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A REVIEW OF QUATERNARY PALAEOBOTANY AND PALYNOLOGY IN CANADA

J. Terasmae

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ABSTRACT

A review of Quaternary palaeobotany and palynology in Canada shows a development from the early exploratory studies before 1900 to more systematic investigations after 1940. Extensive peat bog surveys in the early nineteen hundreds stand out because of their economic objectives.

Since 1930 palynological studies have become dominant over investigations of plant macrofossils. In recent years the potential usefulness of palaeobotanical studies in both physical and biological sciences dealing with our natural environment has been clearly established. The methods used in palaeobotanical research have become more precise and versatile and allow an improved assessment of the basic hypotheses employed in the interpretation of the Quaternary palaeobotanical and palynological record.

A REVIEW OF QUATERNARY PALAEOBOTANY AND PALYNOLOGY IN CANADA

INTRODUCTION

This review is not intended to be a complete bibliographical listing of reports and achievements but rather a discussion of trends of research which can be detected in the historical development of Canadian Quaternary palaeobotany and, in addition, a necessarily speculative prediction of future trends based on the scope and objectives of current research.

The writer feels that it is appropriate to define some of the relevant terminology because of existing uncertainties and inconsistencies of usage. In recent years the term 'Quaternary' has gained preference over the still widely used 'Pleistocene', a term approximately equivalent to 'Anthropogene' in U.S.S.R. terminology. All these terms refer to the period extending from the end of Pliocene (Tertiary) to the beginning of postglacial (or Holocene) time. Considerable uncertainty exists about the stratigraphic as well as the chronologic position of the lower boundary of the Quaternary. The estimates of age for that boundary range from less than one million years to more than two million years. The upper boundary of the Quaternary is almost equally ill-defined. In the peripheral areas of the last glaciation this boundary (or the Pleistocene and Recent boundary, or the Pleistocene and Holocene boundary) has been placed at about 11,000 years B.P. (before present), when the final rapid retreat of the continental ice-sheets began. However, northern Canada was still largely ice-covered and in the grip of fully glacial conditions. Postglacial time arrived in northern Quebec some 7,000 years B.P. It is apparent that the late-glacial to postglacial boundary is not synchronous in a north-south direction.

For the purpose of expedience the term Quaternary is used in this report in its widest sense and thus includes all of post-Pliocene time and also the postglacial, or Holocene. The main reason for this rather unorthodox usage is to separate this discussion from those concerned with Mesozoic and Tertiary palaeobotany. Furthermore, this usage of the term Quaternary might be considered permissible in view of the much larger number of palaeobotanical studies made of postglacial deposits than of those of properly Quaternary age.

The following discussion is subdivided into: the early years, the period 1900-1930, the renaissance, 1930-1960, and the recent years. These subdivisions are discerned on the basis of scope and emphasis of studies which are characteristic of each period.

THE EARLY YEARS

In this episode the writer includes the studies made before 1900. The early studies can be best described as reconnaissance and discovery. The contemporary geological and botanical studies made were generally

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distinguished by their exploratory nature as opposed to the much more systematic studies which followed. A thorough description of these early years, relevant as background for palaeobotanical studies, and of the prominent field men of the time has been given by F.J. Alcock in his report: A Century in the History of the Geological Survey of Canada (Alcock, 1948). One of the best sources of information on Quaternary palaeobotany of the early years can be found in the scattered notes contained in many geological reports published by Geological Survey officers. Much useful information on the studies made before 1920 is found in F.C. Baker's comprehensive summary report (Baker, 1920). Specialization, a characteristic feature of most recent geological reports, was not emphasized in the early years and the field notes contain observations on a variety of subjects, including plant-bearing beds of Quaternary age. Unfortunately, it is frequently difficult to establish whether these beds are of interglacial, interstadial or in some instances of Tertiary age. Compact peat beds of Quaternary age, resembling lignite, were sometimes interpreted as indicating a Tertiary age. Conversely some of the soft Tertiary lignite layers were thought to be of interglacial age.

In addition to occasional notes in geological reports relevant to palaeobotanical studies, some reports were primarily concerned with Quaternary deposits, for example, the studies by Penhallow (1896), and an investigation by Hinde (1878) of the glacial and interglacial strata of Scarborough Bluffs near Toronto, Ontario.

Another characteristic feature of the early palaeobotanical studies was their primary concern with macrofossils. Only in exceptional studies, such as that by Hinde, was any mention made of plant microfossils.

THE PERIOD 1900 - 1930

The reconnaissance and discovery phase of Quaternary palaeobotany continued during this period but other trends also became apparent. Concentrated studies were made of the interglacial deposits at Toronto by Coleman (summarized in Coleman, 1933). In these studies, however, the emphasis remained on plant macrofossils. Johnston (1923) reported on the plant-bearing Quaternary beds at Point Gray in the Vancouver area. In these studies comparisons were made between the fossil assemblages and present vegetation, and palaeoecological as well as palaeoclimatological interpretations were attempted. The results indicated that the interglacial plant fossil assemblages found in the Don River Valley at Toronto represented climatic conditions probably warmer than the present and that those from the Vancouver area indicated cool to cold climatic conditions. The studies by Coleman and Penhallow also suggested that several species identified by them represented extinct plants (Penhallow, 1907) but the results of later studies have seriously questioned the validity of some of these suggestions (Brown, 1942). Palaeobotanical studies of buried plant-bearing beds of Quaternary age were made by Auer (1927a) in the James Bay Lowland, Ontario.

A rather different trend of palaeobotanical studies was introduced early in this century by Anrep (1914), Nyström and Anrep (1909) and later by Auer (1927a, b, 1928, 1930). These investigations were aimed at a survey of peat resources in Canada for the anticipated use of peat as fuel or for other purposes. The peat deposits examined were of postglacial age, and the

classification involved identification of the predominant plant fossils comprising the different stratigraphic layers of peat. In spite of the primarily economic objectives of these studies, they led to a reconstruction of the development of the vegetation responsible for peat accumulation and the probable contemporary palaeoecological conditions.

With the introduction of palynological studies as a stratigraphic tool in comprehensive peat surveys in Sweden by von Post in 1916, and the applications of the same method in studies of forest history and postglacial climatic changes, the peat surveys attained an important position as a source of palaeobotanical information. Although the economic value of these surveys gradually declined because of the unrealized potential which had been expected of the peat resources, the studies of peat bogs nevertheless continued to be useful in geological, botanical and archaeological investigations. The reason for the continued interest in peat deposits lay in their value for dating certain geological and archaeological events and providing evidence for past climatic and ecological and vegetational changes. This information was commonly obtained through palaeobotanical studies (both macrofossils and microfossils) of the peat deposits.

The palynological and palaeobotanical studies of peat bogs in Canada were introduced by Auer (1930) and Bowman (1931). Auer made a comprehensive study of peat bogs in southeastern Canada. However, two major difficulties became evident during these early palynological studies. The methods worked out in Europe were not readily applicable in Canada, because of the larger number of species involved (even when the studies were restricted to tree pollen) and the lack of both palynological and botanical reference data essential for a meaningful interpretation of the pollen record.

The period 1900 – 1930 ended under somewhat discouraging and confusing circumstances. The palaeobotanical studies of Quaternary and postglacial deposits did not receive enthusiastic acceptance by geologists and archaeologists, as had been the case in Scandinavia. The studies were also hampered by the serious lack of necessary, basic reference data. The future for Quaternary palaeobotany looked anything but promising and bright.

THE RENAISSANCE, 1930 – 1960

The renewal of interest in Quaternary palaeobotany did not occur suddenly. Rather it was a gradual development that closely paralleled the rise of interest in Quaternary geology in Canada from the "dark ages", as it gradually became apparent that an improved knowledge of Quaternary deposits and glacial history was necessary for understanding and interpreting existing vegetation and soils. The problems of land use, including forestry and agriculture, further emphasized this need. It also became necessary to know something about the past climatic changes and the palaeoecological development of the existing ecosystems.

The progress of palaeobotanical studies in the earlier part of this period was rather slow for two main reasons. First, the number of people actively engaged in this field was very limited, and second, the size and complexity both of the regions and problems to be studied were enormous (Coleman, 1941). It was not readily possible to adapt and apply directly the

methods worked out in Europe because, for example, of the floristic differences of the vegetation and the ecological requirements and tolerances of the different species involved. Much basic research had to be undertaken both in palaeobotany and botany in general before attempting application of the established methods in the investigation of Quaternary deposits. It might appropriately be called the phase of enlightenment during the early renaissance period of Quaternary palaeobotany in Canada.

The emphasis in palaeobotanical studies between 1930 and 1960 was almost exclusively placed on investigations of plant microfossils (except, for example, notes on macrofossils by Porsild, 1938), commonly known as pollen analysis, or more correctly palynological studies – a term first proposed during the later half of this period.

Major palynological investigations were made in Western Canada by Hansen (1947, 1949, 1950, 1950a, 1952, 1953 and 1955), and a comprehensive summary was published by Heusser in 1960. In 1947 a palynological study was made in Labrador by Wenner, and in northern Quebec by Grayson in 1956. Palynological studies in southern Quebec were made by Radforth (1945) and by Potzger (1953, 1954), Potzger et al. (1956), Potzger and Courtemanche (1956, 1956a), and by Ignatius in 1956. In southern Ontario the interstadial Port Talbot beds were studied by Dreimanis (1958), and in northern Ontario a bog profile was investigated by Janson and Halfert (1936). A palynological study of bogs in southern Ontario was made by Wilson and Webster (1943), and Wilson (1946). The writer studied non-glacial deposits in the St. Lawrence Lowland and in the James Bay Lowland (Terasmae, 1958; Terasmae and Hughes, 1960), and the interglacial beds at Toronto and postglacial deposits in the St. Lawrence Lowland (Terasmae, 1960). In maritime Canada postglacial deposits were studied by Livingstone (Livingstone and Livingstone, 1958) and Ogden (1960). J.C. Ritchie had established a comprehensive and continuing palynological and palaeoecological program in Manitoba.

It should be noted that most of these studies, with the exception of the investigations made by Campbell (1952), Dreimanis (1958) and the writer, were made of postglacial (Holocene) deposits. The writer initiated his palynological program in 1952 in British Columbia, where the studies made included both postglacial and older deposits on Vancouver Island and the lower Fraser Valley. In the following years this investigation was expanded to include studies in Ontario, Quebec and New Brunswick. More recently these studies have been extended to the Canadian Arctic, Newfoundland, Nova Scotia, Saskatchewan and Alberta. Some reports have been published on the results obtained (for example: Terasmae, 1956; Terasmae and Craig, 1958; Terasmae, 1959; Terasmae and Fyles, 1959). This long-term investigation has been characterized by reconnaissance in the palynological sense, and by the application of these studies in Quaternary geological projects. As a rather natural outcome, close cooperation has developed, for example, with colleagues in the fields of forestry, ecology, phytogeography, climatology and soil science. Some of the studies have been applied in archaeological research.

By 1960 Quaternary palaeobotanical studies in Canada had again attained a recognized standing, and the number of people working in this field was steadily increasing. A renaissance of this particular field of science had indeed occurred.

THE RECENT YEARS

In the last six years several important developments have taken place in the Quaternary palaeobotanical research in Canada. Besides the expansion and increased number of studies made (Hegg, 1963; Mackay and Terasmae, 1963; Terasmae, 1963; Terasmae, 1965; Anderson and Terasmae, 1966; Lewis et al., 1966; Terasmae, 1966; Terasmae and Hughes, 1966; Terasmae, Webber and Andrews, 1966) other new trends have also become apparent. Probably the most significant among these trends are the re-emphasis of macrofossil studies and the critical reviewing of several fundamental aspects of the palynological field of research.

Many previously held views have been challenged on the basis of new evidence gained from palaeobotanical studies or from advances made in related fields such as ecology, forestry and climatology. For example, the earlier interpretations of the Quaternary pollen record in terms of palaeo-ecology, climatic changes and history of vegetation have been criticized rather severely on several grounds. The validity of the assumptions on which such interpretations had been based was placed in doubt, and it has become necessary to carefully re-evaluate the earlier accepted hypotheses (Ritchie, 1964; Ritchie and de Vries, 1964). Studies of airborne pollen and modern pollen deposition in surface sediments as related to the existing local and regional vegetation (King and Kapp, 1963; Ritchie and Lichti-Federovich, 1963; Terasmae and Mott, 1964 and 1965; Terasmae, 1967) have helped to improve the interpretation of the palynological record in Quaternary deposits.

The identification of fossil pollen has been difficult because of insufficient descriptive data on modern pollen morphology. Extensive studies in this field are urgently needed in spite of the several minor contributions made to date. Care and caution should be used when identifying fossil pollen with the help of keys and illustrations available in pollen-morphological literature outside of North America. There is always a definite danger that possibly erroneous identifications will be made through superficial similarity of the fossil pollen grain with the illustration available for a non-Canadian species. It might be suggested that palynologists who have established extensive reference collections of pollen and spores at their laboratories should be persuaded and encouraged to publish illustrated reports on pollen and spore morphology of Canadian species.

The usefulness of plant macrofossils in, for example, palaeo-ecological studies has again become recognized because such fossils (including seeds, leaves, and wood) can frequently be identified at the species level whereas the identification of fossil pollen commonly can be made only at the generic level. The macrofossils, furthermore, reflect more accurately the local vegetation.

In data collecting and handling the trend has been towards greater precision and versatility owing to recent technological advances in the field of data processing. The palaeobotanist has become more conscious of the possible use and application of statistical methods, and the cooperation between him and his colleagues in other botanical fields has generally improved to the benefit of both.

An additional trend in the field of applied palaeobotany has been the use of palaeobotanical information in studies other than the traditional stratigraphic correlation of deposits and history of vegetation. The recent emphasis on problems related to pollution and conservation has opened new avenues for palaeobotanical research. The dynamics of our changing environment can be better evaluated and understood in the light of an historical background which helps to distinguish between introduced factors and the natural development of the ecosystems. For example, problems concerned with black spruce growth on peatland and the effects of presently employed management practices can be viewed in relation to the past development of this ecosystem.

In sedimentology the mode of deposition of certain types of layered deposits can be established by the use of palaeobotanical methods. In certain cases it can be shown that these sediment layers are annual or seasonal (Terasmae, 1963). In meteorology airborne pollen dispersal can be used in tracing movements of air masses. The problem of native and introduced species can sometimes be solved by using palaeobotanical studies (i.e. Bassett and Terasmae, 1962).

At the present time the outlook for Quaternary palaeobotany is promising and in Canada the full potential of this research technique is gradually being developed. However, because of the size of our country the most serious limiting factor is the small number of palaeobotanists actively engaged in this field of research.

LOOKING INTO THE FUTURE

There is little doubt that the major efforts for some years to come will be directed towards collecting the necessary basic palaeobotanical data. At the same time palaeobotanical methods will become considerably more sophisticated, both in the data processing field and in precision, as well as in their relationship to other botanical fields such as phytogeography, taxonomy and evolution of vegetation. It seems probable a reasonably complete history of the Quaternary vegetation will be established for several major regions in Canada. The evidence gained from such history will, in turn, help to clarify the evolutionary changes from the Tertiary vegetation to a rather different Quaternary plant distribution pattern.

One might venture a guess that palaeobotanical studies may also contribute towards the explanations required for the solution of the controversial issues about continental drift and polar movements.

The need for considerable expansion of palaeobotanical training at our universities will be seriously felt for several years ahead and every effort should be made to improve this situation.

Quaternary palaeobotany may help to solve the problems related to our forest and agricultural resources management and we may eventually learn how to deal with and master our extensive muskeg areas and northern regions which at the present time are still insufficiently known in many aspects.

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