Geoderma 213 (2014) 193–202

Contents lists available at ScienceDirect

Geoderma

journal homepage: www.elsevier.com/locate/geoderma

The "Fabric" of soil micromorphological research in the 20th century — A bibliometric analysis ☆

G. Stoops *

Vakgroep Geologie en Bodemkunde WE13, Universiteit Gent, Krijgslaan 281, S8, 9000 Gent, Belgium

ARTICLE INFO

Article history:
Received 10 May 2013
Received in revised form 5 August 2013
Accepted 11 August 2013
Available online 10 September 2013

Keywords:
Bibliometry
History
Micromorphology publication language
Scientific journals
Research centres

ABSTRACT

More than 5000 titles of publications (papers in journals, transactions and books) on soil micromorphology, or containing micromorphological research, covering a period from the beginning of the 20th century up to now, were collected and analysed. The parameters evaluated are number of publications, the number of authors per publication, languages, publication media (journals, books and congress transactions), research topics and research centres. For more than 4000 references published between 1900 and 2000 a chronological analysis on the base of a five-year period was carried out. The results presented in a set of tables and graphs illustrate the evolution of micromorphological research during the 20th century.

The number of papers strongly increased till 1986/90, and thereafter slightly declined. Whereas papers authored by one scientist prevailed in the early years, multi-authored ones became more important in the last decades. The multilingual tradition that existed in micromorphological publications till the nineteen seventies is practically completely replaced by a monolingual English one. The wide range of national journals and proceedings used to publish micromorphological material is narrowed to a relative small amount of international journals. The percentage of papers dealing with soil genesis and classification decreased the last decades, whereas those dealing with palaeopedology and archaeology show a spectacular increase. In the last decennia little efforts have been made to develop new concepts and techniques (except for some submicroscopic techniques and image analysis in the 1970s) and accent was mostly set on applications. The evolution of the topics covered matches general tendencies in soil science and technical development. Several centres with a regular and considerable output of micromorphological publications (Bibliometric Identified research Centres, BIC) are identified and discussed. These BICs in many cases ceased to exist and were dismantled when the leading micromorphologist left.

Not all what can be counted, counts,
And not all what counts can be counted.

1. Introduction

The idea of making a bibliometric study of papers dealing with micromorphology came to my mind when preparing a paper on the history of micromorphology (Stoops, 2009) and a lecture on the past and the future of this discipline for an EGU meeting (Stoops, 2010). I then fully realised that many ideas circulate on the history and evolution of soil micromorphology, but that few or no quantitative data were available.

Bibliometry is a methodology used to analyse quantitatively scientific literature on the basis of bibliographic references. Bibliometric studies have been used and misused since many years by decision makers, such as administrators of universities and research institutes, as an imperfect tool to evaluate the output of individual scientists and institutes. But it can also be a useful tool to study the evolution of a discipline, throughout its history and it is probably the only way to obtain "objective" data. It is evident that such a bibliometric study will only measure the scientific output as far as it is published in accessible journals and books, and not the real evolution and the achievements of scientists, which comprises more than only published papers.

This study is not purely bibliometric in all its aspects. For instance when discussing the centres of micromorphological research, I had to make use of knowledge and data not found in bibliographic references, which make that part less objective. Also the assignment of papers to specific disciplines could not always be completely objective, as papers sometimes concerned more than one subject and the choice had to be based on the title only.

☆ Presented at the opening session of the 14th International Working Meeting on Soil Micromorphology, Lleida (Spain) 7–14/07/2012.

* Tel.: +32 92644561.
E-mail address: georges.stoops@UGent.be.

0016-7061/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.geoderma.2013.08.017

The aim of this contribution is to provide an, as objective as possible, overview of the evolution of soil micromorphology, publication policies and geographic distribution of centres.

2. Material and method

This paper is mainly the result of a detailed analysis of a large set of bibliographic references, gathered from three different types of sources: *primary sources* compris books and journals; *secondary sources* (annotated) bibliographies (e.g. "Soils and Fertilizers", the "Annotated Bibliographies" of CAD, the excellent bibliography published in 1990 by Miedema and Mermut, which compiles the abstracts of 1710 papers issued between 1968 and 1986), search tools on the internet (e.g. ISI Web of Knowledge, Google Scholar, Scopus) and publication lists of colleagues; *tertiary sources* consist of references lists of papers and reports.

For the references prior to the 1990s the author's own literature research during several decades, based on primary, secondary and tertiary sources and on unpublished MSc and PhD theses and internal reports, was used. The publications after 1990 were retrieved from literature as far as possible in the same way, but more emphasis was given to search on internet. The final bibliographic list is surely not complete, especially for the more recent period and for papers published in the former USSR and satellite states, and in Chinese, Japanese or Slavic languages. References after 2000 were by definition not included, although a few times indirectly used to confirm specific trends.

All published material, except abstracts of meetings, is taken into account. Unpublished material, such as internal reports, MSc and PhD theses is not considered. This has of course an effect on the global picture: in some countries or centres (e.g. France, Germany, The Netherlands) PhD theses are often published as an issue in a series, in other countries (e.g. Belgium, USA), this is not a common practice.

In order to check the efficiency of internet search tools for older publications, the number of hits for Google Scholar and for ISI Web of Knowledge was compared with the number of entries in of our own database for the period between 1936 and 1975, and applying the criteria mentioned above (Table 1). The search result for Google Scholar was 264 hits (the oldest one from 1934) and for ISI Web of Knowledge was only 23 (the oldest one from 1958), whereas our database contains 1368 references (32 for the period 1900–1940). A similar comparison for the period 1966 to 1970 and including also the number of entries in the annotated bibliographies yielded the following result: 11 references for the ISI Web of Knowledge, 78 for Google Scholar, 66 in Soils and Fertilizers and 346 in our own database.

The following parameters are analysed: number of publications, number of authors per paper, language used, publication media (journals, proceedings, books) and topic (e.g. concepts, methods, micromorphometry, submicroscopy, soil genesis and classification, palaeopedology, archaeology, applied research, geology, laboratory and field experiments). The analyses are made on the base of 5 years' periods, except for 1900–1940 and 1941–1950. In addition a number of micromorphological research centres is identified. The information used for this study was derived mainly from the title of the publication, but in some cases the content or abstract was consulted.

Table 1
Number of hits related to micromorphological papers for ISI Web of Knowledge and for Google Scholar, compared with the number of papers in the author's database, for the period 1900 to 1975.

Year	ISI[a]	Google[b]	Database[c]
1900–1940	0	3	32
1941–1950	0	1	23
1951–1955	0	3	15
1956–1960	1	19	83
1961–1965	1	55	267
1966–1970	10	71	345
1971–1975	11	112	603
Total	23	264	1368

[a] ISI Web of knowledge.
[b] Google Scholar.
[c] Author's database.

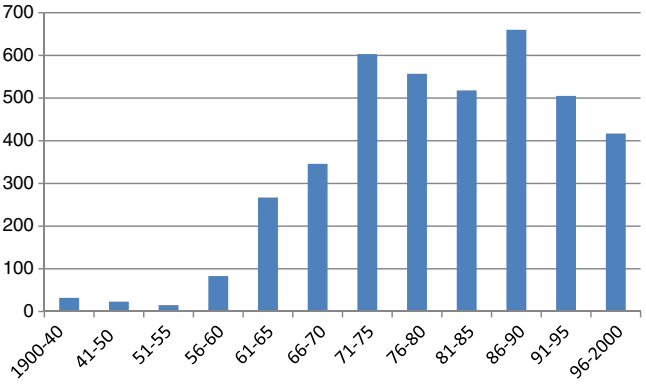

Fig. 1. Total number of publications.

3. Results and discussion

3.1. Is the number of micromorphological papers declining?

As shown in Fig. 1, a gradual increase of the number of papers published is observed till 1986–1990, followed by a slight decrease towards the end of the century. The latter does not necessarily mean that less micromorphological research was carried out, but can be explained partially by the fact that recent papers are less easily retrieved (less primary sources consulted and tertiary references not yet available). Another possible explanation could be that micromorphology became a routine method, no longer mentioned in the title or the keywords, and therefore more difficult to detect through secondary referencing. Moreover, a lot of micromorphological studies in archaeology are publishes in excavation reports, not retrieved by secondary sources as micromorphology. Last, but not least, non-English papers are less easily retrieved with modern search tools, and therefore underestimated.

3.2. One single author, or et al.?

As shown in Fig. 2, till 1955 almost 100% of papers had one or two authors. This amount gradually decreased to about 55% in the last decade of the century, reflecting a general tendency in science for team work; nevertheless, about a quarter of the papers on micromorphology was still authored by a single scientist.

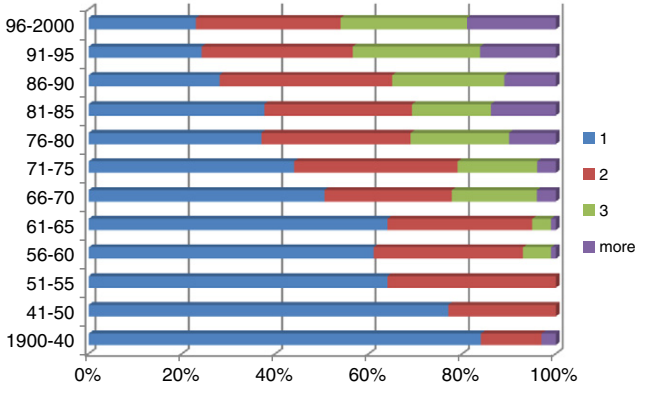

Fig. 2. Number of authors per publication.

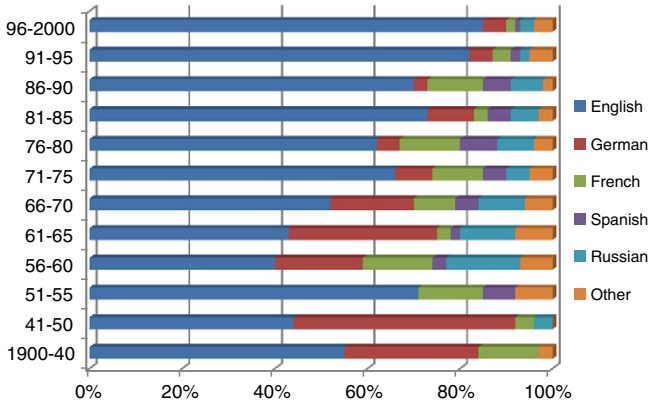

Fig. 3. Relative proportion of the main languages used in micromorphological publications.

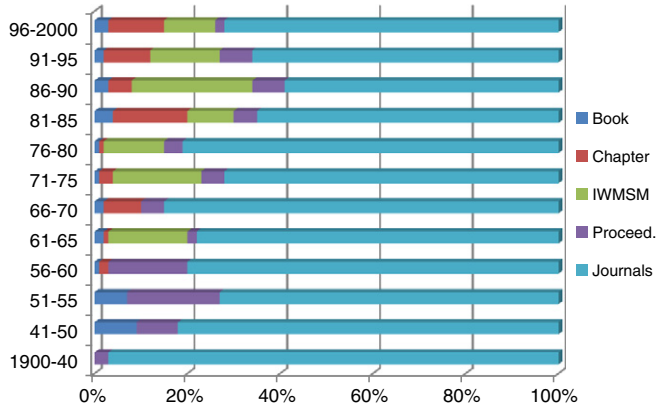

Fig. 4. Publication media for papers on soil micromorphology. IWMSM: Proceedings of the International Working Meeting for Soil Micromorphology; proceed..: proceedings of other meetings.

3.3. From multilingual to almost exclusively Anglo-Saxon

The language of publication is not always clear in tertiary sources as authors often refer to the tiotle of the English abstract, rather than to the original French, German, Spanish or Russian title of a publication, resulting in an overestimation of English. This is also often the case for references retrieved from bibliographic lists or from the "Annotated Bibliographies" of "Soils and Fertilizers" and by Miedema and Mermut (1990). Other reasons for an overestimation of English literature are the facts that they are easier retrieved in bibliographic systems, more often mentioned (especially a strong positive discrimination is evident in English and American literature), and the cover to cover translation programmes of Russian works (e.g. Pochvovedenie translated formerly as Soviet Soil Science, now as Eurasian Journal of Soil Science). In our analysis only the original Russian versions were taken into account, when known, to avoid duplication of papers.

Fig. 3 shows that in the period 1941/50 only 40% of the papers were written in English, but this percentage increased gradually to almost 90% in the last five years of the 20th century. German, once the most important language (50%) decreased to less than 10%. Also French and Spanish played in some periods an important role, even as Russian. Other languages are mentioned in Table 2. A similar evolution is observed in the proceedings of the International Working Meetings on Soil Micromorphology (Fig. 5).

As a conclusion one can state that the multilingual tradition in soil micromorphology is being replaced by a monolingual English–American–Australian policy. It is clear that for the period before 1980 a lot of information is lost for only-English readers.

Moreover one should realise that this is not a question of language only, but also of culture. Traditionally, scientists whose native language is for instance French, Italian, Spanish or Russian, have a different writing style compared to those coming from the Anglo-Saxon culture, and therefore have an extra difficulty to overcome, efforts often not realised by native English speakers.

Table 2
Languages, other than English, German, French, Spanish and Russian used in micromorhological publications.

Language	Number	Language	Number
Dutch	32	Bulgarian	11
Polnish	26	Romenian	3
Czech & Slovak	23	Greek	2
Portuguese	20	Persian	2
Hungarian	15	Croatian	1
Italian	15	Danish	1
Chinese	13	Indonesian	1
Japanese	12		

3.4. Publication strategies

For publication media a distinction is made between books, proceedings or transactions, and journals. Journals are the most important source of information, ranging from 97% in the first part of the 20th century to 59% in the period 1986/90 (Fig. 4). In this period more than 30% papers were published in proceedings of international congresses, especially of the International Working Meetings on Soil Micromorphology, organised every four years, but often the proceedings were only published a few years later (Fig. 5). Books are only a minor source of information, less than 9%, generally only 1 to 2%, whereas chapters in books may amount 16%.

Table 3 presents an overview of the number of micromorphological papers published by specific journals. The most popular journal is without doubt Geoderma, followed by the much older "Journal (later Proceedings) of the Soil Science Society of America". Also the Russian "Pochvovedenie" and the Spanish "Anales de Edafologia y Agrobiologia" are important. The "European Journal of Soil Science", replacing several journals of European societies since the period 1991/95, did not succeed to get a same proportion of micromorphological papers as the former national journals. The fact that both the "Journal of the Indian Society of Soil Science" and the "Egyptian Journal of Soil Science" have published a considerable number of papers on soil micromorphology is an indication that this discipline is not restricted to the industrialised world. Also the "Revista Brasileira de Ciência do Solo" have published some micromorphological papers during the last decade of the 20th century. Other journals, such as "Earth Surface Processes and Landforms", "Journal of Sedimentary Petrology" and "Journal of Archaeological Sciences", although not directly related to soil science, regularly publish

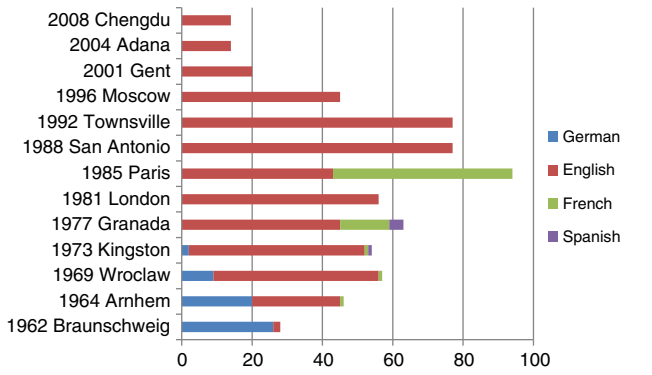

Fig. 5. Evolution of the number of papers published in the proceedings of the International Working Meetings on Soil Micromorphology and languages used.

Table 3
The 25 most important journals with respect to micromorphology.

Journal	Total number of papers	Period
Geoderma	255	1966/70–2000
Soil Science Society of America (Journ. or Proc.)	217	1900/40–2000
Pochvovendenie	161	1941/50–2000
Anales de Edafologia y Agrobiologia	107	1956/60–1986/90
Journal of Soil Science	91	1956/60–1991/95
Catena	84	1971/75–2000
Pedologie (Belgium)	76	1956/60–1991/95
Soil Science	74	1900/40–2000
Canadian Journal of Soil Science	63	1961/65–2000
Journal of Sedimentary Petrology	62	1961/65–1991/95
Zeitschrift für Pflanzenernährung und Bodenkunde	44	1956/60–1991/95
Cahiers ORSTOM, Série Pédologie	41	1961/65–1991/95
Australian Journal of Soil Research	41	1961/65–1991/95
Mitteilungen der Deutschen Bodenkundlichen Gesellschaft	39	1961/65–2000
Netherlands Journal of Agricultural Science	31	1961/65–1986/90
Earth Surface Processes and Landforms	29	1976/80–2000
Indian Journal of Soil Sciences	25	1971/75–2000
Moscow University Soil Science Bulletin	22	1976/80–1986/90
Egyptian Journal of Soil Science	21	1971/75–2000
Science du Sol	20	1966/70–1991/95
Journal of Archaeological Science	19	1976/80–2000
Bulletin de l'Association Française pour l'Etude du Sol	16	1966/70–1986/90
Revista Brasileira de Ciência do Solo	13	1991/1995–2000
European Journal of Soil Science	10	1991/95–2000
Palaeogeography, Palaeoclimatology, Palaeoecology	10	1991/95–2000

papers on applied micromorphology (mainly methodology, palaeosoils and archaeological materials.

3.5. From focus on methodology, description and classification to application and understanding

It is in many cases difficult, even sometimes misleading, to assign a paper to a particular topic only based on its title. Moreover, overlapping often occurs: a paper on genesis may treat also some concepts or methodology, and a paper on palaeopedology often deals also with genetic processes and vice-versa. Classification and genesis are mostly so entangled, that it is impossible to separate them.

Taking this into account, three groups were defined. Books and papers dealing with the general conceptual and methodological aspects of micromorphology "advertising" papers explaining the usefulness of micromorphology its history and its future as a discipline were

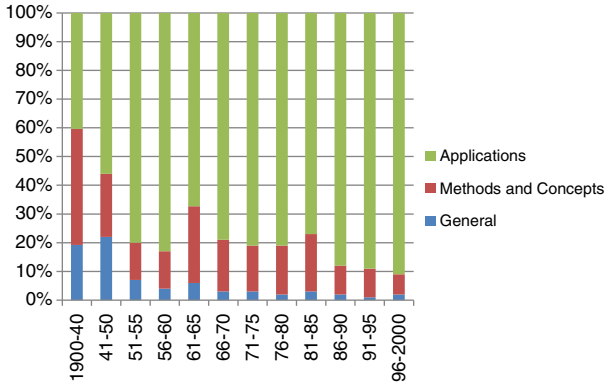

Fig. 6. Relative proportion of papers devoted to general items, methods and concepts, and applications.

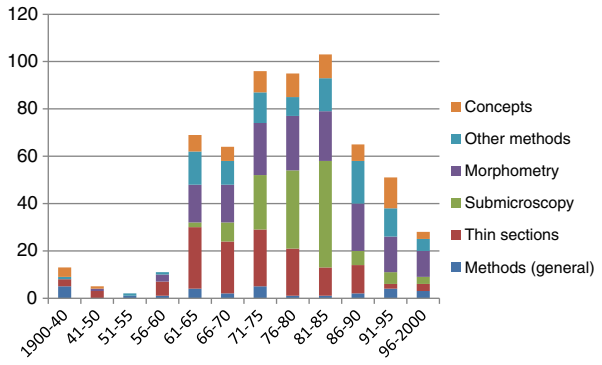

Fig. 7. Number of papers on methods and concepts subdivided into specific topics.

considered together under the name "General publications". A second group has been called "Methods and concepts" and comprises papers essentially dealing with specific preparation and observation techniques, concepts and terminology. The largest group named "Application" includes papers dealing with the use of micromorphology in soil genesis and classification, palaeopedology, archaeology sedimentology and applied sciences.

As shown in Fig. 6, the general trend is a decrease towards the end of the century of the number of general papers and books and those dealing with methods and concepts, in favour of those dealing with applications. Once concepts and methodologies were well defined and established, the focus was mainly set on their application and testing.

3.5.1. General publications

The number of general publications is rather low. The highest percentage is noted in the period 1941/50 (22%) when micromorphology started being promoted, and the lowest in 1991/95 (1%). In absolute numbers the highest quantity was 17 in the period 1971/75.

3.5.2. Methods and concepts

The percentage of papers about methods and concepts was highest in the first part of the 20th century, and in the period 1961/65, strongly decreasing towards the end of the century (Fig. 6). In absolute numbers the period 1961–1990 was the most important one for these subjects.

A detailed analysis, based on subdivision of "methods and concepts" into specific topics (Fig. 7), shows that in the period 1961 1975 much attention was given to refining techniques of thin section preparation. Papers on the application of submicroscopy start to appear in the period 1961/65; their amount sharply increases till 1981/85 when it accounts for 44% of papers dealing with concepts and methods, but it decreases to 10% by the end of the century. This evolution, is the result of the commercialisation of new equipment, such as SEM, EDXRA, WDXRA, which started in the 1960s, and prompted researchers to develop new methods to apply these techniques to soils. Once the methodology was adjusted, it could be easily applied and no more or little theoretical research was carried out. Morphometry became important after the 1960s when image analysis systems started becoming available; because of continuous evolution of computer technology, this topic remains important till the end of the century. The subdivision "others" refers to papers dealing with for instance staining or selective dissolution techniques on thin sections, fluorescence microscopy, microdrilling.

The number of papers dealing with concepts remains more or less constant from the 1960s to end of 1990s, but a clear decrease is noticed in the period 1996/2000. This trend also continues after 2000, pointing to a stabilisation of concepts and terminology in soil micromorphology.

3.5.3. Applications

The following fields of applications are considered: mineral weathering, mineral new formation, soil genesis and classification,

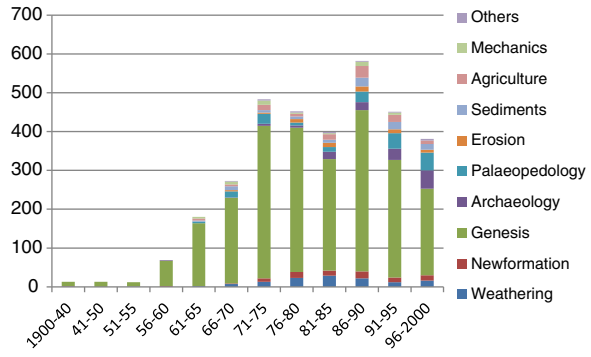

Fig. 8. Number of micromorphological papers devoted to different applications.

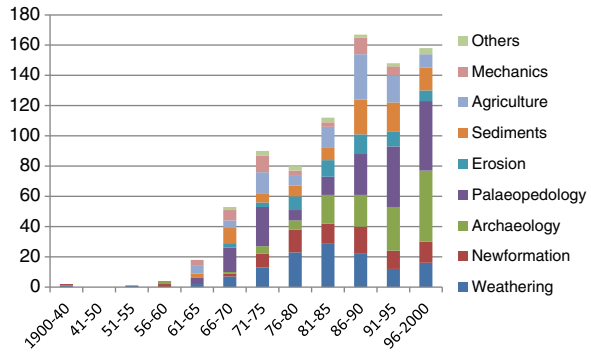

Fig. 9. Number of papers about specific applications other than soil genesis and classification.

archaeology, palaeopedology, soil erosion, (soil)sediments, agriculture, soil mechanics and others. The great majority of papers deal with soil genesis and classification (Fig. 8 reaching almost 100% of all applications in the first half of the century and decreasing to 59% in the period 1996/2000. This seems to be a parallel evolution to what happens in soil science, where genesis and classification is beccoming less important since the last decade of the 20th century.

When considering applications other than those concerning soil genesis and classification (Fig. 9), some trends are clear:

Papers on mineral weathering and new formation started to appear in 1966/67 and have their maximum expression in the period 1976/80, accounting for 40 papers in a 5 year period.

Archaeology appears for the first time in the 1966/70 period, gradually becoming more important and reaching even 12% of all papers on applications in 1996/2000. A similar trend is noticed for palaeopedology. The application of micromorphological techniques to soil erosion studies (including a number of field- and laboratory experiments) and sedimentology (comprising also different types of colluvium, solifluction deposits, etc.) produced 13 papers in the period 1966/70, and this number gradually increased to 36 in the period 1986/90, slightly decreasing afterwards.

Publications on the applications to agriculture appear already in 1961/65 (5 papers) and increase to 30 papers in 1986/90 to decline to 9 in 1996/2000. Many of these papers deal with soil compaction, crust formation and aggregate stability under different soil management systems; they often comprise micromorphometric research.

Papers on soil mechanics are rather scarce, and generally deal with formation or transformation of b-fabrics during compaction, stress tests, etc.

3.6. Rise and decline of micromorphology research centres

The information on "research centres" cannot be derived directly from the bibliographic references. An attempt was made to adjudge publications to the most important centres, based on the author's experience, and acquaintance with colleagues, and the names of well-known scientists of a given centre. This part is therefore less bibliometric and less objective than the former. In the case of multi-authored publications the paper was assigned to the centre of the first author. For instance, in the case of the book Bullock et al. (1985) the publication was marked as one of the Rothamsted Experimental Station, where Bullock was active. If the first author does not belong to a centre were micromorphological research is commonly done, the next author that can be related to a centre is used. In addition there is a problem for papers started by researchers in one institute, but published after their move to another. Moreover, some researchers have two or more affiliations, e.g. in France the name of the research institute and that of the hosting university. Nevertheless, I think this tentative and incomplete analysis is useful to evaluate the rise, decline and fall of centres and their influence.

By identifying as much as practically possible the laboratory, university or institute to which authors of publications were affiliated, a number of micromorphological active centres could be recognised. Some are small, some large, some ephemeral, other long lasting. A "Bibliometric Identified Centre" (BIC), as used in this text, is a department, laboratory or institute that, during a defined period, had a more or less regular output of scientific papers dealing with, or applying micromorphology. A minimum of five publications within a period of five years is required for a centre to be considered as a BIC. It is clear that this is only a partial expression of reality. More centres exist where micromorphological research or training was done, that did not result in a regular output of international or national publications, but that without doubt produced important research for practical agricultural applications. Where information could be acquired, such centres will be mentioned in the discussion, not in the graphs and tables. The period of activity mentioned in the text and in Table 4 starts with the first publication and ends with the last one, even if the criterion of five publications in five years interval was met only once.

Not all BICs have the same weight in development and propagation of micromorphology. The simplest ones are in fact one-person centres exclusively focussed on research. Others count more staff members, often different during subsequent periods, or function also as training centres for students. Less common are the centres where micromorphology is taught as a regular subject of the curriculum. This information cannot be retrieved from the bibliometric data as such, but when available from other sources it will be incorporated in the discussion. Only those centres discussed below that explicitly are mentioned as BICs meet the requirements.

In some cases mostly temporarily overlaps can exist between different BICs when scientists of different centres had formal or informal collaboration. This is often the case when universities collaborate with institutes or governmental services. Table 4 lists BICs with a total output of twenty or more publications on micromorphology during their existence.

3.6.1. Africa

Africa south of the Sahara is a blind spot on the map of BICs. Nevertheless important research has been done, and some well-equipped laboratories have been founded. Under the impulse of ORSTOM (now IRD) micromorphological laboratories were active, for instance in Cameroon and Ivory Coast, but publications mainly have an ORSTOM-France signature. In other places laboratories for micromorphology have been organised (e.g. Kinshasa, Lusaka) but never resulted in publications.

In Northern Africa the National Research Centre (NRC) in Cairo (BIC 1971/75–1991/95) regularly produced papers on the micromorphology of Egyptian soils, mainly by F. Hanna and F. Labib, often published by the Egyptian Journal of Soil Science, showing the interest of local scientists for this discipline.

Table 4
Bibliometric Identified Centres (BICs) with a total output of at least 20 papers before 2001.
* A: > 200, B: 100–150, C: 50–100, D: 20–50.

BIC	Output*	Period of activity
Braunschweig – FAL (Germany)	D	1956/60–91/95
CSIRO (Australia)	B	1956/60–2000
Gent Univ. (Belgium)	A	1956/60–>2000
Moscow Dokuchaev Soil Sci. Instit. (Russia)	B	1956/60–2000
Moscow Lomonosov Uni. Fac. Soil Sci (Russia)	C	1956/60–>2000
North Carolina (USA)	D	1956/60–>2000
ORSTOM (France)	C	1956/60–>2000
Reinbek Research Centre. (Germany)	C	1956/60–81/85
STIBOKA Wageningen (The Netherlands)	B	1956/60–91/95
Alberta Univ. (Canada)	D	1961/65–2000
Hohenheim Univ. (Germany)	D	1961/65–>2000
Madrid–CSIC (Spain)	D	1961/65–1991/95
Moscow Ac. Sci. Instit. Geography (Russia)	D	1961/65–>2000
Ottawa Instit. (Canada)	D	1961/65–2000
Paris–Musée d'Hist. Nat. (France)	D	1966/70–86/90
Praha Univ. (Czech Republic)	D	1961/65–91/95
Rothamsted Station (United Kingdom)	D	1961/65–2000
Saskatoon Univ. (Canada)	D	1961/65–2000
Sevilla Univ and CSIS (Spain)	D	1961/65–86/90
Soil Survey Laboratories (USA)	C	1961/65–>2000
Texas Univ. (USA)	C	1961/65–>2000
Wageningen Univ. (The Netherlands)	B	1961/65–>2000
Aberdeen Univ. (United Kingdom)	D	1966/70–>2000
Amsterdam Univ. (The Netherlands)	C	1966/70–2000
Bonn Univ. (Germany)	D	1966/70–>2000
Granada Univ. (Spain)	D	1966/70–>2000
Grignon Univ. (France)	C	1966/70–>2000
Wroclaw Univ. (Poland)	D	1966/70–86/90
INRA (France)	C	1971/75–>2000
La Laguna Univ. (Spain)	D	1971/75–91/95
Moscow Lomonosov Uni. Fac. Geography	D	1971/75–>2000
NRC Doki (Egypt)	D	1971/75–91/95
CNRS (France)	D	1981/85–>2000
London Univ. (United Kingdom)	C	1981/85–>2000

3.6.2. America

In North America a number of important centres for soil micromorphology clearly appear, both in Canada and the USA. In Latin America were practically restricted to the most industrialised countries: Argentina, Brazil and Mexico, and to a lesser extend Chile. Most of the Latin-American scientists were trained in Europe, what is reflected in the approach and the methods they used.

3.6.2.1. Canada. The oldest centre in Canada is the Land Resource Research Centre in Ottawa (BIC since 1961/65), where J. A. McKeague studied genesis and classification of Canadian soils in close relation with field observations, with a maximum output end of the 1970s. Later C. Fox published several studies on organic material. Also the University of Saskatoon (BIC since 1961/65) contributed substantially to the understanding of soil formation, especially in the cold regions (R. St. Arnaud) and later also to micromorphometry (A. Mermut). S. Pawluk was active at the University of Alberta (BIC 1961/65–2000). Smaller and less long-lasting centres were those of Queens University, Kingston (BIC 1961/65–1985/90) (G.K. Rutherford), Guelph University (BIC 1971/75–2000) (R. Protz) and Mac Masters University, (BIC 1971/75–68/90) where B. Bunting applied micromorphology to geography, and since a few years the University of Northern British Columbia (J. Arocena). Glacial sediments are studied since the last years of the 20th century at Brock University (Ontario) by J. Menzies.

3.6.2.2. United States. At the occasion of the 10th International Working Meeting on Soil Micromorphology in Moscow, L. Wilding (1997) presented a paper analysing the situation of micromorphological research in the USA. He emphasised that the basis for micromorphology is different in Europe and the USA. In the former several full time micromorphologists are or were active, systematically working on methods, concepts and soil types, whereas in the USA micromorphological research is rather considered as an occasional by-product of research or project work. Nevertheless there are several institutions and organisations that meet the requirements to be considered as a BIC.

The University of North Carolina seems to be the oldest micromorphology research centre in North America (BIC since 1956/60) where first S. Buol contributed to genetic studies, and later M. Vepraskas made a pioneering work on the relation between morphology and hydromorphism. At Texas A&M University (BIC since 1961/65), important research was done on genesis of local soils (J.B. Dixon, L.R. Drees, L. Wilding, www.uea.ac.uk). A large number of publications is authored by officers of USDA and the Soil Survey Laboratories (BIC since 1961/65) mainly working on soil genesis and classification (e.g. H. Eswaran, K.W. Flach, W.D. Nettleton, L.D. Norton). Other centres in the USA are for instance the University of Georgia, Athens (L.T. West), University of Idaho (R. Blank, M. Fosberg), University of Maryland (BIC since 1986/90) (D. Fanning, M.C. Rabenhorst), University of Nevada Las Vegas (B. Buck).

At the end of the century, P. Goldberg started a micromorphological laboratory specialised in archaeological research at the Boston University. More detailed information on the activities in the 1990s is given in Wilding (1997).

3.6.2.3. Argentina. Micromorphological research in Argentina was mainly situated in Buenos Aires (INTA and University of Buenos Aires) where H. Morrás studied several Argentine soils, and lectured on this discipline. Occasionally micromorphological research was also done in other institutes (e.g. Universidad Nacional de La Plata with P. Imbelone). Argentine students in Europe contributed substantially to the knowledge of the micromorphology of their national soils.

3.6.2.4. Brazil. Only since the beginning of the 21st century a group of scientists is active at the University of Viçosa (e.g. C. Schaefer), studying mainly tropical soils, but recently also archaeology. It will appear as a BIC after 2000. In the past, several papers on weathering and tropical soils were published in cooperation with ORSTOM scientists.

3.6.2.5. Mexico. Two institutes, the Colegio de Postgraduados Montecillo (MdC. Gutierrez-Castorena) and the Geological Institute of Universidad Nacional Autonoma de Mexico (K. Oleschko, S. Sedov), collaborating since several years, contributed much to the understanding of local soils and especially soils on volcanic material (e.g. tepetate). Earlier, several micromorphological studies were done in collaboration with ORSTOM scientists.

3.6.3. Asia

The number of BICs in Asia remains rather limited. This is partly biased by the fact that local publications (e.g. in China and Japan) are not readily accessible to western readers, and therefore the number of references retrieved is smaller than the real number of micromorphological publications. In many countries local micromorphological research was not continuous over a longer period of time, or did not result in several official publications.

3.6.3.1. China. Based on bibliometric information available, it is not possible to situate BICs in China, although it is clear that interest for micromorphology is important, and many papers were published, but access to them is difficult. At the Academia Sinica Z. Gao studied several Chinese soils and in Hongkong C.Y. Jim investigated the evolution of the micromass.

3.6.3.2. India. A number of micromorphological papers appear in the reference list, but no specific BIC could be detected. Among the scientists active in micromorphology we mention H. Achyuthan (Anna University, Chennai) and J. Seghal (National Bureau of Soil Survey & Land Use

Planning, Nagpur). The fact that 25 papers on micromorphology were published in the "Journal of the Indian Society of Soil Science" points to an active research in this field.

3.6.3.3. Indonesia. Several micromorphological papers were published on Indonesian soils, most with the support of Dutch, Belgian or American institutes.

3.6.3.4. Iran. Interest for soil micromorphology has been large in Iran since the 1980s. Although several universities are involved, two centres are important: the University of Teheran where Sh. Mahmoodi created a laboratory, and the College of Agriculture, Shiraz University, where A. Abtahi supervised several PhD students and researchers working on soil genesis and classification.

3.6.3.5. Israel. Micromorphological research was essentially concentrated at the Bar Ilan and the Hebrew University in Tel Aviv where since the 1970s M. Wieder made genetic studies of arid and semiarid soils. Later interest shifted to archaeology, at present the main topic (P. Goldberg, A. Tsatskin).

3.6.3.6. Japan. Last decennia few publications on micromorphology appeared, but in the 1960s several papers were published in Japanese journals. Many of them contain pioneering work on volcanic ash and paddy soils (S. Arimura, K. Kawai, and H. Wada). A total of about 60 publications were retrieved, but it is certain that the local output is much larger.

3.6.3.7. Malaysia. Although not detected as such in the bibliometric analysis, a micromorphological laboratory is active at UPM since 1980 under the supervision of S. Zauyah. The well equipped laboratory hosted several researchers from neighbouring countries (e.g. Indonesia, Thailand), and a number of MSc and PhD theses with a micromorphological approach were made, resulting in several publications.

3.6.3.8. Taiwan. Micromorphological research, especially focussed on redoximorphic features in flooded soils (Z.Y. Hseu and Z.S. Cheng) started during the last decade at the National Pingtun University of Science and Technology (BIC since 1996/2000).

3.6.3.9. Thailand. A Micromorohphology Section existed at the Department of Land Development (Bangkok), but only very few publications were retrieved (M. Dabbakula, V. Chutatis).

3.6.3.10. Turkey. A micromorphological laboratory was organised by S. Kapur at the Department of Archaeometry of the Çukurova University in Adana. It is involved in research on archaeology and Mediterranean soils, using especially scanning electron microscopy.

3.6.4. Australia and New Zealand

3.6.4.1. Australia. Many aspects of micromorphology, including micromorphometry were investigated at the CSIRO (BIC 1956/60–2000) (R. Brewer, C.J. Chartres, C. Moran, and A.J. Ringrose-Voaze). Starting from 1960, R. Brewer and J.R. Sleeman published a series of papers on new concepts that had an enormous influence on the micromorphological community. Their system of fabric analysis, (Brewer, 1964) replaced in short time the then generally accepted morphogenetic approach of Kubiëna (1948). Also in several universities micromorphological research was carried out, amongst others the National University (G. Humphreys), University of New England (BIC since 1991/95) (L.A. Sullivan) and University of West Australia (R.J. Gilkes).

3.6.4.2. New Zealand. At the New Zealand Soil Bureau (BIC 1961/65–1981/85) B. Barrat investigated especially local soils and organic matter.

3.6.5. Europe

Europe can be considered as the cradle of soil micromorphology, although the first manual resulted from Kubiëna's teaching at Rutgers University in the USA (Kubiëna, 1938). But even before Kubiëna, several French and German pedologists made use of thin sections (see Stoops, 2009). In the 1950s and 1960s micromorphological research was started at many universities and research centres in Europe, often related to soil survey programmes. The evolution was speeded up in the late 1960s and the 1970s when several centres became involved in training programmes for students of Africa, Asia and South America. This led to the study of little known exotic soils, needing profound genetic research that included mineralogy and micromorphology. In the next paragraphs a north–south section through Europe will be presented.

3.6.5.1. Scandinavia and Iceland. These countries (Denmark, Iceland, Norway and Sweden) never had a tradition of micromorphological research. Papers published by national scientists are mainly the result of a study stay abroad, generally in Western Europe, sometimes resulting in long lasting collaborations. The research is almost always dealing with local soil genesis or agricultural applications. Several micromorphological studies have been published on Icelandic soils by scientists of the continent and the UK, especially also last decade by archaeologists of the Cambridge and Stirling Universities. No information could be found on micromorphological research in the Baltic States and Finland.

3.6.5.2. Poland. The Agricultural University of Wroclaw (BIC 1966/70–1986/90) has been an important centre under the direction of St. Kowalinski, studying not only Polish, but also other European soils. At present several laboratories (e.g. Lublin, P. Mrozeck www.loess.umcs.lublin.pl/newsletter…) are involved in micromorphological research, often also in the field of archaeology.

3.6.5.3. Germany. The first centre founded was that of the Bundesforschungsanstalt für Forst- und Holzwirtschaft in Reinbek (BIC 1956/60–1981/85), where Kubiëna and several co-workers (e.g. U. Babel, W. Beckmann, E. Geyger, R. Schmidt Lorenz, M.-W. von Buch, G. Zachariae) studied the genesis of different types of soils and developed methods for quantitative studies of soil thin sections (Kubiëna, 1967). This was really the place to be for training in micropedology. Also important is the Forschungsanstalt für Landwirtschaft in Braunschweig (BIC 1956/60–1991/95) where H.J. Altemüller applied a number of advanced microscopic observation techniques to the study of soil thin sections, developed techniques for thin section preparation and established clear concepts for micromorphological analysis. At the Universität Hohenheim (BIC since 1971/75) U. Babel contributed considerably to the description and understanding of soil organic matter. Genetic studies on European and South American soils were made at the Institut für Bodenkunde in Bonn (BIC 1966/70–2000) by S. Stephan. At the Justus Liebig Universität, Giessen (BIC 1961/65–1966/70) H. Borchert used micromorphological techniques for land amelioration studies. A. Bronger studied palaeosoils since 1966/70 at the University of Kiel. Other micromorphologist were working for instance in Hamburg (T. Poetsch), and Bremen (R. Tippkötter, www.microped.uni-bremen.de)

3.6.5.4. The Netherlands. At the Soil Survey Institute (STIBOKA), later called Staring Centre, in Wageningen (BIC 1956/1991/95) A. Jongerius, assisted by E.B.A. Bisdom and later followed by M. Kooistra contributed to the characterisation and classification of soil in the Netherlands, and abroad, and was in addition especially involved in the development of quantitative methods for porosity analysis and applications of submicroscopic techniques. It was an internationally known training centre. The Department of Soil Science and Geology of the (Agricultural) University of Wageningen (BIC 1961/65–2000) was involved in the study of soil genesis, both in the Netherlands and many tropical areas. The main scientists active here were, J. Bouma, P. Buurman, A. Jongmans,

R. Miedema and S. Slager. Micromorphology was part of the curriculum of Soil Science courses and the centre contributed often to the organisation of international micromorphological events. ISRIC, the former International Soils Museum, had a laboratory for thin section preparation and microscopic research facilities, and cooperated for research with the two other centres. The STIBOKA centre was closed a few years after the death of A. Jongerius; at the University all infrastructure was dismantled after A. Jongmans retired a few years ago and also at ISRIC all micromorphological activities stopped in the 1980s.

At the Laboratory of Physical Geography and Soil Science at the University of Amsterdam (BIC 1966/70–2000) several researchers (e.g. J. van der Meer) and many students from Europe and Asia were trained, under the guidance of H. Mücher till his retirement. Research was performed especially in the field of soil erosion (including field and laboratory experiments), Quaternary geology and archaeology and later also glacial sediments. Also here the laboratory was dismantled after J. Van de Meer left for London. After being for many years at the lead, micromorphological research in The Netherlands only survives at this moment in a private consulting company Kooistra Micromorphological Services.

3.6.5.5. Belgium. An important BIC exists since 1956/60 at the Department of Geology and Soil Science of the Ghent University, comprising also the International Training Centre for Post-Graduate Soil Scientists, where soil micromorphology was during several decades an obligatory subject of the curriculum. After the accidental death of its founder, J. Laruelle, in 1967, micromorphological research and teaching were taken over by G. Stoops. Other staff members, such as F. De Coninck, H. Eswaran, V. Marcelino and F. Mees have been also involved in micromorphological research. Particular attention has been given to the study of tropical soils and podzols, the development of concepts, terminology and methods for the study of thin sections. In this centre more than 100 MSc theses and about 30 PhD theses containing micromorphological research were produced but never published, and thus not considered in this analysis, resulting in an underestimation of the output. It is the longest living, still active BIC in the world.

3.6.5.6. Central Europe and Balkan. G. Szendrei prepared many publications, focussing on local dry and saline soils, at the Research Institute for Soil Science Agrochemistry of the Hungarian Academy of Science in Budapest. In Czechoslovakia L. Smolikova was involved in research on palaeosoils and Quaternary Geology at the Karlovy University, Prague (now *Czech Republic*) (BIC 1961/65–1991/95). Some micromorphological research was published in *Romania* by M. Opris in the 1960s and in *Bulgaria* by I. Staikov. No centre was detected in the former *Balkan*; only a few isolated publications, mainly prepared during training periods in Western Europe or the USSR are retrieved (e.g. Z. Gračanin). In *Greece* studies in the field of archaeology were made by P. Karkanas since the end of the 1990s becoming a BIC in the 21st century.

3.6.5.7. Austria. Although micromorphology started in this country, no centre was detected. Only a few isolated papers were retrieved.

3.6.5.8. Switzerland. At the Eidgenössische Landwirtschaftliche Versuchsanstalt in Örlikon E. Frei studied between 1961/65 and 1976/80 the genesis of local and South American soils. Since the end of the century E.P. Verrecchia started a laboratory at the University of Neuchatel and later that of Lausanne.

3.6.5.9. Italy. Several laboratories have been active in the field of micromorphology. Since 1966/70 pedogenic and mineralogical studies based on micromorphology were published in Firenze (G. Ferrari, D. Magaldi). At the CNR-Instituto per la Chimica del Terreno in Pisa (BIC 1976/80–91/95), M. Pagliai studied soil compaction, crust formation and structural changes using micromorphometry. End of the century studies started in the field of Quaternary geology and prehistory at the University of Milano (M. Cremaschi, L. Trombino). Since the 1990s, F. Terribile contributed to micromorphometry at the University of Naples. More small centres exist, several of them active in palaeopedology and archaeology.

France has a rather long tradition of soil thin section studies. Many of the oldest, even pre-Kubiëna papers known were produced in this country (Stoops, 2009). The first centre is without doubt the Institut National Agronomique Paris-Grignon (BIC since 1966/70) where N. Fedoroff and co-workers (e.g. L.M. Bresson, A.M. Courty) were not only active in genetic research of world soils and development of concepts and methods, but also trained and taught students from all over the world. In the field of pedobiology, C. Jeanson was involved in experimental studies at the Museum National d'Histoire Naturelle (BIC 1966/70 -1986/90).

ORSTOM (now IRD) scientists (BIC since 1956/60) contributed considerably to the knowledge of soils in the tropics, especially with regard to genesis, classification and processes. Some worked at the central laboratory in Bondy near Paris, but many were hosted at universities in France (e.g. Dijon, Marseille, Paris, Strassbourg) or abroad (e.g. Brazil, Cameroon), e.g. A. Chauvel, J. Delvigne (working on weathering), V. Eschenbrenner, J.P. Muller, C. Valentin. Through educative programmes, providing training for overseas students, ORSTOM also contributed substantially to the propagation of micromorphology outside the Western world.

A similar situation existed in the laboratories of the Centre National de Recherche Scientifique (CNRS) (BIC since 1981/85) and the Institut National de Recherches Agronomiques (INRA) (BIC since 1971/75) where micromorphologists were active in different universities and institutes (e.g. for CNRS: F. Bartoli, A. J.E. Brochier, Meunier, B. Van Vliet-Lanoë, and for INRA: G. Callot, P. Curmi, B. Jaillart, D. Tessier, F. Van Oort). Due to the structure of CNRS and the policy to move scientists, centres are rather determined by a person than by a physical location. Collaboration between ORSTOM, CNRS, INRA and universities hosting their scientists, makes it often difficult to decide to which BIC a paper should be assigned. Amongst universities that were quite active we mention Poitiers (BIC 1966/70–1991/95) (P. Butel, J. Ducloux, T. Dupuis, N. Nahon, D. Righi) and Rennes (P. Curmi, P.Aurousseau). Archaeological studies were done in Bordeaux (M.A. Courty) and by A. Gebhardt.

3.6.5.10. Iberian Peninsula. Micromorphological research in Portugal is mainly based on work of scientist's study stays abroad, and is especially dealing with soils from the tropics (e.g. A. Réfega, J.L. Condado).

Since the stay of Kubiëna at the Consejo Superior de Investigaciones Cientificas (CSIS) in Madrid from 1950 till 1955, Spain has long time been a centre of excellence for micromorphologists. At this laboratory (BIC 1951/55–1991/95) the first generation of Spanish micromorphologists was formed, and many Spanish and foreign scientists trained under the excellent guidance of J. Benayas. After her retirement the laboratory was closed.

At the CSIS centre of Sevilla (BIC 1961/65–1986/90), mainly Andalusian soils were studied till the retirement of its leading scientist, G. Paneque assisted by N. Bellinfante. In Granada (BIC since 1966/70) micromorphological research was started at the Faculty of Pharmacy and the CSIS centre of Zaidin by M. Delgado and later at the Faculty of Sciences, where J. Aguilar and C. Dorronsoro got strongly involved in micromorphology, including more theoretical work on methodology and morphometry. This BIC realised also a most useful website on thin section studies (www.edafologia.ugr.es). At the University of La Laguna (Teneriffe) (BIC 1971/75–91/95) soils on volcanic ash were investigated (E. Fernandez Caldas, A. Rodriguez-Rodriguez and M.L. Tejedor-Salguero).

End of the 1990s, R. Poch created at the University of Lleida a centre, combsining research, training and teaching, both for European and foreign students, and dealing with local agricultural problems and genesis of world soils. In addition, individual micromorphologists have been

active in several universities and institutes such as Almeria, Palencia, Pamplona, Santiago de Compostella, Zaragosa (J. Herrero).

3.6.5.11. UK and Ireland. Micromorphology in function of soil classification and genesis has been extensively used in several institutes in the UK. At Rothamsted Experimental Station in Harpenden (BIC 1961/65–2000) P. Bullock and C. Murphy did not only research for the Soil Survey of England and Wales, but also fundamental research on concepts and methods, including micromorphometry. At the University of Aberdeen (BIC since 1966/70) the work of E.A. FitzPatrick in the fields of soil genesis, classification and concepts, and his contributions to train students worldwide are very important. J.C.C Romans (The Macauley Institute for Soil Research in Aberdeen) studied especially boreal soils. At the University of Reading (BIC 1971/75–1991/95) J. Dalrymple and students did pioneering research on processes and soil genesis, often based on laboratory experiments. Other institutions where micromorphology flourished are the University of Bangor (D.A. Jenkins), University of London (BIC since 1981/85) (R.A. Kemp for palaeosoils, J. van der Meer for glacial sediments, and R. Macphail for archaeology). Since the last decade of the last century, interest in the application of soil micromorphology to archaeology increased considerable creating new centres: Stirling (BIC since 1986/90) (D. Davidson, I Simpson) (www.thin.str.ac.uk) and Ancient Monuments Laboratory, London (M.G. Canti, especially involved in experimental work), W. Matthews (since 1995)

Two centres involved in the application of submicroscopic techniques to soil studies are the Universities of East Anglia (N.K. Tovey) and of Glasgow (P. Smart).

3.6.5.12. Russia. In Moscow several centres were active in the field of micromorphology: the Moscow Lomonosov University Faculty of Soil Science (BIC since 1956/60) (e.g. G.V. Dobrovolski, K.N. Fedorov, S. Shoba), the Moscow Lomonosov University, Faculty of Geography, since 1971/75 (e.g. M. Gerasimova), the Dokuchaev Soil Sc. Institute (BIC since 1956/60) (e.g. I.I. Feofarova, M. G. Minashina, E.I. Parfenova, T. Tursina, M.P. Verba, E. Yarilova), the Academy of Sciences Institute of Geography (BIC since 1961/65) (e.g. I.P. Gerasimov, I.V. Kovda, T.D. Morozova, A.I. Romashkevich, V.O. Targulian, later also M.A. Bronnikova), the Academy of Sciences Pushcnino Institute of Soil Science and Agricultural Chemistry (BIC since 1971) (e.g. S.V. Gubin). In addition micromorphological research was carried out in other institutes, such as Moscow Pedagogical Institute (1961/65–1986/90) (e.g. V.V. Dobrovolski, A.N. Polyakov). Outside Moscow we mention especially the Leningrad (St-Petersburg) University (BIC 1961/65–1986/90) (E.I. Gagarina), but also in other ex-Soviet Republics research was done. In most centres micromorphological research was focused on genetic studies of Russian soils. It is clear that the number of papers retrieved is surely strongly underestimated, because of the language, and the difficulty to get access to local publications.

4. Conclusions

Four thousand references of papers dealing with soil micromorphology were analysed for several parameters on the basis of five years period. Retrieval of references is biased by language, with a positive discrimination for the Anglo-Saxon. Internet search tools yield only limited information for older and for non-Anglo-Saxon literature. The number of references analysed is without doubt representative for publications accessible in the western world. Chinese, Japanese and Russian publications are probably underrepresented because of language problems and accessibility.

The total number of papers published increased strongly till 1986–1990, but declined slightly afterwards. There is a clear evolution from one- or two-authored papers to publications with three or more authors. In the beginning one can speak of a multilingual publication tradition, with mainly German, French, English, Spanish and Russian papers, and a dozen less important languages, but after 1970 English was used in more than 50% of all publications, reaching about 95% at the end of the century. This means that for the first three quarters of the century only-English readers did not have access to important information. Journals play a major role in the divulgation of results of micromorphological research, directly followed by congress transactions. Books are less important. The role of journals of national societies, especially in Europe, has since the last decade of the 20th century been taken over by international, often commercial journals.

With respect to the topics investigated, it is clear that papers on general aspects, methods and concepts got a maximum of expansion between the 1960s and 1990s, but were always less numerous than those on applications. In the early days of micromorphology the most important applications were soil genesis and classification; gradually these items lost part of their importance, which was compensated by an increased interest for application such as palaeopedology and archaeology.

Based on bibliometric data, a number of Bibliometric Identified Centres BICs) could be recognised. These are centres with a regular scientific output of micromorphological papers during several five-years periods. These BICs are, in the 20th century, mainly situated in North America, Australia and Europe. Their existence quite often depends upon a single scientist, and therefore not reaching the necessary critical mass to continue after retirement or death of that scientist, or after a reorganisation of the institute. In most cases the laboratory is dismantled, know-how lost and collections destroyed. International efforts should be made to safe this scientific heritage and save at least the thin section collections and related documents.

Based on trends confirmed in this research, and on his experience, the author will try to give a prognosis of possible developments of micromorphology the coming years. It seems important to distinguish between regolith micromorphology, in earth sciences and archaeology, and soils micromorphology in soil science.

Use of micromorphology in archaeology tends to increase as the younger generation of archaeologists is better acquainted with geoarchaeological methods, national legislations in many countries make archaeological research compulsory as part of important infrastructure works, and groups of archaeologists/micromorphologists in Europe are very active, organizing regular discussion meetings and courses. It is a pity that some of these courses are almost explicitly focused on archaeological material, so that young students don't realise sufficiently that some “archaeological” features can also be found in natural soils.

In earth sciences, micromorphological research will probably keep the same popularity it has now. Geologists have a long tradition of microscopic fabric studies, the necessary know-how of optical mineralogy, and the equipment. They consider micromorphology as one of their methods to study saprolites, pedogenic rocks (e.g. silcretes, calcretes, laterites) and soil sediments. A partial shift from thin section studies to more sophisticated submicroscopic analytical techniques is on the way. Also Quaternary geologists (e.g. dealing with palaeosoils) and geomorphologists (studying for instance the influence of frost or mass movements on sediments) will continue to use micromorphology. The main problem for earth sciences in this respect is that the available global funding is restricted, and larger parts are often claimed by for instance geochemists, geophysicists or marine geologists, not so much interested in the fabric of material.

The position of soil micromorphology seems less certain, especially in Faculties of Agronomy that evolve rather to Faculties of Biotechnology, where soils become a less important item, especially soil genesis. Moreover, young researchers there often do not have acquired in their graduate studies a sufficient mineralogical background, needed for micromorphological research. Students and starting researchers were in the past often frustrated by the absence of a structured review of related literature needed for interpretations in genesis and classification. This problem is largely solved now by the publication of a detailed compilation of

literature taking into account also different languages by Stoops et al. (2010). It is hoped this will encourage micromorphological studies in new centres. American micromorphologists (e.g. Lindbo et al., 2010; Vepraskas, 1992) proposed correlations between redoximorphic features observed in thin sections, and types and durations of water saturations in soils giving soil scientists a micromorphological tool to characterize present and past soil conditions. Determining more of such correlations would make micromorphology a useful tool in pedometrics, and more appreciated by soil scientists in general. Applications of soil micromorphometry to soil physics are hindered considerably by a lack of uniformity in concepts and methods, making comparisons between data of different authors, sometimes even those of different publications of a same author, almost impossible. At several occasions the author pleaded already for the creation of a working group charged with standardizing methodology and parameters to be used (Stoops, 2009).

Apparently, taking into account the trends illustrated in this paper, and the literature published between 2000 and 2012, no big improvements have to be expected in the field of concepts and terminology. The manual of Bullock et al. (1985) updated by Stoops (2003) seems universally accepted. Efforts to improve thin section preparation would be useful, in a sense that both impregnation time and preparation costs are often mentioned as a factor hindering a wider use of micromorphology. Reconsidering the use of the fast hardening methylmetacrylate and experimenting with more automatic sectioning and lapping procedures is therefore recommended. In order to promote soil and regolith micromorphology the organisation of intensive courses is a must. Good examples are the "European Intensive Courses on Soil Micromorphology", organised in the nineteen-nineties with support of the EU (Erasmus Courses) in Wageningen, Gent, Granada and Naples, where most of the leading micromorphologists active now in Europe were formed. National soil science societies could play an important role, especially in Africa, Asia and South America.

BICs based on only one scientist's work are very vulnerable. It is important that more colleagues of the same institution are involved. In principle, the role of the "home micromorphologist" is then not so much to make descriptions and interpretations, but to help and guide colleagues in their micromorphological research. Micromorphological research should be done as much as possible by, or in close cooperation with, the scientists that performed the experiment or the field work. Collaboration with geology departments, where part of the technical know-how and instrumentation is present, may facilitate the creation of new BICs.

Acknowledgements

The author thanks. Dr. M. Gerasimova for providing most useful information on the affiliation of Russian authors. He also acknowledges precious information and comments of Dr. Hseu, Dr. M. Kooistra, Dr. V. Marcelino, Dr. H. Mücher and Dr. R. Van Ranst.

References

Brewer, R., 1964. Fabric and Mineral Analysis of Soils. John Wiley and Sons, New York (470 pp.).
Bullock, P., Fedoroff, N., Jongerius, A., Stoops, G., Tursina, T., Babel, U., 1985. Handbook for Soil Thin Section Description. Waine Research Publications, Wolverhampton, UK (152 pp.).
Kubiëna, W.L., 1938. Micropedology. Collegiate Press, Ames, Iowa (242 pp.).
Kubiëna, W.L., 1948. Entwicklungslehre des Bodens. Springer Verlag, Wien (215 pp.).
Kubiëna, W.L. (Ed.), 1967. Die Mikromorphometrische Bodenanalyse. Ferdinant Enke Verlag, Stuttgart (196 pp.).
Lindbo, D.L., Stolt, M.H., Vepraskas, M.J., 2010. Redoximorphic features. In: Stoops, G., Marcelino, V., Mees, F. (Eds.), Interpretation of Micromorphological Features of Soils and Regoliths. Elsevier, Amsterdam, pp. 129–147.
Miedema, R., Mermut, A.R., 1990. Soil Micromorphology: An Annotated Bibliography 1968–1986. CAB, Wallingford, UK (250 pp.).
Stoops, G., 2003. Guidelines for Analysis and Description of Soil and Regolith Thin Sections. Soil Science Society of America, Madison, Wisconsin (184 pp.).
Stoops, G., 2009. Seventy Years "Micropedology" 1938–2008. The Past and Future. J. Mt. Sci. 6, 101–106.
Stoops, G., 2010. Kubiëna's heritage: worries and hopes about micropedology (Philippe Duchaufour Medal Lecture). Geophys. Res. Abstr. 12 (EGU 2010-1860).
Stoops, G., Marcelino, V., Mees, F. (Eds.), 2010. Interpretation of Micromorphological Features of Soils and Regoliths. Elsevier, Amsterdam (720 pp.).
Vepraskas, M., 1992. Redoximorphic Features for Identifying Aquic Conditions. N. C. Agric. Res. Serv. Tech. Bull. 301 (33 pp.).
Wilding, L., 1997. Micromorphology emphasis in the United States over the past decade. In: Shoba, S., Gerasimova, M., Miedema, R. (Eds.), Soil micromorphology: Studies on Soil Diversity, Diagnostics and Dynamics. Wageningen, Moscow, pp. 13–22.