sporangia show that the wall is composed of a series of continuous, parallel and concentric lamellae. Such an arrangement is similar to that in extant liverworts, suggesting that these early land plants may have had liverwort affinities.

Fossils of dispersed sheets of cuticle and tubular structures with internal annular/spiral thickenings have featured prominently in research into the earliest land plants. However, such fossils have not been reliably reported prior to the Ashgill (Late Ordovician), and are unlikely to be related to the older spore-producers. Rather, they probably derived from the enigmatic nematophytes, that evolved sometime later.

WELLMAN, C. H., OSTERLOFF, P. L. & MOHIUDDIN, U. 2003. Fragments of the earliest land plants. **Nature** 425, 282-285.

Initial systematics of Cryptospores from the Middle Cambrian Conasauga group, Eastern Tennessee, US

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The Middle Cambrian Conasauga Group contains a rich palynoflora based on recovery from 3 subsurface cores taken on the grounds of the Oak Ridge National Laboratory, Oak Ridge Tennessee, US. The Joy-2 core spans the entire Middle Cambrian and includes underlying Lower Cambrian Rome Fm and the overlying Nolichucky Sh, which is considered to be of Late Cambrian age. Many of the sporomorphs are of indistinct somewhat spherical in shape, some are preserved in polyads, but most occur in discrete sets of two and four cells. Some samples contain a small fraction of very small, < 12 µm, "*Michryrstridium/Asteridium*"-type acritarchs. Their presence has been useful in demonstrating that these Cambrian cryptospores are quite distinct morphologically from the acritarchs.

There are several new distinct morphotypes contained in the core. One is a paired dyad, characterized by two isomorphic dyads that are loosely attached, forming a planar tetrad arrangement. There is a range of dyads that conforms to the generic description for *Abditusdyadus laevigatus* Wellman & Richardson. Another new form is a small tetrad that lacks clefts between the spores and appears more like a single sell that has a four-fold internal partitioning. Other tetrads are more irregular in their arrangement, being more like *Rimosotetras* Burgess in having somewhat loose attachment. Some monads can be placed into *Laevolancis* Burgess & Richardson. *Sphaerasaccus* Steemans et al., an envelope-enclosed monad, occurs in the Pumpkin Valley Shale.

The morphology of these Cambrian species is being carefully checked with Silurian and Ordovician reference samples to insure that the range of morphologies seen in the Cambrian material overlaps with younger taxa. Some important cryptospore genera are so broadly defined, however, that species-level distinctions become increasingly important in understanding fundamental changes in the evolution and diversity of this group of palynomorphs. The possibility that plants at an embryophyte grade existed in the Middle Cambrian is now

becoming exceedingly likely, which makes the almost complete lack of a mesophtye record below the Homerian (middle Silurian) even more of a mystery.

An acritarch and prasinophyte assemblage from the Upper Ordovician Sylvan Shale, southern Oklahoma, U.S.A.: biostratigraphic and paleogeographic significance

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An abundant, diverse, and well-preserved acritarch and prasinophyte palynoflora was recovered from a quarry section of the Upper Ordovician Sylvan Shale in the Arbuckle Mountains region of southern Oklahoma. Based on graptolite and conodont evidence, the Sylvan Shale is assigned to the North American Richmondian stage, which is correlative with part of the international British -Ashgill. The palynoflora consists of 40 species (several new) of acritarchs assigned to 23 genera, together with two species (one new) of prasinophytes assigned to two genera. The Sylvan Shale palynoflora is dominated by acritarchs, with the two prasinophyte taxa comprising only a small percentage of the assemblage. The baltisphaerids are especially prominent and include *Baltisphaeridium adiastaltum*, *B. aliquigranulum*, *B. curtatum*, and *B. perclarum*. Other persistent, though less plentiful taxa are *Cheleutochroa* sp., *Dorsennidium hamii*, *Lophosphaeridium* sp., *Multiplicisphaeridium bifurcatum*, *M. irregulare*, *Orthosphaeridium insculptum*, *O. irregulare*, *Peteinosphaeridium septuosum*, *Polygonium gracile*, *Veryhachium oklahomense*, and representatives of the *V. trispinosum* "complex" and the prasinophyte *Leiosphaeridia*.

The Sylvan Shale palynoflora has almost 50% and 30% of its species in common, respectively, with the age-equivalent Maquoketa Shale of Missouri and Kansas and the Vauréal Formation of Anticosti Island, Québec, Canada. Hence, the assemblage has potential for precise biostratigraphic correlation within Richmondian (upper Cincinnatian) successions of Laurentia. Furthermore, various taxa (including, but not limited to, *Baltisphaeridium perclarum*, *Dorsenidium hamii*, *Multiplicisphaeridium bifurcatum*, *M. irregulare*, *Orthosphaeridium insculptum*, *O. rectangulare*, and *Villosacapsula setosapellicula*) from these formations have been reported from middle to high latitude Ashgill localities in Baltica and Peri-Gondwana. The widespread occurrence of many of the acritarch and prasinophyte taxa from these three Upper Ordovician Laurentian formations supports the view that regional differentiation of marine microphytoplankton -assemblages was much less pronounced during the Late Ordovician than earlier in the period.

Paleontologic and sedimentologic evidence indicates that the Sylvan Shale was deposited in a warm, subtidal, low-energy, offshore marine environment having limited circulation, and thus anoxic bottom conditions. The composition of the acritarch and prasinophyte assemblage corroborates this assessment and correlates with models of offshore, open-marine microphytoplankton associations previously proposed by various authors.

Acritarch and chitinozoan evidence of Palaeozoic marine productivity

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The abundance of preserved phytoplankton in sedimentary sequences, including acritarchs and prasinophycean algae, provides a comprehensive record of the productivity of the Palaeozoic oceans and shelf seas. As in the present day marine realm, the phytoplankton assemblages have a distribution related to water masses within shelf seas and open oceans, which in turn are arranged in broad climatic belts related to latitude. The chitinozoans also show significant differences between shelf and deep water areas, but their distribution is more difficult to relate to patterns of marine productivity.

Within the phytoplankton record, the most frequently recorded assemblages are low abundance, low diversity assemblages characteristic of the open oceans; moderate abundance, moderate to high diversity assemblages characteristic of shelf seas and high abundance and low diversity, low to high abundance assemblages recorded in some inshore areas with highly variable nutrient availability. Areas of apparent low salinity generally show lower diversity phytoplankton assemblages and an absence of chitinozoans.

By examining the relative abundance of acritarchs and prasinophycean algal species, many forms appear to be associated with particular palaeoenvironments. The prasinophycean algal genera *Cymatiosphaera* and *Pterspermella* are widely distributed in oceanic and shelf areas, and may become relatively abundant in assemblages preserved in anoxic sediment water interface conditions. Species of *Micrhystridium* and *Veryhachium* are regularly recorded in shelf sediments from the Cambrian to early Carboniferous. Acritarchs of moderate size, including *Baltisphaeridium*, *Cymatiogalea* and *Pteinosphaeridium* in the Ordovician, and *Cymbosphaeridium*, *Diexallophasis* and *Visbysphaera* in the Silurian to Devonian are a characteristic component of marine shelf assemblages. Within tropical shelf seas, the distribution of some acritarchs can be related to nearshore to offshore trends, as well some associated with reef sediments, as demonstrated by STAPLIN 1961, DORNING 1981 and DORNING & BELL 1987. Though almost all acritarchs are apparently marine, forms including *Moyeria*, and some species of *Leiosphaeridia* and *Lophosphaeridium* have a distribution that suggest a fluvial, lacustrine or terrestrial origin. Some large acritarch species in the late Ordovician and Silurian appear to be restricted to tropical areas, including *Estiastra*, *Hogklintia* and *Pulvinosphaeridium*. Detailed studies of Palaeozoic marine sequences with apparent continuous deposition show a remarkable consistency in the acritarch assemblages over durations of hundreds to thousands of years, as noted for the Wenlock by DORNING & HARVEY 1999. Longer term changes in the phytoplankton assemblages can be related to cyclic patterns in nutrient availability that may be linked to temperature and/or wet to dry climate variability.

DORNING, K.J. 1981. Silurian acritarch distribution in the Ludlovian shelf sea of South Wales and the Welsh Borderland. In: J.W. NEALE & M.D. BRASIER (eds.) Microfossils from Recent and Fossil Shelf Seas, pp. 31-36. Ellis Horwood, Chichester.

DORNING, K.J. & BELL, D.G. 1987. The Silurian carbonate shelf microflora: acritarch distribution in the Much Wenlock Limestone Formation. In: M.B. HART (ed.) Micropalaeontology of carbonate environments, pp. 266-287. Ellis Horwood, Chichester.

DORNING, K.J. & HARVEY, C. 1999. Wenlock cyclicity, palynology, and stratigraphy in the Buildwas, Coalbrookdale, and Much Wenlock Limestone formations, Shropshire, England. Bollettino della Societa Paleontologica Italiana 38: 155-166.

STAPLIN, F.L. 1961. Reef-controlled distribution of Devonian microplankton in Alberta. **Palaeontology** 4: 392-424.

General patterns in the temporal and spatial distribution of Late Silurian acritarchs of Gotland

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One of the largest isotope excursion of the Phanerozoic is so far recorded in the Silurian sediments of Gotland (Baltic Sea, Sweden). In these sediments, the stratigraphical succession is characterised by limestone-marl alternations, in which values of C and O stable isotopes show their maximum in the Late Ludfordian. The isotope excursions in the Silurian have been previously attributed to climate changes between humid and arid periods. To better understand the phytoplankton (acritarch) distribution around the Ludlow isotope excursion the palynological content has been observed in great detail, following one vertical profile and two isochrone transects from the lower Gorstian humid period to the upper Ludfordian arid period. Our results indicate a generic content with distinguished patterns of temporal distribution. Some genera are restricted to the time interval situated before the isotope excursion (humid period), while other taxa show higher abundances during the isotope excursion in the upper Ludfordian interval. The infrageneric composition of abundant acritarch genera is also analysed and shows similar results with high abundances of complex morphologies in the humid time interval and less ornamentated morphotypes in the upper Ludfordian arid period. Additionally, the acritarch distribution of the isochrone transects have been analysed. Our results indicate that the phytoplankton distribution can be related to different ocean circulation models, and possibly to climate changes.

Patterns in Ordovician chitinozoan biodiversity

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Ordovician chitinozoan biodiversity curves are established for three major terranes: Laurentia, Baltica and North Gondwana on the base of a dataset of more than 7000 productive samples (Paris et al. 2004). Despite the bias introduced by the number of considered samples and their spatial and temporal distribution, the curves and their related parameters (normal total diversity, origination and extinction rates and turnover ratios) allow to document the changes undergone by chitinozoan microfaunas at low, intermediate and high latitudes during the Ordovician.

The variation of latitudinal setting is primarily reflected by the distinctiveness of the three regional biozonations. Data show that Ordovician chitinozoan diversity is moderate in all three regions, although it is higher in low-latitude (Laurentia) than in high-latitude (Gondwana). Conversely, the productivity is greater in North Gondwana, than in Laurentia.

The regional curves and the composite curve clearly show an Early to Middle Ordovician chitinozoan radiation. They also show a pulse in the diversification and origination rate in the Darriwilian, as well as a progressive decrease in chitinozoan diversity during the Late Ordovician, with the minimum attained during the Late Ordovician (Hirnantian) glaciation. These patterns can be related to the highstand and lowstand events identified by Nielsen (2004) in comparing North American and Baltoscandian sea level curves.

Some events depicted by the diversity curves seem also to be related to paleolatitudes. For example, the first occurrence of chitinozoans in North Gondwana has been recorded in the lower Tremadoc, while in Laurentia it has been reported from the upper Tremadoc. Maximum diversity occurs in the upper Darriwilian in North Gondwana, whereas in Baltica it spans the upper Darriwilian-lower Caradoc interval; it peaks in the upper Caradoc in Laurentia. On the other hand, the decrease in diversity seems to have begun earlier in Laurentia than in Baltica and North Gondwana.

Because of their pelagic mode of life, chitinozoans are usually associated with graptolites, but no obvious paleolatitudinal diversity has been noted among graptolites (Cooper et al., 2004). As for diversification, the chitinozoan maximum diversity occurs during the Darriwilian or the Late Ordovician, whereas graptolite diversity is at a maximum in the Early Arenig in Australasia and in the late Arenig early Caradoc interval in Britain.

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NIELSEN A., J. 2004. Ordovician sea level changes–a Baltoscandian perspective. In: B.D. WEBBY, M.L.DROSER, F. PARIS & I. PERCIVAL (eds).**The Great Ordovician Diversification Event**. Columbia University Press.

PARIS, F., ACHAB, A. ASSELIN, E., NOLVAK, J., WANG, X.F. CHEN X.-H., GRAHN, Y., SENNIKOV, N., OBUT, O., SAMUELSSON, J., VECOLI, M., VERNIERS, J. & WINCHESTER- SEETO T. 2004. Chitinozoa. In: B.D. WEBBY, M.L.DROSER, F. PARIS & I. PERCIVAL (eds).**The Great Ordovician Diversification Event**. Columbia University Press.

Palynostratigraphy of the Ordovician in western Shahrud city (Deh Molla area) northeastern Alborz Range (between western and central Alborz Range) of Iran

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The sedimentary Ordovician sequence has a thickness of 530m. and it is well-developed and exposed in Deh-Molla area, approximately 25 km. western Shahrud city. The sequence is divided in ascending stratigraphical order into the Lashkarak and Ghelli formations. These rock units consist of dark shale, siltstone and fine-grained sandstone with abundant trace fossils in some horizons

Thje Lashkarak Formation has a thickness of 156m. and conformably rests on the Mila Formation (Middle-Late Cambrian). The Ghelli Formation is 374m thick and it is disconfomably overlain by the Geirud Formation (Late Devonian). 200 surface samples were selected and treated for palynomorphs entities.The encountered well-known acritarchs of this study are:

Vulcanisphaera africana, Vulcanisphaera cirrita, Saharidia spp., Dactylofusa squama ,Cymatiogalea spp., Stellifredium spp., Coryphidium bohemicum, Coryphidium spp., Athabascaella spp., Arbusculidium filamentosum, Striatotheca sp., Veryhachium subglobosum, Navifusa ancepsipuncta, Ordovicidium elegantulum, Orthosphaeridium ternatum, Poikilofusa spinata, Orthosphaeridium insculptum, Orthosphaeridium inflatum, Diexallophasis denticulatum and so on.

The above-mentioned acritarch taxa have arranged in five local stratigraphical zones, suggesting the Early Ordovician (Tremodoc-Arenig) for the Lashkarak Formation and the Late Ordovician (Caradoc-Ashgil) for the Ghelli Formation. Therefore, based on the encountered acritarch species the Silurian strata and Early and Middle Devonian deposits are not present in this part of Alborz Mountain Ranges, corresponding to the Caledonian Orogeny. On the other hand, comparison of the known acritarch taxa of the Ghelli and Lashkarak formations with those of other parts of the world indicate broad similarity with those of Southern Europe, North Africa,, Southwestern China and Southern and Central Iran. This similarity suggests that the all part of Iranian platform have formed a union continent and it was a part of peri-Gondwanan paleocontinent during the Ordovician period.

Upper Ordovician chitinozoan biostratigraphy in the U.K. Towards an Avalonian biozonation ?

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During the last years, several Upper Ordovician key sections and areas on the Avalonia palaeocontinent were studied for chitinozoans. Probably one of the most important amongst these is the type area of the Ashgill in the Cautley District, Northern England. This section yields diverse assemblages of chitinozoans from at least six chitinozoan biozones (from bottom to top): the *Fungochitinina fungiformis*, *Tanuchitina bergstroemi*, *Conochitina rugata* (three Baltoscandian biozones), *Spinachitina fossensis*, *Bursachitina* sp. 1 n. sp. (two typical Avalonian biozones) and the *Belonechitina postrobusta* Zone (a global lower Silurian biozone). In addition, a distinctive *Ancyrochitina merga* level can be observed, a typical biozone of the upper Rawtheyan of Northern Gondwana. All biozones are well correlated with the graptolite (RICKARDS 2002) and shelly fauna (INGHAM 1966) biozones from the region. These results were already presented (VANDENBROUCKE *et al.* 2003). Additional data from other sections are now available and allow the recognition of this new biozonation across the U.K. (see below) and in other parts of Avalonia (Condroz Inlier, VANMEIRHAEGHE, this volume).

A Caradoc succession between Fishgard and Cardigan (south west Wales) has potential to be well correlated with the lower stratigraphical levels in the type Ashgill area, according to preliminary chitinozoan results from 17 samples, the top ones tentatively assigned to the *?Fungochitinina fungiformis* and *Tanuchitina bergstroemi* zones. The samples were taken from graptolite slabs, collected during a recent BGS mapping project in the area (WILLIAMS *et al.* 2003), so the chitinozoan results will be tightly correlated with the graptolite data (*multidens*, *clingani* and *linearis* zones). The same correlation potential with the type Ashgill area goes for the Greenscoe section in the Lake District (northern England three test samples), although the latter section yielded no graptolites, but conodonts from the *superbus* zone (SMITH 1999). In addition, first results from samples from the Pus Gill (northern England, Cross Fell Inlier) and Whitland (south Wales) sections will be discussed. As more data become available from these Caradoc and Ashgill sections, the establishment of a biozonation with chitinozoans for the British part of Avalonia seems obvious, which will of course be a further contribution to a final Upper Ordovician Avalonian chitinozoan biozonation.

Secondly, an attempt will be made to correlate with the Chinese Wangjiawan Section, one of the candidates for the Global Stratotype Section and Point (GSSP) for the base of the Hirnantian Stage of the Upper Ordovician Series at the time of writing. However, the first test samples for chitinozoans are yielding poor results.

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Upper Ordovician chitinozoans from the central part of the Condroz Inlier (Belgium, Avalonia)

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The Condroz Inlier is a narrow strip of Ordovician and Silurian rocks, ranging from Charleroi to Huy. In the Upper Ordovician, the sediments of the Condroz Inlier were deposited on a shelf. The Caradoc Vitrival-Bruyère Formation consists of dark mudstone with intercalated sandstone beds. We also observed several matrix-supported and pebble-supported conglomeratic levels. A supposed hiatus is situated between the Vitrival-Bruyère Formation and the overlying Fosses Formation (Ashgill), which contains fossiliferous calcareous shale and limestone beds in the lower part and mottled mudstone in the upper part. The lower part is often referred to as the Bois de Presles Member and the upper part the Faulx-les-Tombes Member (see Vanmeirhaeghe and Verniers, in press).

The chitinozoans of these upper Ordovician formations are studied from more than thirty samples. In the Vitrival-Bruyère Formation, *Spinachitina bulmani*, *Belonechitina robusta*?, *Desmochitina minor*, *Desmochitina erinacea*, *Desmochitina nodosa*, *Desmochitina amphorea*?, *Desmochitina juglandiformis*? *Spinachitina cervicornis* and *Cyathochitina* spp. occur, amongst other species. In the type locality of this formation, the *Climacograptus peltifer* graptolite Biozone was found (now equivalent to the *Diplograptus foliacus* Biozone). A study of the chitinozoans in this section revealed the presence of *Cyathochitina calix* and *Laufeldochitina stentor* (Herbosch *et al.*, 2002). Apparently, the part of the Vitrival-Bruyère Formation investigated in this study is younger than the part in the type section, as *Spinachitina cervicornis* is an index species for the Johvi to Oandu Stage in Baltica.

In the uppermost part of the Vitrival Bruyère Formation, the first specimens of *Lagenochitina baltica* occur. In Baltica, *Lagenochitina baltica* ranges from the late Oandu until the early Pirgu.

In the calcareous part of the Fosses Formation, the Bois de Presles Member, *Lagenochitina baltica* is present together with *Lagenochitina prussica*. *Desmochitina* spp., *Belonechitina* spp. and *Spinachitina* spp. co-occur. Higher in this part of the formation, *Tanuchitina* sp., possibly *Tanuchitina bergstroemi* occurs. One sample also contains *Conochitina rugata*.

The upper part of the Fosses Formation, the Faulx-les-Tombes Member, bears *Tanuchitina bergstroemi*, *Conochitina rugata* and *Bursachitina* sp.1. *Tanuchitina bergstroemi* is an index species in Baltica and indicates a late Vormsi to early Pirgu age (latest Caradoc–earliest Ashgill) (Nõlvak and Grahn, 1993); *Conochitina rugata* is indicative for the Pirgu (mid to late Ashgill) in Baltica. The latter two species were also found in the type Ashgill area, *Tanuchitina bergstroemi* in the upper Cautlayan-lower Rawtheyan and *Conochitina* *rugata* higher in the lower Rawtheyan stage (Vandenbroucke *et al.*, 2003; in prep.). *Bursachitina* sp. 1 was also recovered from the type Ashgill area, in the upper Rawtheyan.

Surprisingly, the biozones encountered in the mottled mudstone of the Faulx-les-Tombes Member in Faulx-les-Tombes were found in the calcareous part of the Fosses Formation, the Bois de Presles Member in the Puagne Inlier, southwestern part of the Condroz Inlier (Vanmeirhaeghe and Verniers, in press). This indicates a distinct facies change within the shelf between these two localities, nowadays separated only 30 km from each other.

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Chitinozoan biozonation around the Ordovician-Silurian boundary: comparison of the GSSP at Dob's Linn (Scotland, U.K.) with the graptolite dated Lönstorp core (Scania, Sweden)

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A detailed logging and sampling for chitinozoans was undertaken in 2002 and 2003 in the GSSP of the Ordovician-Silurian boundary, at Dob's Linn (Scotland, U.K.). To measure the exact stratigraphical position of the samples and to draw the detailed 10.5 m thick stratigraphical log, many bentonite beds, pyrite rich levels and some fine siltstone beds were used as marker beds (VERNIERS, et al. 2003). The graptolite biozonation of this section was defined by Williams and Ingham (1989) and was recently revised by Melchin (2001, 2003), who recognised the *persculptus*, *ascensus*, *acuminatus* and *vesiculosus* biozones. The position of the GSSP had not to be changed after the revision of the graptolite fauna and is fixed at 1.60 m above the base of the Birkhill Formation. The chitinozoan assemblages extracted from the nearly forty samples contain poorly preserved and moderately diversified chitinozoans, allowing however a biozonation, which is accurately calibrated versus the GSSP and also versus the graptolite biozonation.

To calibrate more exactly the chitinozoan biozonation versus the graptolite biozonation around the Ordovician-Silurian boundary, another chitinozoan study was undertaken in a borehole in Scania (Sweden). Recently a detailed and well documented graptolite biozonation could be established in two boreholes in that part of Baltica (KOREN *et al.* 2003). They could even recognise a new latest Ordovician (Hirnantian) post-*persculptus* and pre-*ascensus* biozone. The Lönstorp borehole was also studied by KOREN *et al.* 2003 and is sampled by us for chitinozoans. The interval under interest is between 60 to 77.3 m depth, with the Ordovician-Silurian boundary at -74.9m; They comprise the *vesiculosus* zone (60 to 69.7m), the *acuminatus* zone (69.7 - 74.3m), the *ascensus* zone (74.3-74.9m), the *minor/avitus s.s.* zone (lacking *persculptus*) (74.9-76.5m), and the *persculptus s.s.* zone (76.5-77.3m). The results of the chitinozoan study in about thirty samples in this interval will be presented.

The chitinozoan biozonation from both areas will be compared with chitinozoan studies from nearby boreholes in Scania (o.a. GRAHN, 1978) and from Avalonia, Bohemia, northern Gondwana and north, central and east Laurentia.

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Chitinozoan biostratigraphy of the basal Wenlock Series (Silurian) Global Stratotype Section and Point

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Diverse and abundant assemblages of chitinozoans allow the recognition of the upper part of the *Margachitina margaritana* Biozone in the uppermost Llandovery and lowermost Wenlock series of the Hughley Brook section, Much Wenlock, Shropshire, UK. A new species of *Pterochitina* is described from the level immediately above the base of the Wenlock Series and this taxon may prove to be useful in recognizing the boundary elsewhere. The *Cingulochitina bouniensis* and *Salopochitina bella* biozones are identified in the lower part of the Buildwas Formation, Wenlock Series. The chitinozoan data indicate that the base of Wenlock Series most probably correlates with a level in the upper *centrifugus* or lower *murchisoni* graptolite biozones. Chitinozoans also indicate that the base of the *riccartonensis* graptolite Biozone may occur within the Buildwas Formation and not the overlying Coalbrookdale Formation.

Chitinozoans and acritarchs of the Famatina System, northwestern Argentina: an Ordovician peri-Gondwanan volcanic arc

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Overlying fine-rained siliciclastic Neoproterozoic to Cambrian sediments deposited on a passive continental margin, the Lower Ordovician Famatina Group is interpreted as an active, subduction-related volcanic-arc on the western Gondwana margin (Astini, 1999). The sedimentary record of this complex terrane was controlled by the combined action of volcanism, tectonism and sea level changes. The sedimentary record, represented by the lower Arenig Suri Formation and the succeeding upper Arenig to Llanvirn Molles Formation, shows an increase in volcanic activity.

Conodonts from the Suri and Molles formations belong to the middle Arenig *Oepikodus evae* Zone (Albanesi & Astini 2000); this age has recently been confirmed by the acritarchs (Rubinstein 2004). Acritarchs from the Suri Formation include *Arbusculidium filamentosum*, *Striatotheca* sp., *Eisenackidium orientalis*, *Dactylofusa velifera* forma *brevis* and *Stelomorpha* sp. This assemblage is similar to that of coeval deposits in the Cordillera Oriental and Sierras Subandinas, although it should be noted that a notable increase in peteinoid acritarchs, as well as in representatives of *Rhopaliophora*, suggests peri-Gondwanan affinities, a suggestion confirmed by the chitinozoan microfauna. The chitinozoan assemblages of the Suri Formation are characterised by species of *Eremochina* and *Velatachitina*. These are typical "Saharan" genera of the Gondwanan chitinozoan zonation. The presence of a species similar to *Desmochitina ornensis*, a species reported only from the Arenig of Armorican Massif and Portugal (Paris 1981), confirms the Gondwanan character of the microfauna. Several specimens figured by Ottone et al. (1992, Pl. 5, fig.1,3,6) also suggest a comparison with the Acoite Formation of the Eastern Cordillera.

A drastic change in acritarch and chitinozoan assemblage composition takes place in the Molles Formation. Characteristic elements of the cold water, peri-Gondwana Acritarch Realm completely disappear, and taxa such as *Baltisphaeridium*, *Rhopaliophora*, *Tongzia*, *Peteinosphaeridiun* and other peteinoids typical of intermediate to low latitudes related to South China, Australia and Baltica become predominant (Rubinstein 2004). The change in chitinozoan assemblages is also marked by the disappearance of species of *Eremochina* and *Velatachitina*, the resulting microfauna being essentially composed of species of *Conochitina* and *Rhabdochitina*. The rare occurence of species related to *D. ornensis* indicates the persistence of a Gondwanan microfauna. This suggests that the changes in acritarch and chitinozoan assemblages were probably the result of local conditions caused by a stressful volcanic-arc environment. This interpretation is also supported by the conodont data (Albanesi & Astini, 2000).

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UPPER PALAEOZOIC PALYNOLOGY / CIMP SIMPOSIUM

Taxonomy Online': internet palynological database that is linked to curated specimens

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In an article in Nature last year (v. 417, p. 17-19), H. Charles Godfray of Britain's NERC Centre for Population Biology, noted how descriptive biological taxonomy suffers from a lack of prestige and resources when compared with the newer disciplines of genome databasing and phylogenetic taxonomy. He described the problematic legacy of 200 years of traditional biological systematics, whereby modern taxonomists attempt to interpret the work of their nineteenth century counterparts by trying to understand inadequate (by today's standards) published descriptions, or looking for poorly curated or even lost type material. Godfray proposed a web-based unitary 'taxonomic process', rather like a bulletin board, to make taxonomy more productive, efficient and worthy of funding.

Palaeozoic palynological taxonomy faces similar problems, particularly over the condition and curatorial status of topotype and holotype specimens. In order to remedy these, the British Geological Survey (BGS) is funding the 'Taxonomy Online' Project, which will use the internet as a forum to illustrate and describe specimens curated in its collections. The initial report and palynological database, which will represent the first 68 taxa of the 'Bernard Owens Single Mount Palynology Collection', will shortly be published and released on the web. This single grain mount collection is one of the most important palynological collections in the world with over 145 taxa represented by up to 25 specimens per taxon, showing a wide range of preservation states and natural variation. Many of the specimens are holotypes or topotypes, while other determinations have been validated by leading taxonomists. The taxa are most closely associated with Britain and NW Europe and are integral to the palynozonation of the Carboniferous of NW Europe published by Clayton et al. (1977), and to earlier regional palynozonations (e.g. Owens et al. 1977, Neves et al. (1972).

The main value of the new database is the link between description/illustration and specimen. Each specimen (contained within a unique single grain mount slide) has a unique BGS collections number, and may be borrowed for examination and photography. We anticipate that the database will grow organically with contributions by workers in the field; but all added taxa will be represented by specimens housed in single grain mounts. In this way the collection will embody the online database, and will become an invaluable resource for future students and researchers.

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Acritarch colour and thermal maturity

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Image analysis is used in this study to quantify the colour of acritarchs (fossil phytoplankton) following work on colour determinations of spores by Marshall et al. (1991). Acritarch colours are characterised in terms of the intensity of their Red, Green and Blue (RGB) components in transmitted light, with values for each colour channel ranging from 0 to 255. The image analysis system used processes images captured by a digital camera attached to a transmitted light microscope.

Colour determinations have been made on specimens from the long-ranging acritarch genera Veryhachium and 'Tasmanites' from a range of North American and Bolivian Upper Devonian samples. North American RGB data plotted against vitrinite reflectance determinations from the same samples show a good correlation, suggesting that acritarch colour may be a viable method for assessing the thermal maturity of vitrinite deficient rocks. Acritarch colour results from the Bolivian samples demonstrate that this technique can also be used effectively to recognise reworking.

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