The John Williams Index of Palaeopalynology

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The John Williams Index of Palaeopalynology (JWIP) is the result of the lifetime's work of Dr John E. Williams. Housed at the Natural History Museum (NHM) in London, the JWIP provides the most comprehensive reference catalogue on palaeopalynology in the world, with 23,350 references as of February 2012. Since its inception in 1969, every publication referring to a palynomorph genus or species has been critiqued by John E. Williams, with each publication being given an accession number and appropriately referenced within the JWIP using index cards which are sorted alphabetically. Once added to the main reference subindex, further entries are completed for three themed subindexes. These are sets of cards on four major palynomorph groups (acritarchs/dinoflagellate cysts, chitinozoa, pollen/spores and miscellaneous), 26 stratigraphical intervals and 17 geographical areas. Additionally, there is a fifth subindex in which each palynomorph taxon has a card (or cards) listing all the records of that species in the literature within six categories (acritarchs, dinoflagellate cysts, chitinozoa, fungal spores, pollen/spores and miscellaneous). Due to the sustained and meticulous recording of data since 1971, users can therefore search the database by major palynomorph group, species, age, and/or geographical region. The comprehensive and cross-referenced nature of the JWIP means that researchers can readily identify key publications on, for example, specific palynomorph types over a particular interval in a prescribed area. The JWIP is

currently entirely analog, but attempts by the NHM to evaluate potential digital catalogue options are currently taking place.

Keywords: card indexes; database; literature; palaeopalynology

1. Introduction

John E. Williams worked for British Petroleum (BP) between 1968 and 1991 and began to amass a comprehensive personal literature collection and associated card indexes on palaeopalynology. This database was constructed in order to help with palynomorph identifications during routine microscopy, and to compile key information for use in biostratigraphical interpretations. It also serves to document a rapidly expanding literature which typically grows by several hundred new articles per year (Jansonius and McGregor, 1996, fig. 1). The archive has since developed into a comprehensive, cross-referenced card index and associated personal library of palaeopalynology. Whilst the Quaternary is covered, the principal emphasis is on the pre-Quaternary. As of February 2012, the card collection comprised 23,350 references and is housed in the Department of Palaeontology of the Natural History Museum (NHM) in London. The John Williams Index of Palaeopalynology (JWIP) is available for use by all palynologists. This contribution aims to describe the collection, its history, how it has been constructed, its potential utility and how it may be developed in the future.

2. The use of card indexes and catalogues in palynology

Prior to the digital era, students of biology, palaeontology and other subject areas would frequently construct alphabetical card indexes for taxa etc. Banks of index cards were a familiar sight in science laboratories as well as, for example, libraries and doctor's surgeries (Figure 1). In science, these indexes would typically pertain to a specific research project but could also be generic. Index cards (typically 150 mm x 100 mm) would be written out, each with the essential details of the individual taxa (or similar entities) and filed in boxes alphabetically. In palynology, the species

included were those expected to be present during the course of the respective research project, or perhaps built up as additional taxa were encountered. Naturally, in recent years, card indexes have been virtually entirely superseded by digital databases.

Students of palynology used card indexes extensively before standard computer software offered more expedient and flexible databasing solutions. Typically research students would write out the diagnoses, descriptions, references, stratigraphical details etc. of each relevant species onto a card, together with photomicrographs. Other card indexes could be made up for key papers, previously-published reports etc.; the possibilities were endless! Card indexes at the time were invaluable, especially if one was asked to study a relatively unfamiliar stratigraphical interval in a far-flung region. The production of a card index helped to rapidly familiarise a palynologist with the flora, and it would be used during microscope work as an identification guide and during report writing. Many catalogue-style books on palynology such as Stover and Evitt (1978), Artzner et al. (1979) and Wilson and Clowes (1980) probably started life as card-indexes.

Some card indexes were actually published. The French micropalaeontologists Georges and Marie Deflandre published their card indexes of acritarchs, chitinozoa and dinoflagellate cysts as a series of books (e.g. Deflandre and Deflandre, 1965; 1966). On each printed page, two of the numbered cards (or *Fiches*) were reproduced. Each *Fiche* has the name, author and reference of the respective taxon, followed by geographical data, stratigraphical details and photomicrographs of the type material. The reproduction was single-sided so that these books could be easily converted into a ready-made card index. The catalogues on acritarchs and dinoflagellate cysts by the famous German researcher Alfred Eisenack and his collaborators between 1967 and 1981 were similar. However, these were far more professionally produced, and hence more widely-distributed than the *Fichier Micropaléontologique Général* produced by the Deflandres. These catalogues comprise illustrations, locations, stratigraphical details and the original descriptions; they were published between 1967 and 1981 (e.g. Eisenack, 1967). Recently, this catalogue has been revived and updated by Robert A. Fensome, Hans Gocht, Raquel Guerstein, Lew Stover and Graham Williams (e.g. Fensome et al., 1991) and the ‘new Eisenack catalog’ series has now reached five volumes.

Traverse et al. (1970) comprehensively described the development and scope of the *Catalog of fossil spores and pollen* (CFSP) (Kremp et al., 1957-1985). This is a

comprehensive species index of all pre-Quaternary pollen and spore taxa; it grew from the card index of Gerhard O.W. Kremp when he moved to Pennsylvania State University in 1955 to collaborate with William Spackman on the palynology of the coals of South Dakota. The CFSP was sponsored by individuals, industry and the US government and volume 1 was published in 1957. It was available bound in loose-leaf volumes or as index cards. Herbert Tate Ames, Gerhard O.W. Kremp, William Spackman and Alfred Traverse were the principal editors. This comprehensive series was discontinued in the 1980s and the final volume, number 44, was published in 1985; it was described by Traverse (2007, p. 35).

Jan Jansonius and Len V. Hills produced an extensive card index catalogue of fossil pollen and spore genera in 1976. The original edition of 3287 index cards was published in 1976, and several supplements were issued from 1977 onwards. Christoph Hartkopf-Fröder subsequently joined the team and has helped produce the supplements. Jansonius and Hills (1976) was extensively described and reviewed by Visscher (1980), and more recently by Traverse (2007, p. 34).

In addition to these published catalogues and catalogue-style publications, most large oil companies who employed micropalaeontologists such as Amoco in Houston and Tulsa, U.S.A., and Esso in Bordeaux, France used card/paper catalogues which were compiled by their in-house staff.

Lentin et al. (1996) reviewed the then state of the art of the digitisation of palynological data. More recently, several online catalogues have been established for example Stephenson and Owens (2006) for Carboniferous spores, Mullins et al. (2007) for acritarchs, Steemans and Breuer (2007) for pre-Mesozoic palynomorphs and Fensome et al. (2008) for dinoflagellate cysts.

3. The development of the John Williams Index of Palaeopalynology

John E. Williams studied for his PhD on the Carboniferous palynology of northern England and southern Scotland at Sheffield University, U.K. between 1965 and 1968. He no doubt saw many of his colleagues in palynology and associated disciplines making and using card indexes. Prior to the completion of his PhD however, John joined BP in 1968 and was assigned projects on stratigraphical palynology from all over the world. John continued to work on his PhD most evenings and subsequently

graduated in 1971. It was during his early years at BP when the card index began to evolve in order to fill significant gaps in knowledge. Many of his first projects at BP related to the biostratigraphical analyses of well documented regions, such as the the Permo-Triassic of the North Sea. However in 1969 John was sent to Libya for three months as a rig geologist. Due to repeated well collapse issues, slow progress was being made and this left John with very little to do. He therefore welcomed the opportunity to visit the BP office in Benghazi to review the current palynological and associated biostratigraphical literature available for the region. He was asked to create some form of order from the chaos of literature he encountered. It rapidly became evident there were serious issues with the robustness of the biostratigraphical integrity of the region at that time. Detailed analyses by John revealed substantial discrepancies within the palynological successions. These were eventually explained by the consistent contamination of the sample materials from the mud additives used in the drilling and not by incorrect identifications. Subsequently, John spent his final weeks in Libya rewriting Libyan palynology, which subsequently resulted in the development of his card index as a means to understand the unfamiliar literature and biostratigraphy.

Following this work in Libya, John decided to continue his card index and it began to incorporate literature from subsequent overseas visits, such as Jurassic to Paleogene of Alaska. The card index was eventually aimed at documenting all records of fossil (i.e. pre-Quaternary) palynomorphs worldwide. Between 1969 and 1991, John continued to add data to his index at BP. In 1991, John left BP to join the Natural History Museum (NHM) in London. He transported his personal library on palaeopalynology together with the card indexes and set them up in the museum. John retired in 1999, became a Scientific Associate at the NHM and subsequently donated the JWIP to the museum. To this day, John continues to scour the Palaeontology Library and the internet for new articles on palaeopalynology. This includes mainstream literature (i.e. scientific journals), textbooks, selected conference abstract volumes and ‘grey’ literature such as downloadable reports from the internet and MSc/PhD theses.

4. The John Williams Index of Palaeopalynology and Palynodata

The closest compilation of palynological data to the JWIP is Palynodata. This digital database of the palynological literature was conceived in 1965 by Gerhard O.W. Kremp of the University of Arizona, U.S.A. as the Kremp Palynological Computer Research Project (KPCRP). The programme commenced in 1968 with considerable financial support from the oil industry. It was taken over in 1974 by Palynodata Inc., which comprised a consortium of oil companies and scientific institutions, and sought to produce marketable software to build and search the database. The history of Palynodata was presented by K.M. Piel in Lentin et al. (1996, p. 967-968).

The aim of Palynodata was to analyse and reformat published palynological data into a digital environment so that the exponential expansion of new palynomorph taxa in the 1960s and 1970s should not result in "taxonomic chaos" experienced by other microfossil groups (Kremp and Methvin, 1968). All pertinent data excluding morphological details were compiled. Palynodata has been used in compilations such as the dinoflagellate cyst indexes (e.g. Fensome and Williams, 2004), and White and Jessop (2002) and White et al. (2009) have proposed that Palynodata records be viewed as a sample that can approximate the distributions of fossils in time and space. Gerhard O.W. Kremp published 21 volumes of *Paleo Data Banks* between 1971 and 1984 under the auspices of Palynodata. Of these volumes, 15 were compilations of references on palynological literature (e.g. Kremp, 1977).

Palynodata Inc. was dissolved in 2007 due to a downturn in sponsorship income, and the last entry was made in 2006. This database indexed 122,422 pre-Quaternary palynomorph species from 22,152 items of literature. The Geological Survey of Canada has taken over Palynodata, houses the database and makes it publically available. Palynodata is now available for free download from the Geological Survey of Canada as Open File Report 5793 (Palynodata Inc. and White, 2008). Palynodata has however not been updated with information from post-2006 literature, thus is rapidly becoming a less comprehensive database. It also uses the outdated timescale of van Eysinga (1978).

By contrast, the JWIP is still in progress and as of February 2012 includes 23,350 publications with an average of around 700 references being added every year. This figure is more than Palynodata (22,152), making the JWIP the largest palynological database in the world. Whilst Palynodata was compiled by numerous non-specialist personnel over its approximately 40 year lifespan, input to the JWIP has only ever been performed by John E. Williams himself, who is a highly

experienced palynologist who checks the precision and quality of the data before entering it. This means that the JWIP provides an accurate and consistent interpretation of the literature. The principal difference between the two databases is in their formats; the JWIP is analog and PalynoData is digital. However, in 2011, the index catalogue of the JWIP was scanned and the NHM are in the process of formatting it into a digital version.

5. How the John Williams Index of Palaeopalynology works

The John Williams Index of Palaeopalynology (JWIP) is primarily designed to be of use to the working palynologist. The main guiding principle is that it is a comprehensive library of pre-Quaternary palynology which is allied to an interlinked series of five interconnected subindexes. A flowchart of the five subindexes of the JWIP is presented as Figure 2.

To explain how the system works, it is most expedient to describe what happens to an individual paper on palaeopalynology. Upon receipt, the article is given what a librarian would term an accession number. John prefaces each of his accession numbers with a capital 'J'. The first paper in the system (i.e. J1) is Alpern (1970) and, as of February 2012, the last number assigned was J17,354. This figure is significantly lower than the 23,350 references within the JWIP, because in the 1970s, articles were bound together with a single 'J' number given to 6-10 items of literature. The J-numbered articles are then stored in John's personal library (Figure 3). Next the full bibliographical reference is entered on a card, and this is filed alphabetically; this is card subindex 1 of Figure 2. This subindex is the cornerstone of the entire system as it represents the 'master listing' of all the reports in the system. An example of one of the cards from subindex 1 is given as Figure 4.

As a parallel system to this master listing, duplicate cards giving the bibliographical reference to the respective contribution are completed for each of four major palynomorph groups mentioned in the paper; this is card subindex 2 of Figure 2. These groups are acritarchs and/or dinoflagellate cysts, chitinozoa, pollen and/or spores and miscellaneous palynomorphs. The miscellaneous palynomorph category includes genera such as *Botryococcus, Pediastrum, Porcatitubulus* and *Scenedesmus,* and foraminiferal test linings. Hence, if a paper includes data on dinoflagellate cysts

and pollen/spores, two separate cards will be made up for these biologically-based categories of subindex 2.

Next, the chronostratigraphy pertaining to the respective report is documented onto index cards, and this is card subindex 3 of Figure 2. A card is completed with the bibliographical reference for each geological epoch that was described in the paper. (e.g. Early Carboniferous; Late Jurassic). There are 26 time slices from the Precambrian to the Quaternary (Table 1). Naturally if a paper covers a wide span of geological time, several cards will need completing. Additionally, bibliographical reference cards are written out for the geographical subindex, which is card subindex 4 of Figure 2. There are 17 geographical regions recognised in the system (Table 2). Should a paper cover a wide geographical area, several cards will need completing as appropriate.

Arguably the most important subindex is the one for the individual palynomorph species and this is card subindex 5 of Figure 2. This subindex is subdivided into six sections based on the main palynomorph groups (acritarchs, dinoflagellate cysts, chitinozoa, fungal spores, pollen and spores, and miscellaneous palynomorphs). An example of one of these index cards is given as Figures 5 and 6. Here, the front side of the index card has the taxon name with full author citation and the nomenclatorial synonymy. Full details are given on the type material of each entry where appropriate (Figure 5). On the reverse side of these ‘species cards’, every occasion the respective taxon is mentioned in the literature is documented. These entries comprise the author and year of publication, the age and geographical location (Figure 6). Subindex 5 therefore enables researchers to rapidly establish all the mentions of a taxon in the literature and hence to derive the geographical and stratigraphical extents of the species. For example, a search using the JWIP for the Palaeogene dinoflagellate cyst species *Apectodinium homomorphum* (Deflandre & Cookson 1955) Lentin & Williams 1977 provides over 250 references, with each entry giving the geographic location and the stratigraphical extent of each record in the literature. The focussed, quality-controlled nature of the data in the JWIP is of far better quality than data derived from the leading generic and scientific internet search engines.

A further subindex comprises cards with illustrations and descriptions of the respective taxon, however this part of the database is not comprehensive and consequently is not illustrated in Figure 2.

6. The use of the John Williams Index of Palaeopalynology

The purely analog JWIP can be accessed and used by visiting the Department of Palaeontology of the Natural History Museum in South Kensington, central London by prior arrangement. To use the JWIP bench fees are requested from industrial/commercial users, but these may be waived for academic researchers and students dependent on the nature of research and its contribution to the NHM.

The comprehensive nature of the JWIP means that it is ideal for obtaining the full range of published palynological data on specific stratigraphical intervals, geographical areas and/or palynomorph groups. It enables a palynologist to rapidly become familiar with all pertinent literature on a geographical region, a stratigraphical interval or selected taxa.

Users can clearly ensure that their synonymy lists and assessments of spatial/temporal ranges are complete and up-to-date and many users acknowledge the JWIP in their publications on these topics (e.g. Raeveskaya and Servais, 2009; Taylor et al., 2011). It is also possible to make comprehensive compilations of palynological literature for use in studies on, for example, biodiversity, biogeography, global vegetation reconstructions and palaeoecology (e.g. Alroy, 2003; Pound et al., 2011; 2012; Riding, 2012). Moreover, the the collection can be used as a training tool.

7. The future of the John Williams Index of Palaeopalynology

Clearly it would be far more convenient for the compiler and users of the JWIP if the card indexes could be digitised and/or web-enabled. Discussions regarding the digitisation of the card indices are taking place and a scanned version of the card index is currently being formatted by the NHM. If sufficient demand is encountered, a database version would be considered in the future.

If achieved, once established, a digital card system would be easier and quicker to update. Finally, whilst the NHM actively encourages users to visit the museum in order to take advantage of their micropalaeontological resources, the

306 global relevance of this resource means that such a digital version could potentially
307 allow access to the JWIP card system remotely.
308 If the full digitisation of the JWIP was ever seriously considered, a suitable
309 future-proof databasing system would need to be selected in order to ensure that the
310 several subsets of the card index system continue to be fully interlinked and cross-
311 referenced. The first step probably should be the typing out of the 23,350 references
312 and the placing of this bibliography into a suitable database which would allow
313 seamless access to the palynomorph group, species, geographical location and
314 stratigraphical subsets of the index. Further more applied opportunities include
315 converting the JWIP into an indexed GIS database, which would allow the current
316 level of cross-referencing to continue and enable the JWIP to be explored spatio-
317 temporally, in a manner similar to other palaeontological databases (e.g. Alroy, 2012;
318 Fortelius, 2012).
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329 **Author biographies**
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331 JAMES B. RIDING is a palynologist with the British Geological Survey based in
332 Nottingham, UK. Jim is a specialist on Mesozoic-Cenozoic palynology and works on
333 a wide variety of domestic and international projects. One of his principal tasks is a
334 RCUK Individual Merit research programme entitled *Jurassic dinoflagellate cyst*
335 *palaeobiology and its applications.* This work aims to use the Jurassic dinoflagellate
336 cyst record to effect long-scale correlations, to assess floral provincialism and to use
337 dinoflagellate cysts to solve palaeobiological questions.
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References

Alpern, B. 1970. Notes sur les concepts d'espèce et de biozone. *Les congrès et colloques de l'université de Liège*, 55: 81-89.

Alroy, J. 2003. Global databases will yield reliable measures of global biodiversity. *Paleobiology*, 29: 26-29.

Alroy, J. (coordinator). 2012. *The Paleobiology database*. National Center for Ecological Analysis and Synthesis. http://paleodb.org/cgi-bin/bridge.pl?a=home.

Artzner, D., Davies, E.H., Dörhöfer, G., Fasola, A., Norris, G., Poplawski, S. 1979. A systematic illustrated guide to fossil organic-walled dinoflagellate genera. *Life Sciences Miscellaneous Publications of the Royal Ontario Museum*, 119 p.

Deflandre, G., Deflandre, M. 1965. Fichier Micropaléontologique Général – Série 14. Dinoflagellés IV – Deflandreaceae 1. *Archives Originales de la Centre de Documentation, Centre National de la Recherche Scientifique*, No. 407, I-V + Fiches: 2522-2875.

373 Deflandre, G., Deflandre, M. 1966. Fichier Micropaléontologique Général – Série 15.
374 Dinoflagellés V. *Editions du Centre National de la Recherche Scientifique*, No. 407,
375 X + Fiches: 2876-3175.
376
377 Eisenack, A. 1967. *Katalog der Fossilen Dinoflagellaten, Hystrichosphären und*
378 *Verwandten Mikrofossilen. Band I. Dinoflagellaten. 1. Ergänzungslieferung*. iii + 241
379 p. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, Germany.
380
381 Fensome, R.A., Williams, G.L. 2004. The Lentin and Williams index of fossil
382 dinoflagellates 2004 edition. *American Association of Stratigraphic Palynologists,*
383 *Contributions Series*, No. 42, 909 p.
384
385 Fensome, R.A., Gocht, H., Stover, L.E., Williams, G.L. 1991. *The Eisenack Catalog*
386 *of Fossil Dinoflagellates. New Series*. Volume 1, 828 p. E. Schweizerbart'sche
387 Verlagsbuchhandlung, Stuttgart, Germany.
388
389 Fensome, R.A., MacRae, R.A., Williams, G.L. 2008. DINOFLAJ2, Version 1.
390 *American Association of Stratigraphic Palynologists Data Series*, No. 1
391 http://dinoflaj.smu.ca/wiki/Main_Page.
392
393 Fortelius, M. (coordinator). 2012. *Neogene of the Old World Database of Fossil*
394 *Mammals (NOW).* University of Helsinki. http://www.helsinki.fi/science/now/.
395
396 Frederiksen, N.O. 1983. Middle Eocene palynomorphs from San Diego, California.
397 Part II. Angiosperm pollen and miscellanea. *American Association of Stratigraphic*
398 *Palynologists Contributions Series*, No. 12: 32-109.
399
400 Hochuli, P.A. 1978. Palynologische Untersuchungen im Oligozän und Untermiozän
401 der Zentralen und Westlichen Paratethys. *Beitrage zur Paläontographie von*
402 *Österreich*, 4, 132 p.
403

Jansonius, J., Hills, L.V. 1976. *Genera File of Fossil Spores and Pollen*. Special Publication , Department of Geology, University of Calgary, Calgary, Alberta, Canada, 3287 filing cards (supplements issued from 1977).

Jansonius, J., McGregor, D.C. 1996. Chapter 1. Introduction. In: Jansonius, J., McGregor, D.C., editors, *Palynology: principles and applications*. American Association of Stratigraphic Palynologists Foundation, 1: 1-10.

Kremp, G.O.W. 1977. Lower Cretaceous palynological literature: six hundred implemented references. *Paleo Data Banks*, 8, 61 p.

Kremp, G.O.W., Methvin, J.G. 1968. Taxomonic crisis in pre-Pleistocene palynology. *Oklahoma Geology Notes*, 28: 146-153.

Kremp, G.O.W., Spackman, W., Traverse, A., Ames, H.T. (editors). 1957-1985. *Catalog of fossil spores and pollen*. Pennsylvania State University, volumes 1-44 plus 6 supplementary volumes.

Krutzsch, W. 1959. Mikropaläontologische (sporenpaläontologische) Untersuchungen in der Braunkohle des Geiseltales. *Beiheft zur Zeitschrift Geologie*, Jahrgang 8, Beiheft 21/22, 425 p.

Lentin, J.K., Davis, O.K., Muncey, T.S., Piel, K.M. 1996. Chapter 24. Personal computers in palynology. In: Jansonius, J., McGregor, D.C., editors, *Palynology: principles and applications.* American Association of Stratigraphic Palynologists Foundation, 3: 961-984.

Mullins, G.L., Aldridge, R.J., Dorning, K.J., Le Hérissé, A., Moczydlowska-Vidal, M., Molyneux, S., Servais, T., Wicander, R. 2007. *The phytoPal Project*. http://www.le.ac.uk/geology/glm2/phytopal.html.

Palynodata Inc., White, J.M. 2008. Palynodata Datafile: 2006 version, with Introduction by J.M. White. *Geological Survey of Canada Open File Report*, No. 5793, 1 x CD-ROM and http://geopub.nrcan.gc.ca/moreinfo_e.php?id=225704.

Pound, M.J., Haywood, A.M., Salzmann, U., Riding, J.B., Lunt, D.J., Hunter, S.J. 2011. A Tortonian (Late Miocene 11.61-7.25Ma) global vegetation reconstruction. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 300: 29-45.

Pound, M.J., Haywood, A.M., Salzmann, U., Riding, J.B. 2012. Global vegetation dynamics and latitudinal temperature gradients during the mid to Late Miocene (15.97 - 5.33 Ma). *Earth Science Reviews*, in press.

Raevskaya, E.R., Servais, T. 2009. *Ninadiacrodium*: a new Late Cambrian acritarch genus and index fossil. *Palynology*, 33(1): 219-239.

Riding, J.B. 2012. A compilation and review of the literature on Triassic, Jurassic, and earliest Cretaceous dinoflagellate cysts. *American Association of Stratigraphic Palynologists Contributions Series*, No. 46, in press.

Steemans, P., Breuer, P. 2007. PalyWeb: A palynomorph database project on the web. In: Steemans, P., Javaux, E., editors, Recent Advances in Palynology. *Carnets de Géologie/Notebooks on Geology*, Memoir 2007/01, Abstract 08 (CG2007_M01/08), 48-52.

In: Jansonius, J., McGregor, D.C., editors, *Palynology: principles and applications*. American Association of Stratigraphic Palynologists Foundation, 3: 961-984.

Stephenson, M.H., Owens, B. 2006. Taxonomy online 2: The 'Bernard Owens Collection' of single grain mount palynological slides: Carboniferous spores part I. *British Geological Survey Research Report*, RR/06/05, 80 p.

Stover, L.E., Evitt, W.R. 1978. Analyses of pre-Pleistocene organic-walled dinoflagellates. *Stanford University Publications, Geological Sciences*, 15, 300 p.

Taylor, W.A., Gensel, P.G., Wellman, C.H. 2011. Wall ultrastructure in three species of the dispersed spore *Emphanisporites* from the Early Devonian. *Review of Palaeobotany and Palynology*, 163: 264-280.

Traverse, A. 2007. *Paleopalynology*. Second Edition. Springer, Dordercht, The Netherlands, 813 p.

Traverse, A., Ames, H.T., Spackman, W. 1970. The *Catalog of fossil spores and pollen* – history and status. *Review of Palaeobotany and Palynology*, 10: 165-173.

Visscher, H. 1980. The genera file, a major achievement in palynology – a review. *Review of Palaeobotany and Palynology*, 30: 159-164.

White, J.M., Jessop, C.M. 2002. Population-based analysis and graphic interpretation of fossil palynomorph records from Palynodata: taxonomic and biostratigraphic implications. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 180: 129-146.

White, J.M., Lai, G., Jessop, C.M., da Roza, R., Scotese, C.R. 2009. Depicting biostratigraphical data from Palynodata: experiments and questions in data presentation and manipulation. *Palynology*, 33(2): 157-174.

Wilson, G.J., Clowes, C.D. 1980. A concise catalogue of organic-walled fossil dinoflagellate genera. *New Zealand Geological Survey Report*, No. 92, 199 p.

Display material captions:

Figure 1. John E. Williams consulting a card from one of the five subindexes in the John Williams Index of Palaeopalynology (JWIP) (photograph taken by Susanne Feist-Burkhardt).

Figure 2. A flowchart to illustrate the five subindexes of the John Williams Index of Palaeopalynology (JWIP) and hence the integrated nature of this system.

Figure 3. John E. Williams consulting a paper from his personal library on palaeopalynology which is associated with the John Williams Index of Palaeopalynology (JWIP) (photograph taken by Susanne Feist-Burkhardt).

Figure 4. An example of the index card for Krutzsch (1959), which represents accession number J4295, from card subindex 1 (i.e. the main reference card subindex) of the John Williams Index of Palaeopalynology (JWIP).

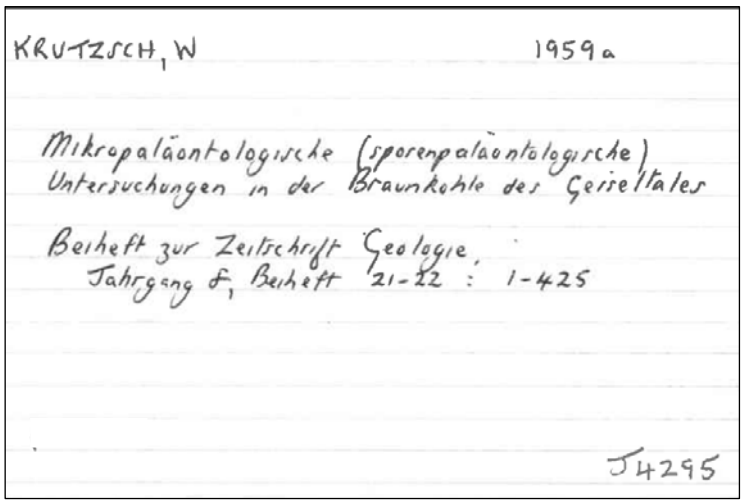

Figure 5. An example of the front side of the index card for the Palaeogene-Neogene pollen grain *Gothanipollis aerius* Krutzsch 1959 from card subindex 5 of the John Williams Index of Palaeopalynology (JWIP). This is the subindex which provides all the mentions in the literature of a specific taxon. Note that the front side of these cards gives the species name, the author citation, the nomenclatorial synonymy as appropriate and details of the type material.

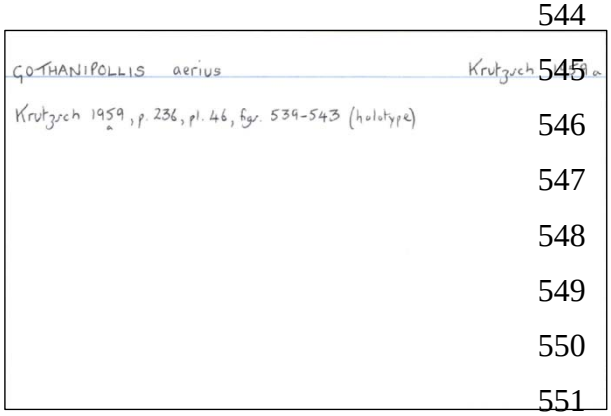

Figure 6. An example of the reverse side of the index card for the Palaeogene-Neogene pollen grain *Gothanipollis aerius* Krutzsch 1959 from card subindex 5 of the John Williams Index of Palaeopalynology (JWIP). Note that the reverse side of these 'species cards' lists every occasion the respective taxon has been mentioned in the

literature. These listings comprise the author, the year of publication, the age and the geographical location (Figure 6). Note that, following its original description from the Eocene of Germany by Krutzsch (1959), *Gothanipollis aerius* has been mentioned and figured by Hochuli (1978) from the Miocene of Paratethys and Frederiksen (1983) from the Eocene of California.

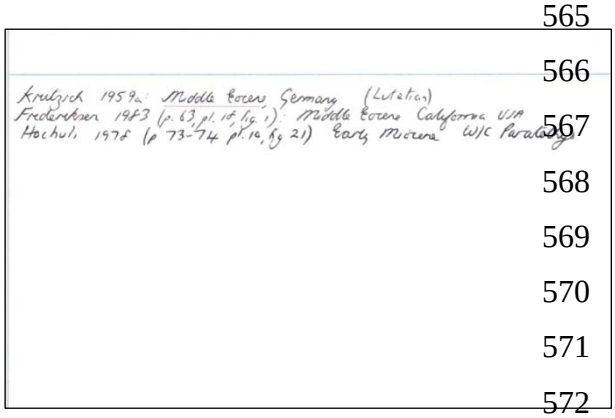

Table 1. A list of the 26 timeslices in card subindex 3 of the John Williams Index of Palaeopalynology (JWIP).

Table 2. A list of the 17 geographical regions in card subindex 4 of the John Williams Index of Palaeopalynology (JWIP).