# INTERNATIONAL SUBCOMMISSION ON JURASSIC STRATIGRAPHY

Newsletter No. 14

Jim

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A SUBCOMMISSION OF THE INTERNATIONAL UNION OF GEOLOGICAL SCIENCES (IUGS)

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Dear members,

1. First of all the next International Symposium on Jurassic Stratigraphy will take place in Lissabon (Portugal) from 12.-21. September 1987 (including the pre- and post-excursions, and the meeting itself from 15.-18. September 1987).

All inquiries should be directed to the organizer:

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First announcement has been mailed.

2. New Guidelines for the work of the commission on stratigraphy appeared and are attached as enclosure No. 1. All work at present has mainly to concentrate on the establishing of boundary stratotypes for stages, series and systems.

In a further circular the commission urges the subcommissions to submit proposals of those stratotypes as soon as possible.

All members therefore are asked to read the guidelines and to contribute or assist as far as possible to this programm. If you can make good proposals for possible stratotypes, you are asked to send your suggestions directly to the working group concerned (enclosure No. 2 is a list of working group coordinators). Also other contributions

...2

to this work are welcome. Please contact the coordinators. Especially non-ammonite workers are asked to inform the coordinators about possible contributions.

3. The planned meetings in Hungary and Poland cannot take place. We try to find other solutions. The second International Field party with members of the Bajocian to Callovian working Groups took place as planned at Sengenthal 1st-3rd May 1986. A report will follow in the next newsletter.

4. New statutes have been edited by the Commission on Stratigraphy. Interested members may apply for a copy at the secretary, O. Michelsen.

4. A report on the Jurassic in Canada by T.P. Poulton is enclosed (enclosure No. 3).

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Enclosure No. 1

# Guidelines
## of the International Commission on Stratigraphy (ICS)

by

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Contents

Preamble

In recent years the increasing volume and complexity of the work of the International Commission on Stratigraphy (ICS), a commission of the International Union of Geological Sciences (IUGS), has created a demand for procedural guidelines and for updating and reissue of the Statutes of ICS.

The following Guidelines have been shown to the President and Secretary-General of IUGS but the Bureau of ICS are solely responsible for their content.

The Statutes, however, constitute a formal directive document which has been ratified by the Executive Committee of IUGS in February 1986.

The Commission is responsible for the coordination of international stratigraphy from the earliest part of the Archaean Eon through the Proterozoic and Phanerozoic Eons to the Recent and includes studies on all aspects of stratigraphy - physical, chemical and biological. A considerable part of these guidelines is devoted to the currently important topic for ICS of selection and definition of Boundary Stratotypes. It must not be assumed, however, that other aspects of stratigraphy are not of great importance too and developing studies in future years may considerably change the present emphasis and require further guidelines to be drawn up.

These guidelines are not necessarily retrospective and do not automatically affect decisions already approved and made by ICS and ratified by IUGS. The International Stratigraphic Guide (Hedberg 1976), prepared and published by the Subcommission on Stratigraphic Classification of ICS, contains valuable discussion and recommendations but it was never adopted by ICS as a statutory policy document; it is now being revised. These Guidelines and Statutes prepared by the Bureau of ICS should be used in preference when and where there is a difference between them and the International Stratigraphic Guide.

## A. GENERAL

### A.I. Introduction

1. Included in the statutory objectives of the International Commission on Stratigraphy (ICS) under IUGS are development of a standard global stratigraphic scale, distribution of information on its major subdivisions, establishment of their boundaries and correlation of their subdivisions. To achieve these objectives on an agreed international scale ICS has been established as the motivating, guiding and approving organization, subject to the oversight, monitoring and ratifying function of the IUGS Executive Committee and drawing upon ICS's constituent Subcommissions, Working Groups and Committees. These constituent bodies of ICS continue to elaborate and correlate standard global Series, Stages and Systems and a major part of this work has been to define boundaries between them. "Accurate communication without definition is impossible" (McLAREN 1977:23). Boundary Definition, utilising a unique point in a rock sequence represents (if correctly selected in accordance with the practice given in these guidelines) as nothing else in material geology can, a unique instant of time thus defining, unequivocally, a standard against which other sequences can be correlated by the analysis of all available data. Unit and composite stratotypes do not fulfil these requirements.

2. Biological/Palaeontological species are subjective and the full range is unknown - due to incomplete research, or incompleteness of the geological

record. This can be overcome by using several independent groups of fossils to correlate faunal/floral assemblages.

3. It is salutary to recall that "matters of positive science that concern nature, require discovery and apply some test of truth" should be distinguished from "matters of normative science, that are regulated by man as part of his method of understanding nature and which apply tests of correctness and utility." (HARLAND 1973:571).

4. It can be argued that choices in international stratigraphy should violate historical priority as little as possible: this consideration can often be overridden by the higher priority of going for the best and making progress. Confusing historical precedents may need to be set aside by an authoritative international decision (which is very likely to violate some established usage) by a recognized authority like ICS.

5. Some ICS bodies may find it useful to have ex officio, voting, organizational, titular, honorary, associate and corresponding categories of membership. For the work within subcommissions, working groups and committees this is entirely acceptable to the Bureau of ICS. For the formal business of ICS (the Commission as a whole) it is necessary to identify all categories of members of ICS and its bodies as either Voting or Corresponding (Non-Voting) Members and these two categories must be clearly distinguishable and so reported in the annual return of membership.

6. It was decided at the 27th IGC in 1984 that decisions of ICS or of ICS bodies can best be achieved by postal ballot of all Voting Members of ICS or of ICS bodies, as the case may be.

This does not diminish the importance of face-to-face plenary meetings, of course, but enables them to make recommendations (to go later to a postal ballot) even when attendance at the meeting is restricted. A quorum for ICS or ICS bodies' Voting Members is fixed at the comparatively low figure of 35%. Under present financial restraint this quorum requirement can thus allow valid recommendations from meetings to be put to a postal ballot.

7. ICS is expecting that more proposals will be forthcoming in the next four/five years. Intersystem Boundary Working Groups (independently responsible to ICS and with their own financial allocation) and Intrasystem Boundary Working Groups of a Subcommission should normally conclude their work within a time not exceeding eight/nine years from their initiation.

## A.II. Voting and other procedures

These can be generalised to include all approvals of decisions of both ICS itself and its constituent bodies.

1. ICS having been persuaded of the need of a special study a Committee, Working Group or Subcommission will be set up and by consultation a convening Chairman will be asked by the ICS Bureau to convene it. When the founding Voting Members have been recruited then officers are elected by them and submitted to the ICS Bureau for approval together with the list of Voting Members. Corresponding Members can later be recruited by the Working Group officers without recourse to ICS for approval. The membership should have a wide geographic spread and include experts with specialities in various disciplines but also a comparable proportion of those particularly interested in the stratigraphic subdivision above and below in the case of a boundary stratotype.

2. Study and review in field, laboratory and in the literature, with consultation of all with contributions to make can then proceed.

3. Discussion at a plenary session of an ICS body (or a series of plenary sessions) should lead to a selection of a candidate*(or candidates but not more than two or three) to be put to a postal ballot of <u>all</u> the Voting Members. The time and place of a plenary session must be advertised, at least a year in advance, through circulars and geological magazines and journals. The place of meeting should be where all members have convenient access (with visas provided for all where appropriate). Any voting results of those present at the plenary session can be circulated for information (in an impartial fashion) but such votes have no mandatory status: the substantive measure is the postal ballot. If all members at the plenary session are allowed to vote it should be made clear in circulated information the proportions of Voting Members, Corresponding Members and guests and the voting numbers separately itemised. The quorate or non-quorate proportion of Voting Members must be given.

*for stratotype

It is rarely, if ever, that <u>all</u> Voting Members can attend a plenary session because of competing commitments, some of which may be unavoidable, often because of paid employment duties.

4. Ideally the postal ballot should be for only one candidate at a time. If there are two or three candidates then these should be reduced to one by a preliminary postal ballot with an absolute majority of 50% + 1 for it. The final postal ballot must be YES or NO for one candidate decision. The Chairman and Secretary-General of ICS or of the ICS body should conduct the postal ballot, supplying full and adequate documentation (including reports on plenary sessions) to each Voting Member. If there are more than one candidate, then the voting on each should be kept quite separate and not interdependent or grouped under one vote. Assistance in the work from Secretary or Vice-Chairman would not remove responsibility from the Chairman.

5. In order to proceed to a Submission to ICS the vote should achieve a 60% majority of the total vote of Voting Members. A clear consensus is desirable. A difficulty, of course, is the perennial one of 'non-voters', 'too-late voters' and 'abstainers' - should they be excluded from the total from which the 60% majority is demanded? One device is to stipulate on the voting paper that if a vote of YES or NO (abhorring 'Do not knows') is not received by a given deadline date from a Voting Member then that person's vote will be recorded as a YES on the grounds that if a Voting Member really wants to disagree then he will take the trouble to say NO in time. It is the responsibility of the Bureau of ICS to ensure that each Voting Member has actually received the Voting Papers. Genuine declared abstentions can be excluded from the calculation of the 60% majority.

6. Intersystem and Intrasystem Boundary Working Groups will include members with interests on either side of the boundary and this representation will normally ensure that the flanking Subcommissions (X system and Y system, for example) will have full confidence in democratic decisions made by the Boundary Working Groups. The Bureau of ICS through the Chairman and Secretary General will ensure that this is so before proceeding to the next stage (7 below). In exceptional circumstances votes of the Subcommissions (X & Y) may be taken by postal ballots under the supervision of ICS. The motive at this stage is to monitor procedure and fulfilment of guidelines to ensure a fair decision and not to challenge geological scientific points.

7. The officers of the ICS body should then, having received the mandate of a 60% majority vote, prepare a Submission to be sent to the ICS Chairman and by him to the Bureau. At this stage the submission will be checked against ICS guidelines and, if necessary, returned for amplification and amendment. THE SUBMISSIONS CAN BE SENT TO ICS AT ANY TIME. After processing and possible return to the Working Group for amplification a postal ballot of all Voting Members of ICS will require a majority in favour of 50% + 1 votes for approval of the Submission. If it is wished for the ratification by IUGS Executive to be completed before a change of Chairman at the next International Geological Congress (or during the IGC) then a Submission deadline date of 8 months before the IGC must be fulfilled (e.g. 1 December 1988 for the 28th IGC in August 1989).

8. The Submission approved by ICS will then be sent by the ICS Chairman/ Secretary General to the Executive Committee of IUGS for final approval and will be formally promulgated when approved. In 1985 this has been done in the official IUGS journal Episodes. It is expected that a full final report will be fully published in a widely circulated international geological journal.

9. Permanent artificial marking and recording in print and by visual aids (photographs, remote sensing, video recording, etc) of the Global Boundary Stratotype Section and Point (GSSP) in the field follows. Establishment of arrangements for preservation of the GSSP and accessibility for responsible and authorised study (having regard to conservation) should then be completed.

A.III. Notes on the role of ICS officers (Bureau) and the officers and members of Subcommissions, Working Groups and Committees generally.

These are in amplification of the ICS Statutes.

1. The Chairman of ICS

(i) The Chairman (or a deputy from the Bureau of ICS) may attend all meetings of the Commission and its Subcommissions, Working Groups and Regional and other Committees.

(ii) The Chairman (or deputy) may ask to address the meeting in order to present any matters which ICS wishes to bring to the attention of the meeting.

2. Members of Subcommissions, Working Groups and Committees

Members are individual scientists with expertise and experience in their field and are not delegates of their nation, organisations, associations or any other bodies. They cannot, of course and rightly, shed their origins and allegiances but should vote as individuals. Membership should have a wide global geographic spread except in more limited Regional Committees.

As McLAREN so clearly argued (1977:24) "The principle to be learned here is that in this kind of a committee (Silurian-Devonian Boundary Committee) there must be no delegates who represent a particular point of view from a 'school', society or nation. It is only by interacting among themselves, with freedom to change their minds that there can be any possibility of reaching an agreement."

As was stated in 1977 (VAN DER HEIDE: 3-4) after outlining the chief aims and objectives of IUGS: "It is important to stress that the above mentioned aims and objectives relate to the cooperation of geologists in their personal scientific capacity." In a later IUGS pamphlet (LAFFERTY 1981:2) it is again stated that IUGS is "A voluntary professional organization. It is non-governmental, non-political and non-profit-making." MARTINSSON (1976:459-462) addressed these aspects relating to IUGS and IGCP advocating influence for a wide spectrum of geologists.

Voting Members shall be retired after a number of years of service (at the time of an IGC) so that ⅓ of the voting members become Corresponding Members at the time of each IGC. New Voting Members can then take their place.

Voting Members are subject to approval in their appointment by the Bureau of ICS; they are expected to have a number of years of professional experience and wisdom with wide geographic spread of coverage.

Corresponding Members do not need to be approved by the Bureau of ICS - they should be active workers in the field of interest of the body and keep in touch by correspondence and/or personal contact.

There is no limit to the number of Voting or Corresponding Members except practicality in communication and availability of finance. Personal contact and attendance at meetings would normally be expected of Voting Members.

Exceptions may be made in retirement rules given in both the ICS Guidelines and the Statutes if there is a real shortage of candidates with sufficient expertise and experience to replace officers and members of ICS bodies (or even the ICS Bureau).

The Bureau of ICS would expect to be consulted before this abnormal procedure was followed. Approval could then possibly be given by ICS and IUGS after consultation.

## A.IV. Past, Present and Future of ICS

Beginning with the first International Geological Congress in Paris in 1878, most International Geological Congresses have had commissions and committees, with various names and with various durations, which have been concerned with international cooperation in stratigraphy, stratigraphic classification, and stratigraphic terminology.

At the 11th Congress, Stockholm, 1910, a Commission on a Lexicon of Stratigraphy was created. This Commission functioned modestly through many subsequent Congresses. At the 19th Congress, Algiers, 1952, however, its name was changed to Commission on Stratigraphy and it was made to include two Subcommissions, namely, a Subcommission on the Lexicon of Stratigraphy and a Subcommission on Stratigraphic Nomenclature. Since this time the Commission on Stratigraphy has functioned continuously and many new Subcommissions have been added.

In May, 1965, the Commission formally applied for admission to the IUGS and was accepted as a commission of the IUGS. At that time the membership of the Commission was drastically reduced from 150-200 members to consist only of its officers and the presidents of its Subcommissions.

The Commission currently operates in a general framework provided by Article VII, Sections 24-28, of the IUGS Statutes and supplementary sections of the By-laws and Regulations of IUGS. Having lacked any statutes of its own, many of the governing rules of the Commission and its subordinate bodies have grown up quite informally. The presently proposed Statutes have been formulated both to accord with the Statutes, Bye-laws and Regulations of IUGS, and to meet a need for specific rules while at the same time preserving, as far as they have proved satisfactory, the existing informal organizational outlines and operating procedures.

At the request of the organizers of the 28th International Geological Congress to be held in Washington, D.C., U.S.A. in August 1989 the Bureau of ICS is itself initiating and also soliciting from ICS Bodies details of planned meetings, seminars and symposia for the IGC.

The Commission on Stratigraphy's meetings (as distinct from ICS bodies) will be devoted to original scientific contributions and reviews on stratigraphy. These will be comparable with those given at the IUGS's "Stratigraphy: Quo Vadis" symposium held at Bad Honnef, Federal Republic of Germany in 1982. Only a limited time will be allocated to a short ICS business meeting.

Submissions from ICS bodies of proposals for ICS approval and subsequent ratification by IUGS can be dealt with AT ANY TIME using correspondence and postal ballot.

Through ICS scientific meetings the advancing fronts of stratigraphy can be presented at the 28th IGC.

## B. BOUNDARY STRATOTYPES

### B.I. Introduction

1. Historical geology depends on positional relationships of rock and mineral bodies and identification of earth's evolutionary trends. "The importance of the boundary stratotype lies in its role as a future anchor to which all subsequent correlations can be tied, even if new palaeobiological or physical methods become available" and the importance of the boundary stratotype is because it is "the only place where we actually know (by definition) that time and rock coincide within our classification" (HOLLAND, 1984:149).

2. Global Boundary Stratotype Sections and Points (GSSP) allow maximum flexibility with the use of multiple hypotheses to give minimum ambiguity and the greatest likelihood of stability. It is essentially a unique and specific point in a specific sequence of rock strata in a unique and specific geographical location. This Boundary Stratotype Section and Point is the designated type of a stratigraphic boundary identified in published form and marked in the section as a specific point in a specific sequence of rock strata and constituting the standard for the definition and recognition of the stratigraphic boundary between two named chronostratigraphic units.

The prefix Global is used to emphasise that the GSSP is a unique time signal for the world geological stratigraphic time scale.

Insistence on a Boundary Stratotype Point is in order to define without doubt an instant of geological time. A horizon will, at the GSSP locality, contain the Point but the horizon may, traced laterally, be diachronous (cutting across time-planes) and may drift away from the instant of time defined by the point thus vitiating the unique concept. The correctly selected GSSP gives an actual point in rock and is not an abstract concept - all other methods can prove to be diachronic. It will be expected to remain fixed in spite of discoveries stratigraphically above and/or below. The main criterion must be that any horizon and point selected must be capable of being correlated over wide areas by any or all available methods. In a world which is not ideal it is most unlikely that all selected stratotype points can meet all the ideal requirements and stratigraphy must be a practical subject and responsive to the needs of working geologists.

The type locality of a GSSP is the specific unique geographic locality in which the stratotype is situated. A submission to ICS of a GSSP cannot be ratified on the basis of a recommended stratigraphic level only: the geographic locality must be exactly and precisely given.

The use of the prefixes holo-, para-, neo-, lecto-, hypo- to stratotype does little or nothing to assist in the definition of a GSSP for the purposes of international acceptance by ICS. Bodies of ICS may, for their own purposes wish to use prefix terminology but for the present at least ICS will not ratify it.

It is considered preferable not to use parabiological analogies which imply unsound analogies and cause confusion (e.g. holostratotype or parastratotype) but to confine nomenclature, for ICS candidates, to two categories of stratotype:

(a) global stratotype section and point (GSSP) and (b) auxiliary stratotype point (ASP) - the latter will be particularly useful in drawing upon stratigraphic correlation between markedly different facies, e.g. New Red Sandstone contrasted with marine Triassic or Devonian neritic facies contrasted with pelagic facies.

Supplementary sections furnishing additional elements of correlation will in any case be helpful and should be published but designations like "para-" or "hypostratotype" should be avoided as diluting and clouding the value of the GSSP. "It is not reasonable to expect the Commission on Stratigraphy presently to handle the matter of parastratotypes in a formal way. There is too much other urgent primary work on hand" (HOLLAND 1984:151).

The GSSP is unique and should not be subject to competition from these 'failed candidates' or 'syntypes' after a GSSP has been decided upon by ICS and IUGS. Otherwise international acceptance, prestige and respect for GSSPs will be delayed and may be diluted.

ICS still has a great volume of work to get through in the rest of this century and beyond and it will expedite matters if a plethora of lower status candidates are not submitted until the main GSSPs down to stage level are decided. Similarly regional stratotypes are the business of the region concerned and not relevant directly to the choice of a GSSP and the submission to ICS of a GSSP.

3. A Boundary Stratotype Point can be changed if a strong demand arises from further important research but will in the meantime give a stable point in time from an actual point in rock. For a change to be considered by ICS it would require support from 60% of the Voting Members of the ICS body responsible for the Boundary and a 50% + 1 majority of the Voting Members of ICS itself.

Boundary Stratotype Definition is a normative question which can be settled by a vote ... an operational boundary capable of being extended as a line on a map. (GLAESSNER 1984:139).

B.II Summary

Requirements for Submission to ICS of a candidate for a Global Stratotype Section and Point (GSSP)

A summary of the requirements are:

1. An explicit motivation for the choice of the boundary level, especially with respect to its correlation potential.

2. A correlation table showing the position of the proposed boundary with respect to former usage and to the most important markers, also clarifying rank and relative position of the unit under question.

3. An explicit motivation for the choice of the stratotype locality, taking into account palaeogeography, facies, tectonic 'environment' and other relevant factors including facility of access.

4. Exact data about the location of the type section and point: coordinates on a detailed topographic map of large scale, explanatory maps, diagrams and photographs (including aerial) and remote sensing.

5. A detailed description of the type section and point with vertical section to a large scale with graphic and written details of all relevant stratigraphic data: lithology, rangechart of index fossils, magnetostratigraphy and geochronometry are very desirable.

6. Relationship of stratotype section and point sequence to globally significant marker horizons in the immediate and accessible region, e.g. faunal or floral zone assemblages stratigraphically above or below the stratotype point, climatic markers such as tillites and many other factors assisting long-range or preferable global correlation. Correlation must precede, and accompany, definition of a boundary. The choice of an appropriate boundary level for the point is only possible in the presence of a marker horizon which has proved to be isochronous within the limits of precision attainable by stratigraphic methods. Auxiliary marker horizons as close as possible to the boundary level will give good approximate stratigraphic positioning where and when the primary marker is missing.

B.III Detailed guidelines for requirements and discussion:

1. Lithological succession, thickness, mineralogy, structure, geomorphic expression and other features. Vertical and horizontal sections, structure sections, graphic presentation of relevant factors e.g. isopachs. Seismic stratigraphy should be utilised. Photographs are particularly helpful.

2. The details of the global boundary section and point and its relationshi- to adjacent units. Markers (isochronous within limit of precision, palaeobiological, geochronometric, magnetostratigraphic, catastrophic, sedimentological, climatological etc.) near the GSSP and also correlatable with the GSSP succession in the region are of prime importance.

3. Clear and succinct reasons for the choice of the GSSP in both stratigraphic level and geographic location.

4. Methods used (or to be used if ratified) for the actual marking of the GSSP and particularly the actual stratotype point - "the golden spike". This should be a permanent artificial marker but described in position in words and visually by drawings and photographs so that removal by vandals or others does not prevent accurate restoration or replacement.

5. (a) Continuity of sedimentation through the boundary interval - preferably a marine succession without major facies change. A continuous monofacial (or with only rapidly alternating and repeating facies changes) will reduce possible errors resulting from stratigraphic gaps and biostratigraphic limitations due to the occurrence of facies fossils and appearances and disappearances associated with only environmental change and not to biological evolution of lineages.

(b) Completeness of exposure: not in an isolated position but with a succession which can be followed easily - above and below the GSSP and preferably laterally as well.

(c) Adequate thickness of sediments.

(d) *Abundance and diversity of well-preserved fossils: appearances and* disappearances of single fossil species can be expected to be diachronous and therefore a bad guide for the location of a GSSP. Multispecies fossil zones (e.g. faunal assemblages) may be preferable biostratigraphic signatures for GSSP guidance. Exclusion from consideration of taxa which are palaeoecologically tied to a facies would be the ideal although all fossils are to some extent facies fossils. In order to minimize possible effects of environmental controls on different fossil-groups, recognition of the boundary level should preferably be based on all available faunal and floral data.

The selection of appropriate fossils will vary greatly in different parts of the geological column. Ideally, selection of a point within an evolutionary lineage would be desirable but recognition of such lineages can be subjective and not necessarily more accurate than the recognition of a particular assemblage zone. Such decisions must be left to the experts in each case. The case for autochronology i.e. a single species taken out of a phylogenetic lineage (with its predecessor and successor known in detail) as the biological way of approaching a boundary free of ecological, facial or sedimentary disturbing effect was given by *WEDDIGE & ZIEGLER (1979)*.

(e) Favourable facies for development of widespread reliable and time-significant correlation horizons: this requires that the GSSP should not be in or close to conglomerates, breccias, olistostromes, turbidites or remanie deposits. This should, as far as possible, exclude variation of chronostratigraphic or chronometric age within the stratotype section near the stratotype point. Even if at the present stage of research, for example, fossils in derived blocks and surrounding matrix appear to be of the same age the danger exists that new techniques or new finds (palaeobiological or physical such as magnetostratigraphy) might discriminate between the blocks and matrix introducing an unacceptable imprecision in the future. even the "model" decision on the Silurian-Devonian Boundary has had, retrospectively at least, its weakness - the GSSP was placed within a turbidite on the basis of the "first" occurrence of a species. Nevertheless it is the first and longest-lived GSSP and no disrespect can be levelled. The boundary decision is internationally accepted. In 1985 it was sampled for magnetostratigraphic studies.

(f) Freedom from structural complication, metamorphism or other alteration: currently the question of exotic accreted terrains is pressing but the problem of the relationship between present and past position may not adversely affect global stratigraphy. Speculation here, which affects all historical geology, does not need to lead to despair or defeatism.

(g) Freedom from unconformities: an obvious boundary should be suspect. Either it is too obvious because there is a marked change in lithology or because there is a marked change in fauna or flora. In either instance the change may imply a time break, and consequently an unsuitable horizon at which to fix any time definition; no disconformities, unconformities, cryptic paraconformities or time-breaks in sedimentation any longer than a brief diastem can be tolerated close to a GSSP.

(h) Amenability to magnetostratigraphy and geochronometry. Although these factors are mentioned last they are probably the most important for future work and some would argue that no GSSP should be accepted without one or both.

6. One of the main aims of the Boundary Stratotype procedure of ICS is to attain a common language of stratigraphy that will serve geologists worldwide and to avoid the dissipation of energy in petty argument and unproductive controversy. Development of a standard global stratigraphic scale which is stable for a considerable period of time is the objective here. Testing can then proceed. If new developments demand revision it will be set in motion by ICS if a majority (50% + 1) of the Voting Members of ICS support the setting up of a new Working Group. In any case only in very exceptional circumstances will this be entertained until the next International Geological Congress (IGC) but one after the ratification of a GSSP (at present at the 1992 IGC in Tokyo, Japan). Very exceptional circumstances could include: - (i) permanent destruction or inaccessibility of an established stratotype, (ii) violation of accepted stratigraphic principles as clearly agreed by ICS.

Correlation of GSSP with elsewhere: the prefix global means, of course, that intercontinental correlation and with different facies must have been achieved. Choice of GSSP by working groups may involve an interrelated series of decisions in order to achieve optimum acceptability. In the overwhelming majority of cases in the Phanerozoic Eon (ICS is concerned with all Eons) correlation must precede the definition of a boundary but unless preliminary choices are made it may be that progress will be slow as the process of testing a candidate or the competition between candidates may be the required stimulus for the desirable improvement of needed correlation techniques and correlation itself. Correlation must precede the selection of boundary stratotype candidates to a considerable extent but in practice the sequence may be reversed. The finding of the best level and geographical site may have to go on side by side for a time. The choice between two more or less equally suitable boundary levels may be influenced by the availability of a better GSSP for one of them. Correlation to a satisfactory degree is necessary but improvements in correlation should continue after a boundary stratotype has been selected. In this context of correlation (actual at present and with future potential) an ideal GSSP would have the maximum possible correlation by magnetostratigraphic and geochronometric methods: this is of increasing importance for future work. In reality there is probably no GSSP in existence which can satisfy all desired criteria. Compromise seems inevitable if progress is to be made with the global stratigraphic scale. In the Phanerozoic Eon (and with the Precambrian-Cambrian Boundary also) the prime polarity factor being biological evolution, boundaries will normally be guided in their definition by chronostratigraphy (mainly biostratigraphy) but in the Proterozoic and Archean Eons the guidance will be chronometric at the present stage of research. Chronostratigraphy can be expected to be used increasingly for boundaries late within the Precambrian successions.

Because of the multiplicity of criteria involved and the variation in circumstances through the geological time scale it would be unwise (or impossible) to specify which criteria are essential and which are desirable up and down the scale. Expert assessment must be the responsibility of the appropriate experts in that field of study. It is unlikely that all boundary stratotypes will possess all criteria and some compromise must be expected.

7. Accessibility and Conservation: these two topics are contrasting but complementary factors (two sides of the same coin). Recent experience has shown that if access to an important outcrop is too easy and unrestricted then excessive collecting, even vandalism and plunder, may destroy the outcrop. Conservation and some restriction is therefore necessary in developed regions. Conservation in more remote regions may be easier but this depends on regional geological activity (with helicopters maybe) by outsiders. A stratotype in a large disused quarry may seem ideal until planning permission is given in its urban area for garbage-dumping. In some countries large holes in the ground are at a premium for the growing mountains of garbage which are a costly disposal problem to authorities.

A problem for conservation/access may be weathering which in some cases may be rapid and caused by heavy rainfall forming rapid mud-flows from, for example, a marly sequence. Frost may form screes which can soon cover an outcrop. Outcrops on sea coasts may be subject to very rapid erosion. All are factors which must be considered when choosing a GSSP.

There must be no insuperable physical and/or political obstacles for access by geologists of any nation; without great expense and ideally without much bureaucracy. At the International Geological Congress in Moscow (1984) the plenary session of ICS agreed that a reasonable amount of collecting must be possible at a stratotype section. Although it is difficult for any group of geologists to commit any nation or organization to guarantee access and conservation for the indefinite future, total accessibility must assume considerable importance. One important safeguard is that if there is some prestige and responsibility in being "host" to a Global Stratotype Section and Point (GSSP) then that may in itself guarantee access and conservation. If a GSSP is found not to be accessible in the future this would be a very powerful argument for a reassessment of the geographic location. In a Submission of a GSSP to ICS all these factors should be discussed in detail as far as is feasible.

8. There is a metamorphosis once a GSSP has been ratified by IUGS: -

(i) beforehand all methods of correlation are enlisted to define a globally valid boundary stratotype section and point between what is decided should belong to System X or System Y.

(ii) After the decision the GSSP can be used to indicate without ambiguity what constitutes earliest System X and latest System Y. Correlation has in any case to precede the definition of a GSSP. Possibilities of correlation should be, of course, tested simultaneously at different levels close to the boundary being defined. The most suitable level would then be chosen as the boundary level and strictly defined by a GSSP, becoming thus the only standard of reference.

There is no conflict between the global boundary stratotype concept and global, isochronous, event stratigraphy. The combination of global environmental change and major biotic changes (which may be caused by biological evolution) brings together lithostratigraphy and biostratigraphy to provide event stratigraphy. Stratotypes bring stability through an agreed point in rock representing a unique instant of time (cf. BERRY 1984). The ultimate reference is to rock and not to abstractions.

In this work in the past decade or two much inspiration and guidance has been derived by the international geological community from the brilliantly-expressed published results of the Silurian-Devonian Boundary Committee (McLAREN, 1977), which have the great virtue of being based on practical experience in actually defining a GSSP. One recommendation made by this committee was that, in the case of the Silurian-Devonian Boundary, the "horizon chosen defines the base of the Devonian, and not necessarily the top of the Silurian. Should it subsequently be shown that the selected horizon is at the level of an undetected time break or hiatus, unrepresented by sedimentation in the section, then the time missing would, by definition, belong to the Silurian". (McLAREN, 1977:20).

Although there is no scientific principle involved in considering the base of a unit any more important than the top of a stratigraphic unit, ICS bodies (e.g. Subcommissions) are responsible by convention for the base of their units.

Boundary Working Groups set up by ICS or its constituent bodies must, however, include experts on the unit below as well as experts on the unit above. Hence the appellation of intersystem working groups is the composite term e.g. Silurian-Devonian, Jurassic-Cretaceous etc. The convention that chronostratigraphic units are defined by their lower boundary (which automatically becomes the upper boundary of the underlying unit) is intended to guarantee the creation of a time scale of contiguous units with no man-made gaps or overlaps. This is also one of the justifications for the preference for boundary stratotypes and not unit or composite stratotypes (HEDBERG et al. 1976).

After ratification of the Silurian-Devonian Boundary stratotype in 1972 a period of great activity by ICS and its bodies has resulted in the ratification in 1985 by ICS and IUGS of a number of boundary stratotypes (Ordovician-Silurian; Series and Stages of the Silurian System; Series of the Devonian System; Pliocene-Pleistocene) (BASSETT 1985).

The submissions to ICS for these and other stratigraphic boundaries illustrate well the substantial progress which has been made during the past 13 years, but there is an undeniable heterogeneity in the format and quality of the presentations and hence the need for the formulation of these guidelines. Guidelines have to reconcile conflicting demands: freedom of scientific opinion and free choice of methods of correlation on one side and a reasonably unified procedure which ensures that the basic questions are answered. It is essential that the general geologist is helped and not just the specialist stratigrapher. The method of ratification by the Voting Members of ICS (representing the whole field of stratigraphy) and by the IUGS Executive (representing all aspects of the geological sciences) means a submission to ICS should clearly summarise all relevant points and be expressed in a cogently organised format. The vital minimum of agreement concerning general problems of procedure is here given with a set of rather precise technical recommendations about how to present submissions of stratotypes.

It is essential that, although there is a geographic component in all opinions, agreement under ICS is sought in an international manner, excluding considerations tied to a region or, in the main, other than those which are scientific. It is therefore strongly stressed that in the work of ICS members are scientists who are involved in an individual capacity.

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Appendix I

Brief CHECK-LIST
for criteria used in selection of a
GLOBAL STRATOTYPE SECTION AND POINT (GSSP)
under ICS Guidelines

1. Explicit motivation for the preference ✓
2. Correlation on a global scale ✓
3. Completeness of exposure
4. Adequate thickness of sediments
5. Abundance and diversity of well-preserved fossils
6. Favourable facies for widespread correlation
7. Freedom from structural complication and metamorphism
8. Amenability to magnetostratigraphy and geochronometry
9. Accessibility and conservation

Enclosure No. 2

Distribution:

Triassic/Jurassic boundary working group:

| | |
|---|---|
| R.Mouterde | Facultes catholiques de Lyon<br>25 rue du Plat<br>F - 69 288 Lyon Cedex 02 |
| J. Guex | Institute de Géol.,<br>Palais de Rumine<br>CH - 1005 Lausanne |

Hettangian/Sinemurian boundary W.G.

| | |
|---|---|
| Bloos, G. | Staatl.Museum für Naturkunde<br>Königstein<br>7000 Stuttgart |

Sinemurain/Pliensbachian boundary W.G.

| | |
|---|---|
| R.Schlatter | Museum zu Allerheiligen<br>Naturhistorische Abteilung<br>CH - 8200 Schaffhausen |

Pliensbachian /Toarcian boundary W.G.

| | |
|---|---|
| R.Fischer | Geologisches Institut<br>Callinstr. 30<br>3000 Hannover<br>(agreed to continue once more) |

Toarcian/Aalenian boundary W.G. (Lower/Middle Jurassic)

| | |
|---|---|
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| H.Rieber | Paläont.Institut u.Museum<br>Künstlergasse 16<br>CH 8006 Zürich |

Aalenian/Bajocian boundary W.G.

| | |
|---|---|
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Bajocian/Bathonian boundary W.G.

| | |
|---|---|
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Bathonian/Callovian boundary W.G.

| | |
|---|---|
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Callovian/Oxfordian boundary E.G. (Middle/Upper Jurassic)

| | |
|---|---|
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| X G.Melendez | Depart.Paleontologia<br>Fac. Ciencias, Universidad<br>Zaragoza/Espana |

Oxfordian/Kimmeridgian boundary W.G.

| | |
|---|---|
| X F. Atrops | Institut des Sciences de la Terre<br>Université Claude Bernard<br>F - Lyon 1 |
| X F. Melendez | Zaragoza |

Kimmeridgian/Tithonian (Portlandian, Volgain) W.G.

| | |
|---|---|
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| M. Mesezhnikov | VNIGRI<br>Liteiny 39<br>Leningrad 191104/UdSSR |

Jurassic/Cretaceous boundary W.G.

| | |
|---|---|
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| x V. Zakharov | Siberian Branch of the USSR<br>Acad of Sciences<br>Inst.of Geology and Geophysics<br>Novosibirsk 90/USSR |

Jurassic micropaleontology W.G.

| | |
|---|---|
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Jurassic brachiopods

| | |
|---|---|
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Jurassic Magnetostratigraphy W.G.

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Jurassic Sponges and Coelenterata W.G.

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2000 AD Haarlem/Netherlands

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Newsletter No. 14

Supplement to the list of coordinators (encl.2):

For the Kimmeridgian/Tithonian Working Group the following three persons may be contacted as coordinators:

- J.C.W. Cope, chairman
- M. Mesezhnikov, handles Volgian problems
- A. Zeiss, handles Tithonian problems.

# THE JURASSIC IN CANADA 1986

T. P. Poulton, Geological Survey of Canada

## INTRODUCTION

The general character of the Jurassic basins, except for some in the tectonically and stratigraphically complex western Cordillera, and their fossils is now reasonably well known in a general way. Current studies concentrate on refinement of the lithostratigraphy and stratigraphic nomenclature, evaluation of the petroleum potential, involving organic geochemical and other techniques, interpretation of basin margin and sediment source direction characteristics, and detailed description and biogeographic and biostratigraphic characterization of the fossils.

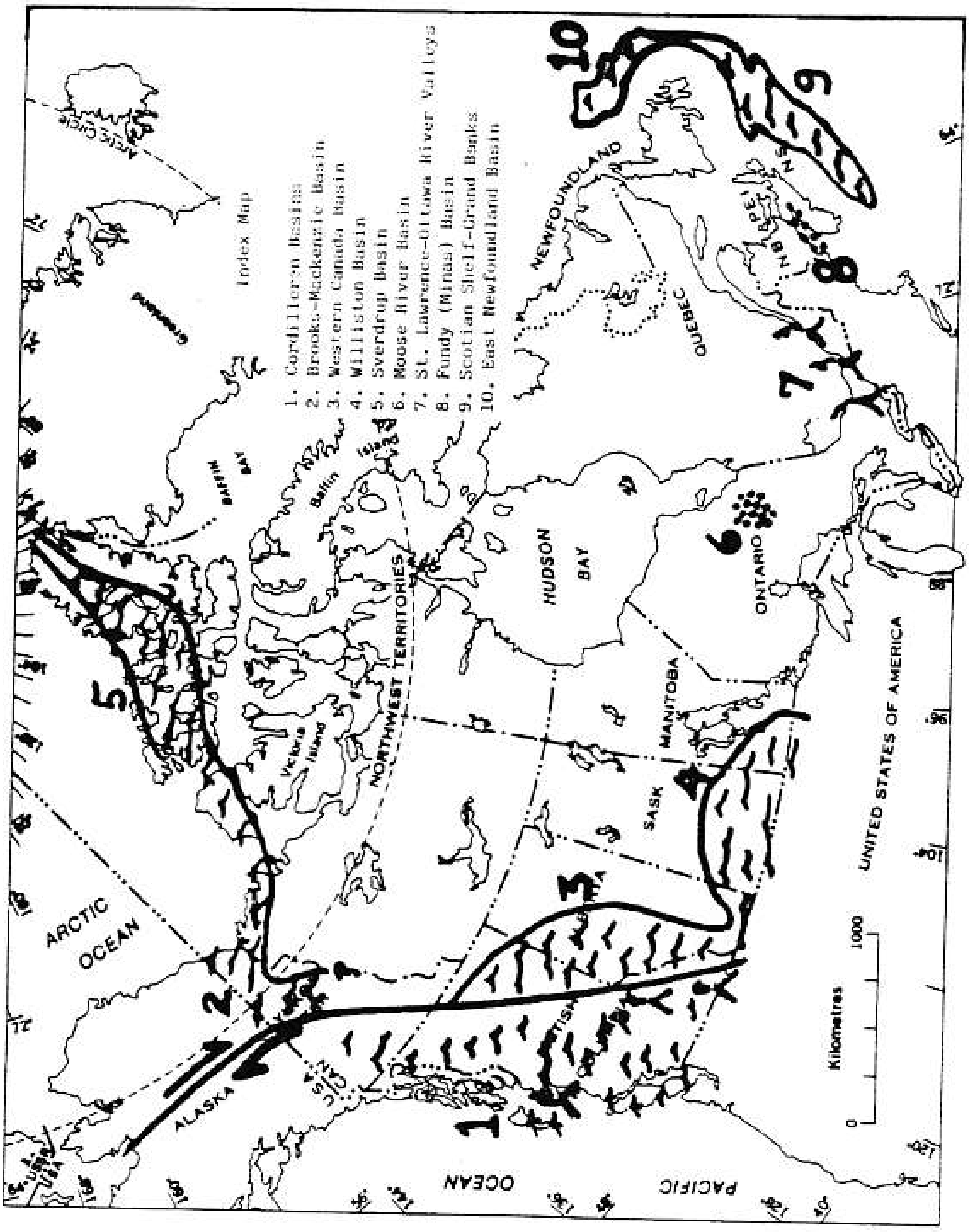
A major effort to synthesize the geology of North America is currently underway. It is a series of 27 volumes, organized by regions primarily, and by ages secondarily, and is known as "The **Decade of North American Geology" (D-NAG)**. Contributors from all parts of North America are involved. The major emphasis is on synthesis and understanding, so that a simplified yet comprehensive treatment of the Jurassic basins of each area of North America is a reasonable expectation. Those parts dealing with Canada and Alaska are currently well under way.

## BASINS SYNOPSIS AND TECTONIC STUDIES

### 1. Cordilleran Basins

Progress is being achieved rapidly in unravelling the tectonics, stratigraphy and paleontology of the Cordilleran Jurassic. The Cordillera in Canada and United States is an amalgam of exotic terranes that were accreted to North AMerica at different times, and which have moved northward to varying extents along transcurrent faults since they were accreted. The best of many recent reports on these subjects are by Monger et al. (1982), Jones et al. (1983), Saleeby (1984), Irving et al. (1979), Irving (1984), Gabrielse (1985) and papers in volumes edited by Howell et al. (1984) and Tempelman-Kluit (1985).

Current interpretations (Monger et al., 1982; Tipper, 1984) involve coalescence of some of the terranes prior to their being accreted against the westerly-drifting continent. In particular, a widespread Early Jurassic volcanic unit indicates coalescence of the Stikinia, Cache Creek, Quesnellia, and Eastern Terranes into a single superterrane (I) which was accreted to North America in Middle Jurassic time. The accretion event resulted in Jurassic plutonism (Archibald et al., 1984), crustal thickening, and uplift in southeastern British Columbia and subsidence of Alberta Trough foredeep adjacent to the mountain belt in Western


Index Map
1. Cordilleran Basins
2. Brooks-Mackenzie Basin
3. Western Canada Basin
4. Williston Basin
5. Sverdrup Basin
6. Moose River Basin
7. St. Lawrence-Ottawa River Valleys
8. Fundy (Minas) Basin
9. Scotian Shelf-Grand Banks
10. East Newfoundland Basin
ARCTIC OCEAN
PACIFIC OCEAN
ALASKA
USA
CAN
Victoria Island
Baffin Island
BAFFIN BAY
Greenland
Arctic Circle
NORTHWEST TERRITORIES
HUDSON BAY
SASK
MANITOBA
ONTARIO
QUEBEC
NEWFOUNDLAND
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PEI
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UNITED STATES OF AMERICA
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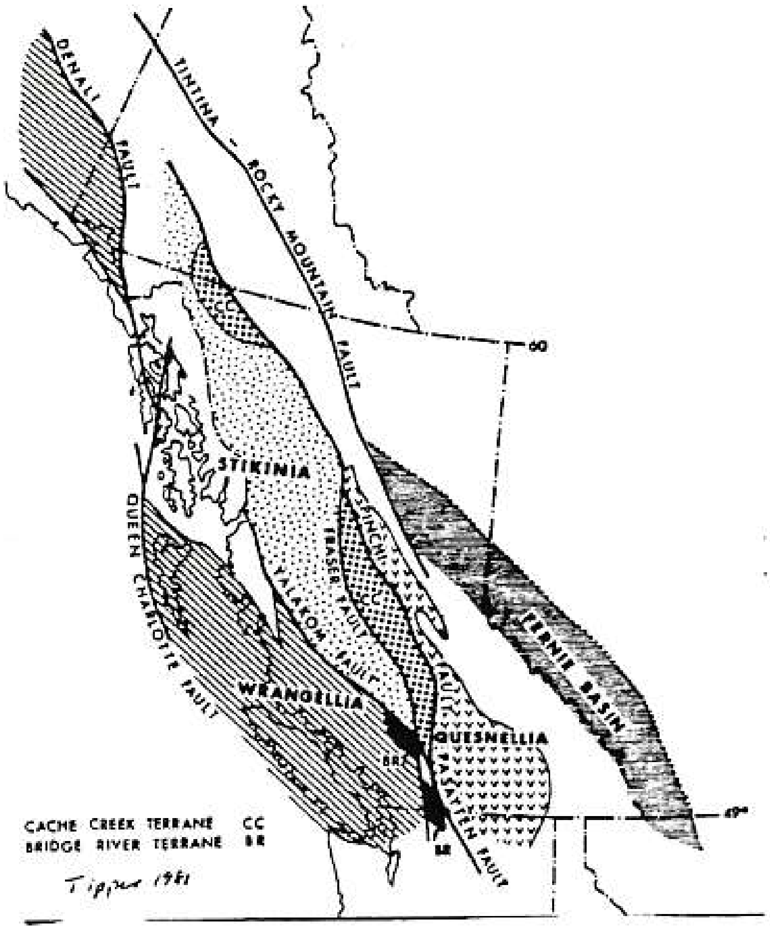
Canada Basin (Poulton, 1984). Similarly, the Wrangellia and Alexander terranes farther west coalesced in about Late Jurassic time as indicated by the common occurrence of the Gravina-Nutzotin assemblage, and this superterrane (II) was accreted in Cretaceous time, resulting in formation of the Coast Plutonic Complex.

Some of the earliest evidence contributing to interpretation of juxtaposition of unlike terranes was produced by paleontology (Tozer, 1970, p. 635), and the bearing of fossils on these questions continues to be discussed. Tipper (1984) has discussed the implications arising from the Jurassic evidence. Jurassic dates from some plutons which cut both exotic and North American rocks in southeastern British Columbia indicate Jurassic suturing in that area (Archibald et al., 1984), so that the exotic terranes cannot, in Jurassic time, have lain a long distance away. This is supported by paleontologic studies which indicate that the Jurassic fossils of the exotic terranes are of not only northern hemisphere, but of eastern Pacific (i.e. North AMerican) affinities (Tipper, 1984; Taylor et al., 1984; Callomon, 1984; Jeletzky, 1984). Discussions of this sort place useful controls on the sometimes extravagant hypotheses of tectonics and paleomagnetic specialists. None of the reports to date however, has discussed the very close similarities of western Canadian Jurassic faunas with those of eastern Asia, nor treated the potential role of larval migrations longitudinally along the western coasts of Jurassic North America. These fruitful lines of study might point to alternative interpretations of the faunal similarities. The discussions mentioned above inevitably suffer from a lack of basic published data, although the authors involved have knowledge of much of the unpublished data:- most of western Canada's fossils remain undescribed, and not surprisingly new faunas are still constantly appearing, some of which are endemic, some of which support the speculations mentioned above, and some of which re-inforce the cosmopolitan character of some species, and the European, Arctic, East Asian, or South American character of others. Regarding the interpretation of where a fossil was initially deposited, only their present location is known. Their ancient location can be interpreted from paleomagnetic or tectonic data, but we simply do not know the ancient distributions, and so no primary data source is available when speculating on ancient fossil distributions. In the Cordillera, the fossil data should be considered as interesting supportive material for 'harder' data - matching halves of plutons split by transcurrent faults, paleomagnetic evidence, etc. Interestingly, most paleontologists now seem to agree on the North American affinities of the Jurassic Cordilleran faunas, as mentioned above and as indicated strikingly by the attitudes expressed at the 1985 Geological Society of America Cordilleran Section Annual Meeting in Vancouver (May, 1985), and this consensus is swaying the non-paleontological tectonic community. Just as there is never a "right" time to write a synthesis, there is never a wrong time either, and the contributions mentioned above are a large step forward, speculative as they may be, and a basis for fruitful discussion.



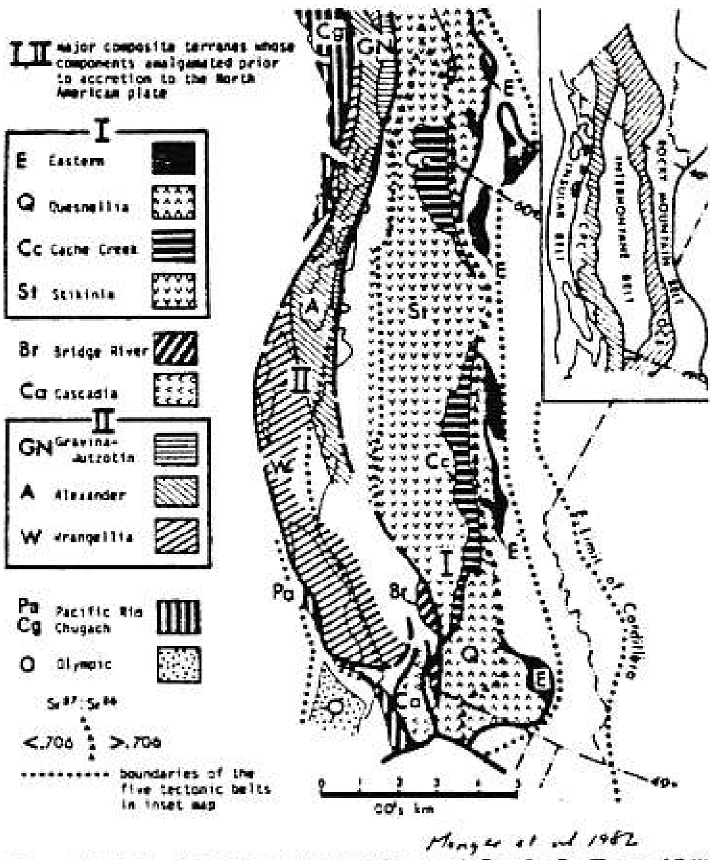




Figure 1. Distribution of allochthonous (or suspect) terranes in Canadian Cordillera, and their relationship to the five geologic and physiographic belts in inset map. Heavy lines enclose terranes (I, II) composed of small, originally independent terranes that amalgamated prior to accretion to western margin of the North American craton. Note coincidence between former boundaries of North America and I, and of I and II with, respectively, Omineca Crystalline Bel (OCB) and Coast Plutonic Complex (CPC). $^{87}Sr:^{86}Sr$ line (Armstrong and others, 1977; Armstrong, 1979; personal commun.) marks probable western limit of Precambrian continental crust at ancient continental margin or in blocks that may have been displaced outboard from

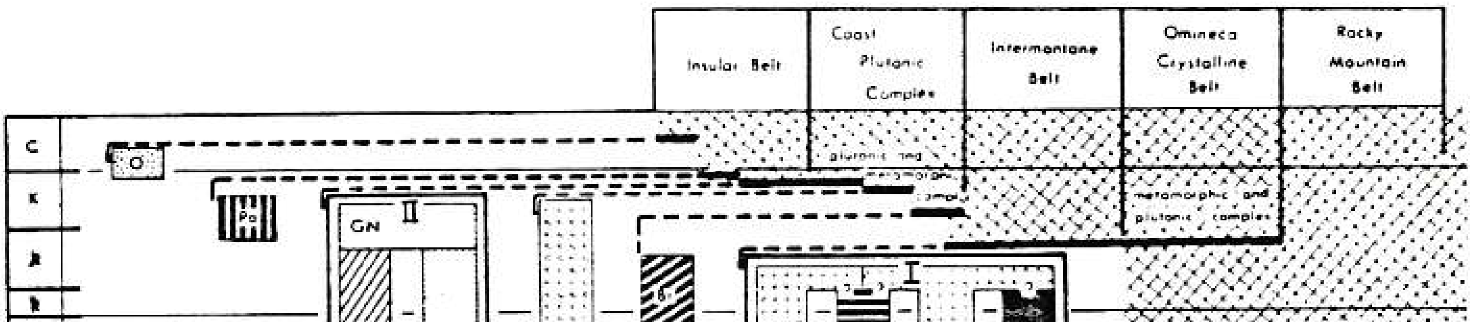



Figure 2. Space and time relationship of allochthonous (or suspect) terranes in Canadian Cordillera. Shown are depositional interval represente by each terrane; overlap assemblages in terranes I and II, indicating coalescence prior to accretion to western North America; unknown spatial relationships during deposition of allochthonous terranes, indicated by vertical spaces separating them; times of accretion to western margin of North America and present location with respect to the five belts; coincidence of metamorphic and plutonic Omineca Crystalline Belt and Coast Plutonic Complex with boundaries between, respectively, I and North America and II and (mainly) I; and accretionary, westward-built, nature of western margin of North American plate. Figure does *not* show structural relationships between terranes. These may be thrust faults (for example, Ca on II, I on North America) or strike-slip faults (for example, Ca with Br and I). Monger et al 1982

Cordilleran Basins,

British Columbia

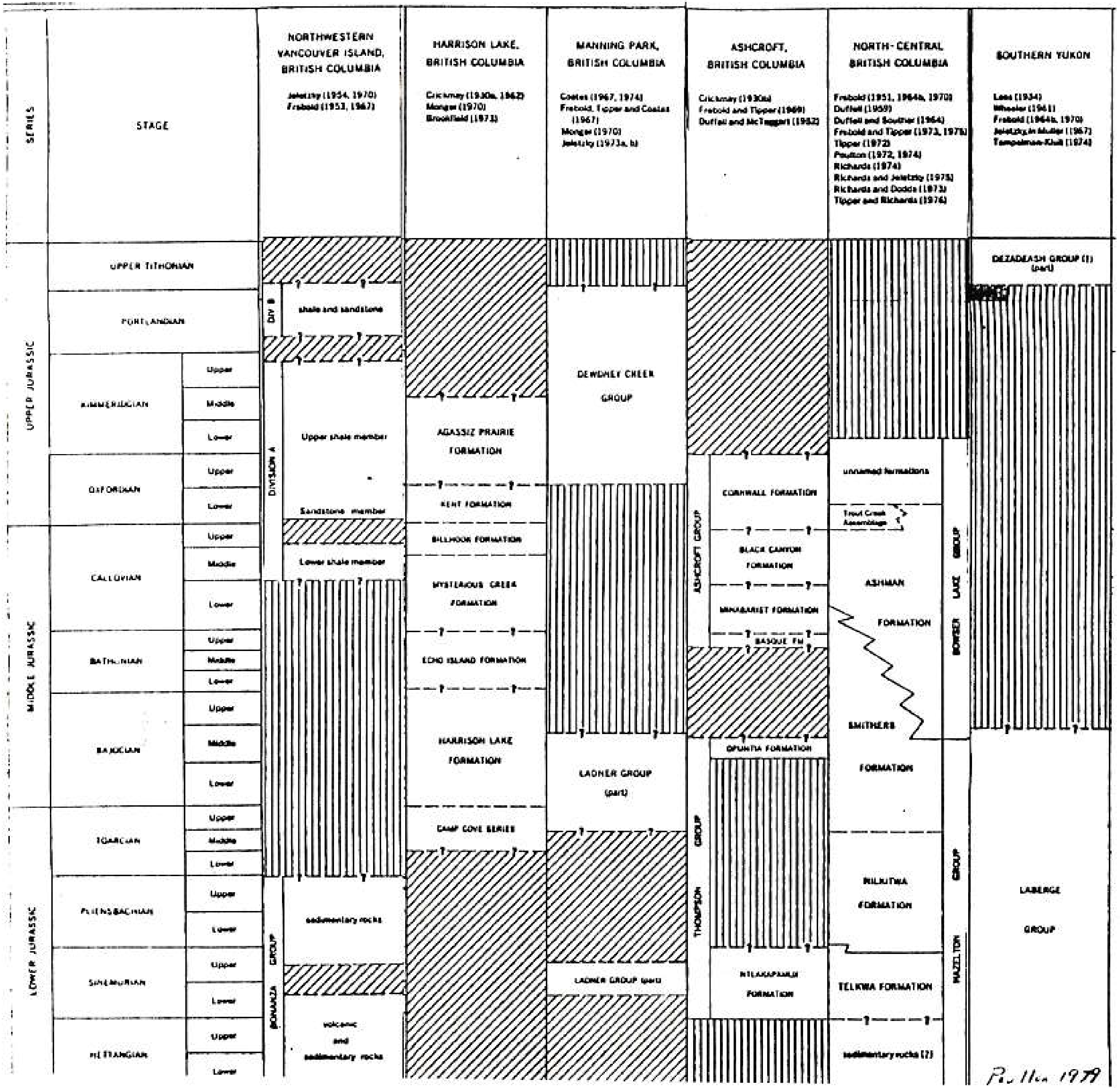



**Table 1.** Jurassic formations, Queen Charlotte Is

*Cameron + Tipper 1985*

| STAGE | GROUP | FORMATION |
|---|---|---|
| KIMMERIDGIAN to TITHONIAN | | |
| L. CALLOVIAN to U. BATHONIAN | MORESBY | ALLIFORD<br>NEWCOMBE<br>ROBBER POINT |
| LOWER BAJOCIAN | YAKOUN | RICHARDSON BAY<br>GRAHAM ISLAND |
| AALENIAN to U. TOARCIAN | MAUDE | PHANTOM CREEK |
| U. TOARCIAN to M. TOARCIAN | MAUDE | PHANTOM CREEK |
| MIDDLE TOARCIAN | MAUDE | WHITEAVES |
| L. TOARCIAN & U. PLIENSBACHIAN | MAUDE | FANNIN |
| LOWER PLIENSBACHIAN | MAUDE | RENNELL JUNCTION<br>GHOST CREEK |
| UPPER & LOWER SINEMURIAN | KUNGA (in part) | SANDILANDS |

The Queen Charlotte Islands Jurassic stratigraphy has been described in detail recently by Cameron and Tipper (1985), who have subdivided the earlier lithostratigraphic units, named finer ones, and listed their characteristic fossils.

New finds of radiolarians from what was called the Leech River Formation document for the first time the presence of Late Jurassic to Cretaceous rocks on southernmost Vancouver Island (Rusmore and Cowan, 1985), suggesting similarities with the Spieden Group (Johnson, 1981) of adjacent San Juan Islands.

The Cordillera remains an active area, and a rash of reports on all aspects, including Jurassic fossils, can be expected in the near future.

## 2. Brooks-Mackenzie Basin

Detailed work continues on the paleontology of the Jurassic deposits. The most recent comprehensive summary and reference list is by Poulton (1984). Microfossils and palynomorphs from the Late Jurassic Husky Formation have been, or are currently being, studied but the results have not been published yet. The formation was recently described in detail by Braman (1985). Jurassic rocks are no longer thought to have any western source (Poulton, 1984), nor to be affected by Arctic Ocean tectonics, which initiated in Cretaceous time (Norris, 1983).

## 3. Western Canada Basin

Stratigraphic studies of detailed areas continue. Stronach (1984) has treated much of the Fernie Formation from a paleoenvironmental viewpoint, and Hall (1984) has discussed and summarized its lithostratigraphic character and nomenclature. The most recent comprehensive summary of all the Jurassic of this basin is by Poulton (1984). Highlights include confirmation of the great sub-Upper Jurassic unconformity in the north part of the basin where the Middle Jurassic appears to be entirely missing and further documentation of the relation of the onset of subsidence of the foredeep in the Late Jurassic concomitant with loading by thrusting of the Cordilleran orogen to the West. Gibson (1985), Hughes and Cameron (1985) and Ricketts and Sweet (1986) have described in detail the nonmarine coal-bearing Late Jurassic Kootenay Group. Ricketts and Sweet have also described latest Jurassic palynomorphs and characterized the Jurassic/Cretaceous boundary palynologically. The Late Jurassic Swift formation in southeastern Alberta, where the western Canada Basin and Williston Basin join over Sweetgrass Arch, has been treated by Hayes (1983).

Toarcian shales of the Fernie Formation have yielded some interesting new fossil discoveries, including the first Jurassic teuthid from North America (Hall, 1985) and well preserved fish (Neuman and Wilson, 1985).

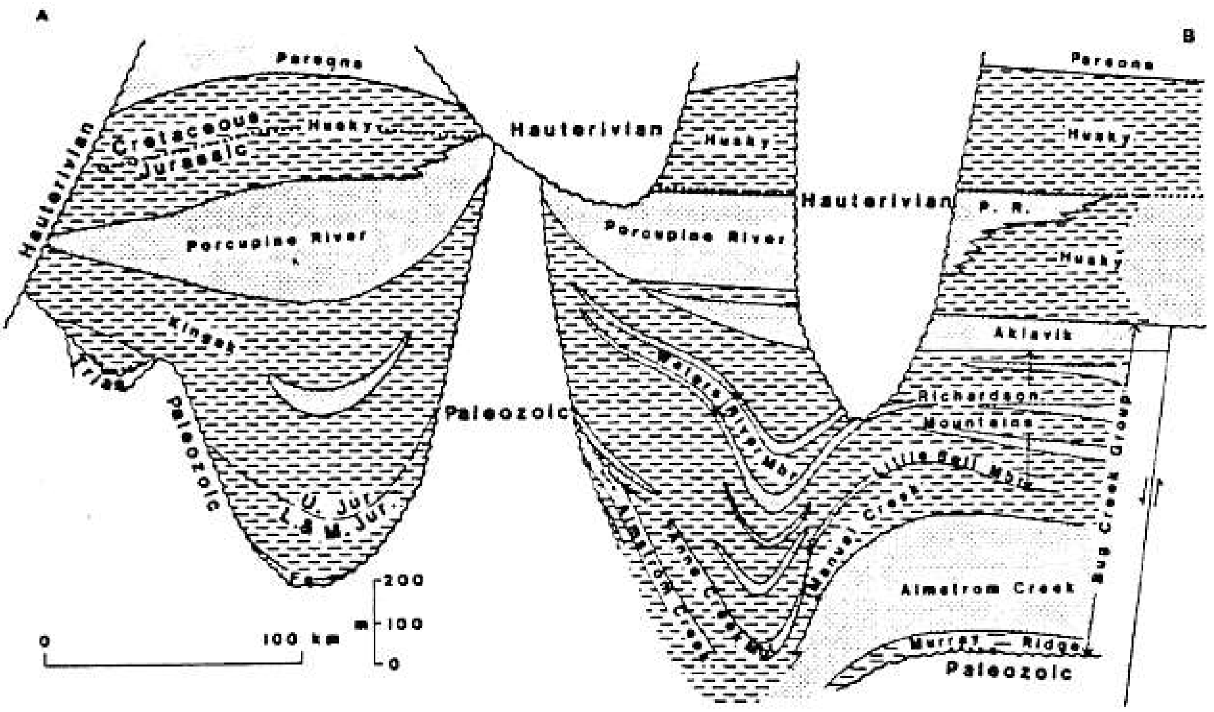



**Fig. 4.** Southwest-northeast stratigraphic cross-section along southeast edge of the Brooks-Mackenzie Basin, northern Yukon. Location of section shown in Figure 2. The thicknesses and relationships in the southwest half are poorly known and largely speculative. Those shown are based partly on data of Jeletzky (1975, 1977, 1980). Other parts of the diagram draw on data from Dixon (1982a,b, pers. comm.) and Young (1975). Poulton 1984

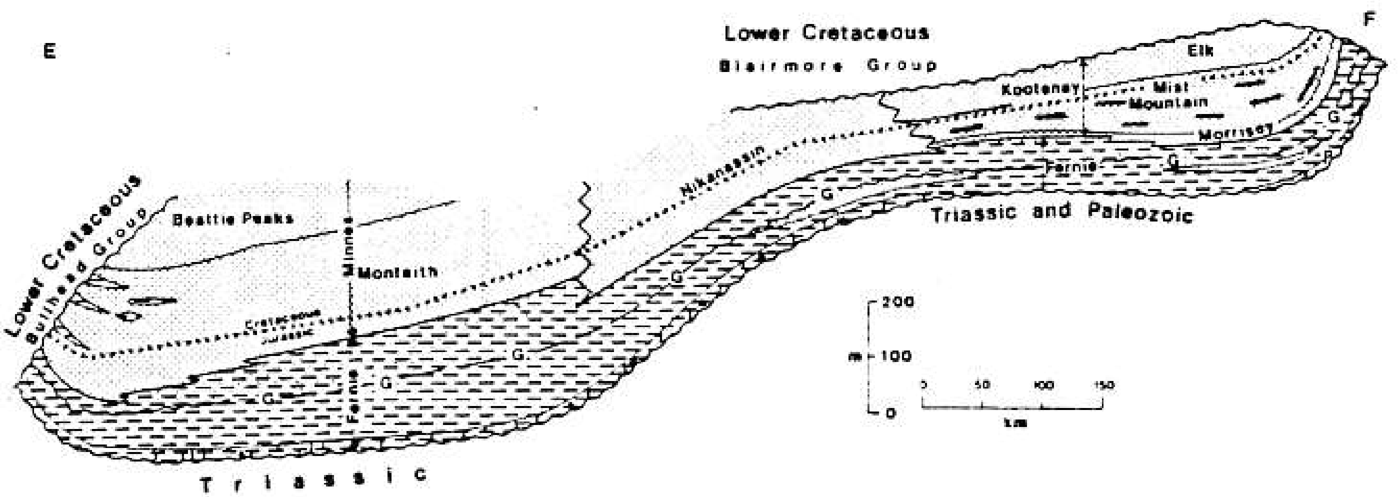
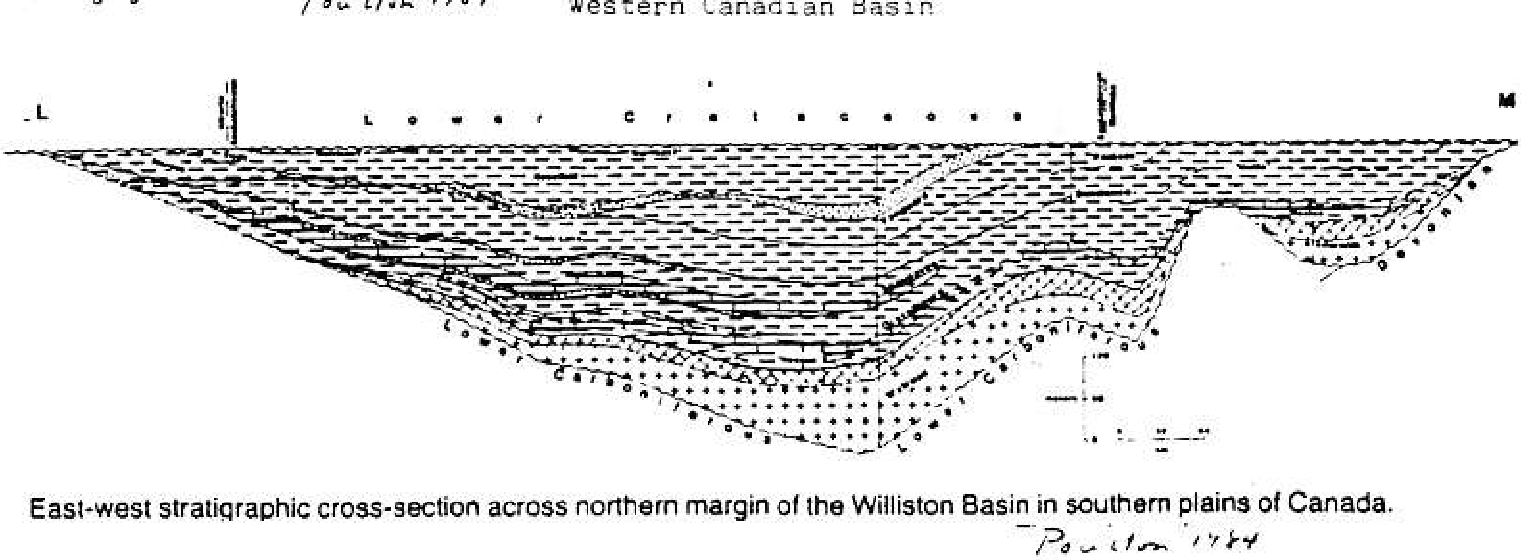
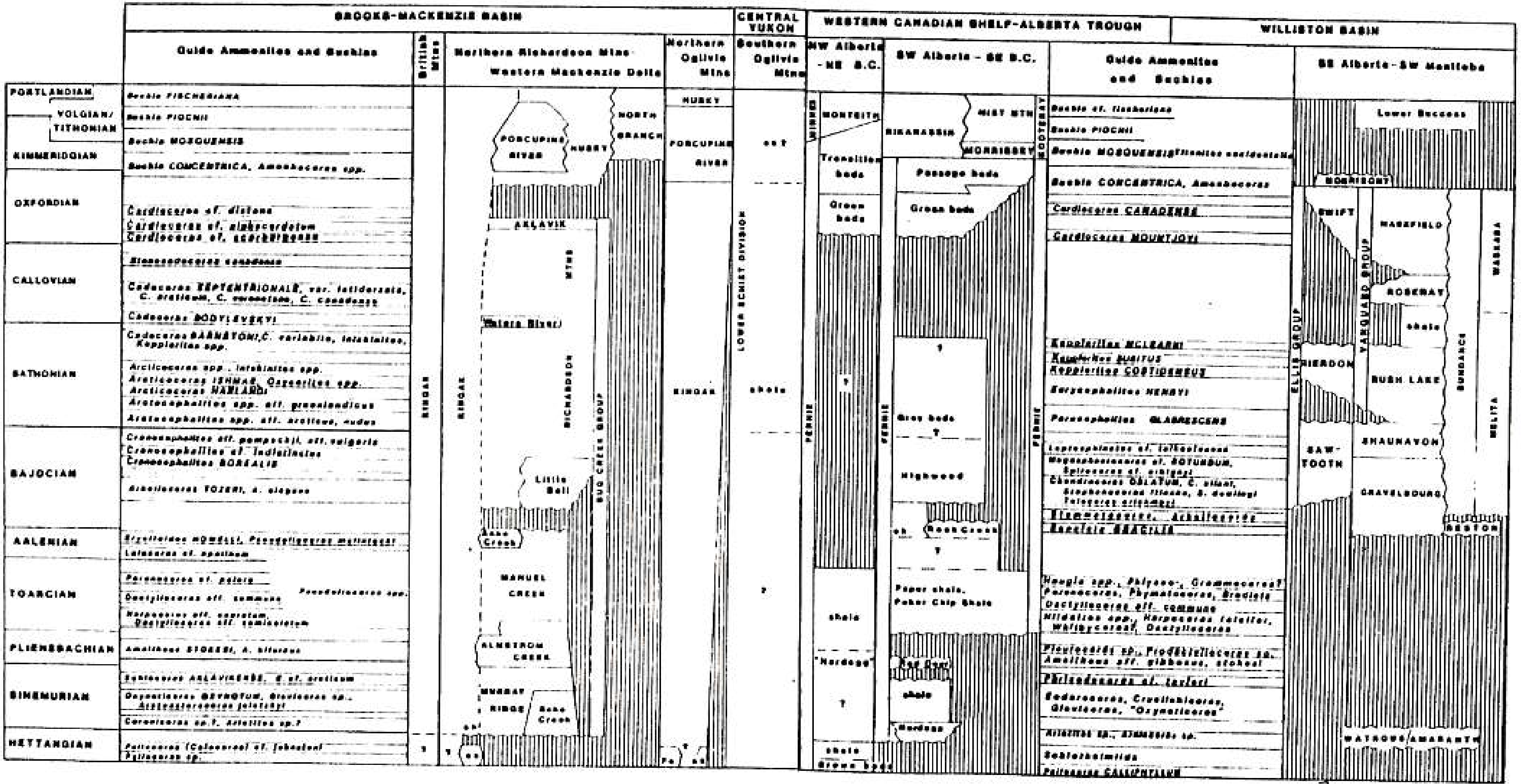



**Fig. 6.** Northwest-southeast stratigraphic cross-section along the western miogeocline and Alberta Trough in western Alberta and eastern British Columbia, data from many sources, particularly Stott (1967a) in northeastern British Columbia. Location of section shown in Figure 2. Symbols shown following Figure 22. Poulton 1984 Western Canadian Basin




East-west stratigraphic cross-section across northern margin of the Williston Basin in southern plains of Canada.

Poulton 1984




Poulton 1984

## 4. Williston Basin

The most recent comprehensive summary of this important Jurassic, subsurface province, is by Poulton (1984) and the essentials of the basin are outlined by Christopher (1984). Detailed stratigraphic studies of particular intervals or regions are by Christopher (1984) on the late Jurassic and Cretaceous, of southern Saskatchewan, and Barchyn (1984) on the Lower Jurassic of southern Manitoba. Both these intervals are very poorly understood. Late Jurassic rocks are now recognized in the base of the Mannville Group by palynology; the Lower Jurassic is in a red-bed/evaporite, entirely unfossiliferous facies. These contributions essentially treat detailed aspects of oil and gas occurrences. Particularly interesting are the interpretations of ancient meteorite impact craters preserved in the basin, and revealed by seismic reflection profiles in both Canadian and american parts of the basin (Sawatzky, 1977; Bally, 1983). Some of them appear to be part of a worldwide swarm at about the Triassic/Jurassic boundary.

## 5. Sverdrup Basin

The basic Jurassic stratigraphy of Sverdrup Basin is by now fairly well known. Recent advances are in detailed study of the strata in the subsurface, where they are penetrated by boreholes as a result of hydrocarbon exploration. New nomenclature reflects the new understanding and interpretations (see Embry, 1982, 1983a, b; 1984, 1985). This work emphasizes transgressive-regressive relationships more than it does more traditional mappability criteria for lithostratigraphic nomenclature. The sea level fluctuations are being compared to others worldwide to evaluate their significance for interpreting eustatic effects. Much of the oil in Sverdrup Basin is in Jurassic reservoirs; the first tanker load was taken out in 1985.

The tectonic history, involving the subsidence history of Sverdrup Basin and its development prior to the still poorly understood, probably Cretaceous initiation of the adjacent parts of the Arctic Ocean Basin, remains a topic of much interest. The most interesting recent papers are by Sweeney (1985) and an abstract by Norris (1983) emphasizing aspects of the geophysics and tectonics respectively. Norris (1983) clearly separates the effects of ocean-ridge spreading and transcurrent movement along the northwestern margin of the Arctic Islands in two distinct Cretaceous events, and indicates their effects on older rocks, including the Jurassic. The summary of the Mesozoic of Arctic North America by Balkwill et al. (1983) remains a good general summary and source of references.

The first comprehensive zonal schemes of microfossils and palynomorphs have been published (Wall, 1983a, b; Davies, 1983). The boreal character of the microfauna and microflora is firmly established, in parallel with that of the molluscs.

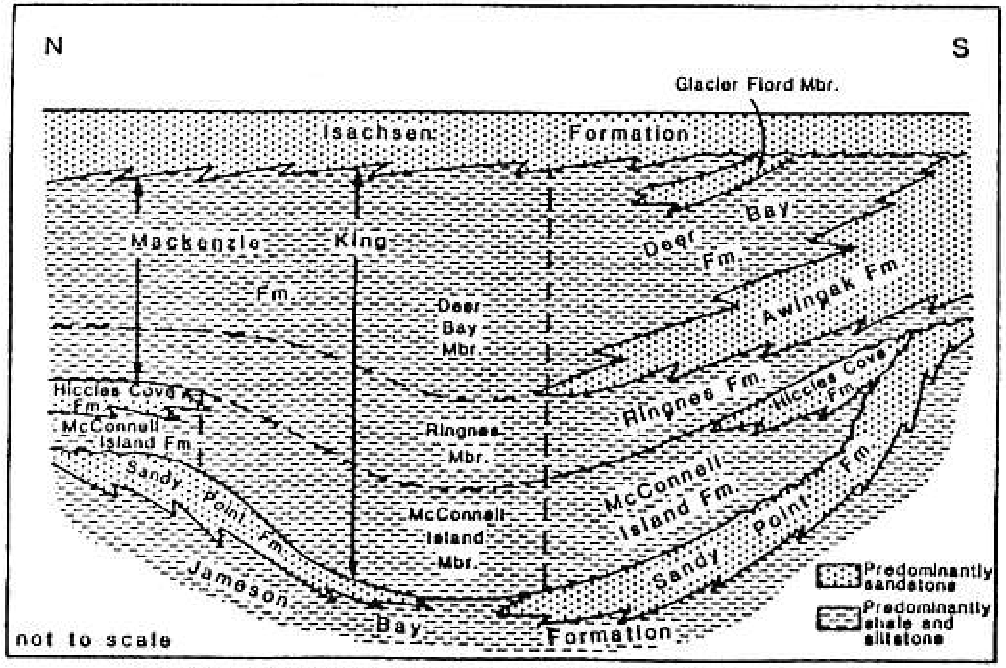



*Figure 22.2. Schematic stratigraphic cross-section, Bajocian-Valanginian strata, Sverdrup Basin.*

Embry 1985

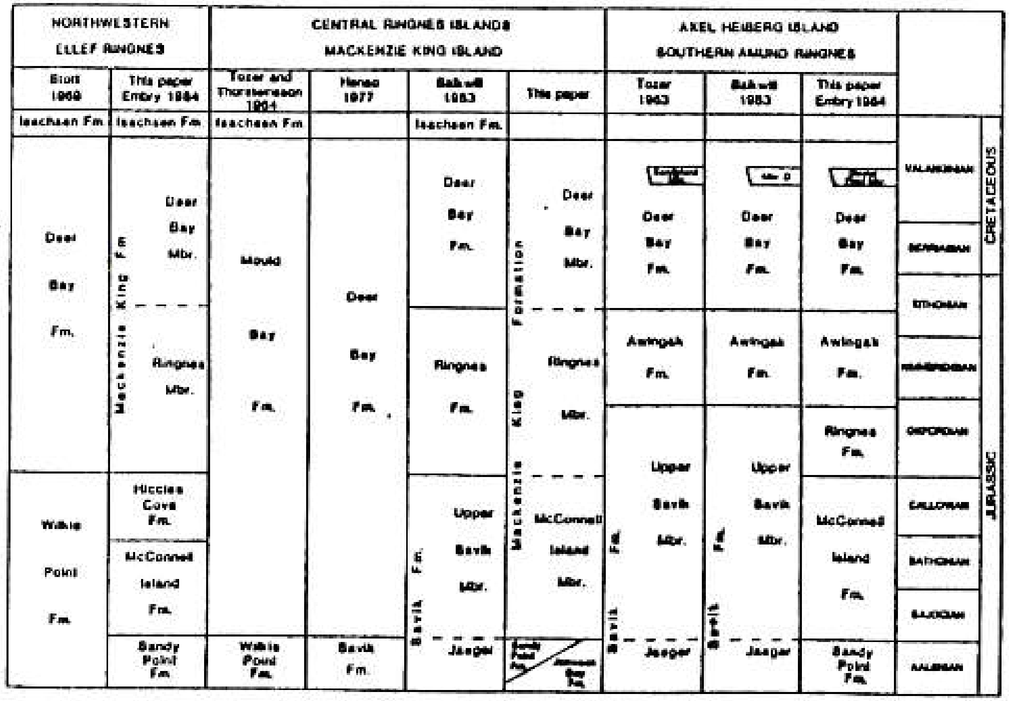



*Figure 22.3. Past and present nomenclature of Bajocian-Valanginian strata, Sverdrup Basin.*

Embry 1985

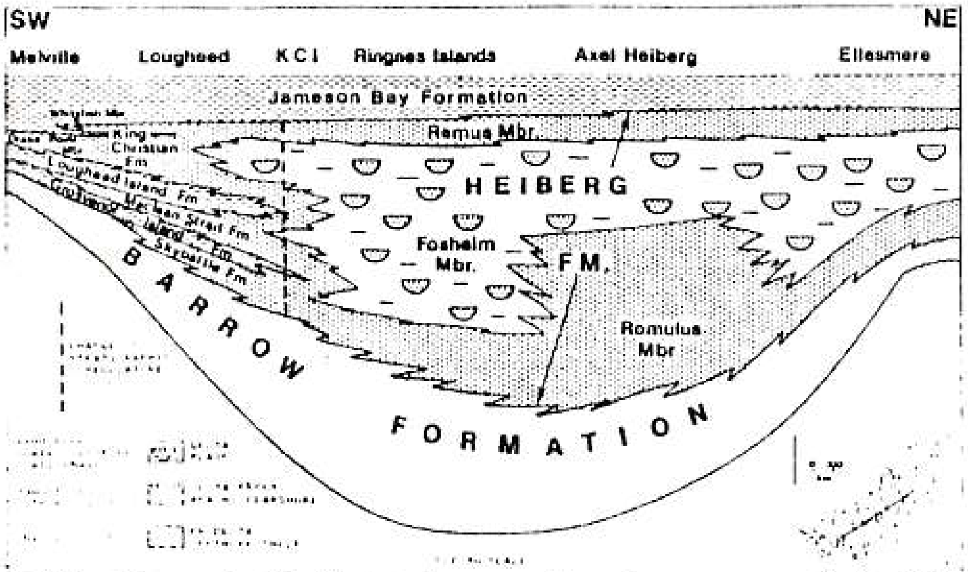



Fig. 3 ... Norian Pliensbachian strata using present stratigraphic nomenclature system

Embry 1982

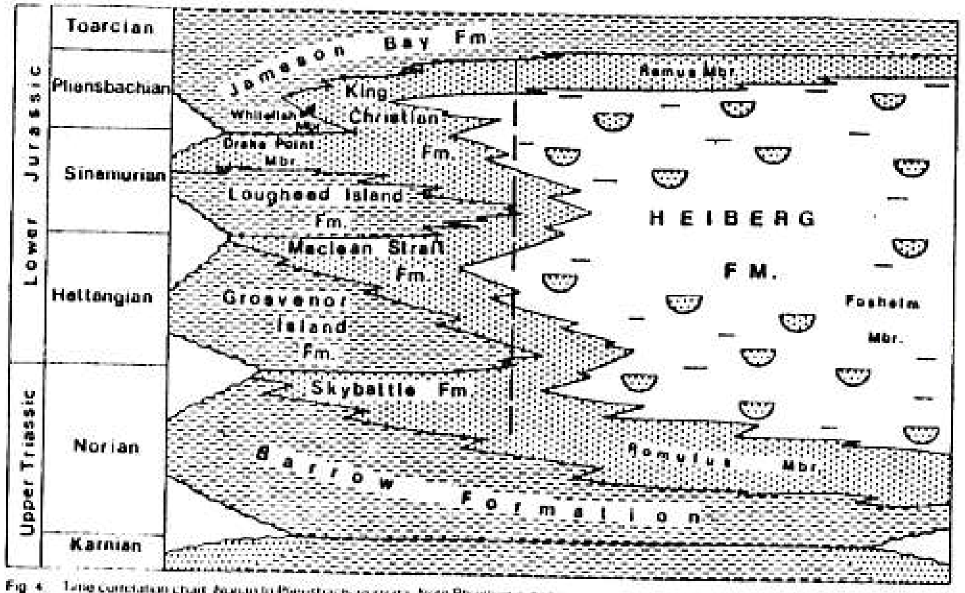



Fig 4 Time correlation chart Norian to Pliensbachian strata. Note Rhaetian is no longer recognised as a stage and the Norian stage includes latest Triassic time (Tozer 1979)

Embry 1982

Surface mapping on Melville Island produced a reasonably good plesiosaur skeleton in 1985 (Dale Russell, in Harrison et al., 1985).

## 6. Moose River Basin

A thin, nonmarine Middle Jurassic sandstone unit has been recognized only recently in boreholes. The palynomorphs and stratigraphy are newly described by Norris (1982) and Telford (1982).

## 7. St. Lawrence Lowlands

The Monteregian intrusives are a group of Jurassic and Tertiary ultramafic and kimberlite-like dykes and pipes that indicate Mesozoic tectonism along the general St. Lawrence-Ottawa Valley axis. They are of economic significance, particularly for certain strategic metals. One recent description, of dykes at Picton and Varty Lake, were presented by Arima et al. (1984).

## 8. East coast, onshore

The Newark Supergroup, continental clastics, has recently yielded a diverse reptile fauna from probable Lower Jurassic beds (Bower, 1985). Olsen et al. (1982) have discussed correlations and vertebrates within the supergroup. Hubert and Mertz (1983) recently discussed some eolian sandstones from this interval. Interest is high in the paleoclimatological implications. The regional and tectonic setting of these Late Triassic and Early Jurassic red bed units is outlined by Emery and Uchupi (1984, p. 270) and discussed in some detail by Robinson and Froelich (1985).

## 9, 10. East coast, offshore

Stratigraphic, sedimentologic, and paleontologic research continues on samples from boreholes derived from the oil exploration. (NO.) wells have been drilled on the east coast. Jurassic rocks were deposited in discrete basins, in the Grand Banks and Scotian Shelf petroleum areas. The principal oil generating horizon is the Kimmeridgian shale. This feature, as well as the general character of the Mesozoic stratigraphy, ties the area to its European counterparts across the Atlantic Ocean, and record the effects of the opening of the Atlantic. Brief summary reports which place the area into perspective for the Jurassic are by Manspeizer (1981, 1982), Wade (1981), Jansa (1981), McMillan (1982), Emery and Uchupi (1984), but there is no very recent comprehensive synthesis.

Variations in Mesozoic sedimentation rate and type were recently discussed by Ehrmann and Thiede (1985), and paleoclimatology of the Liassic by Hay et al. (1982).

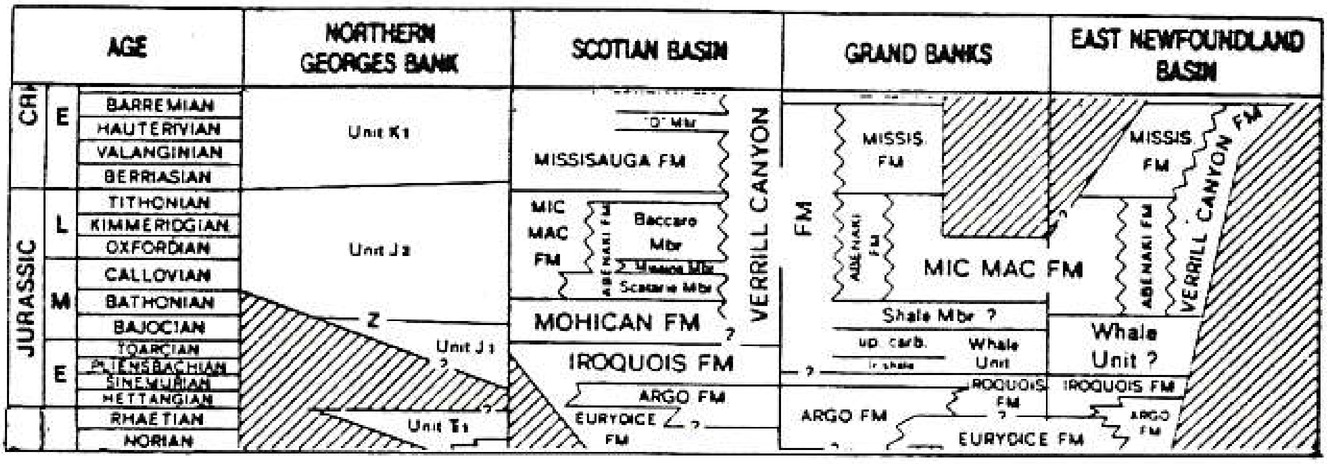



Fig. 4. Generalized stratigraphic columns. *JOHN A. WADE* 1981

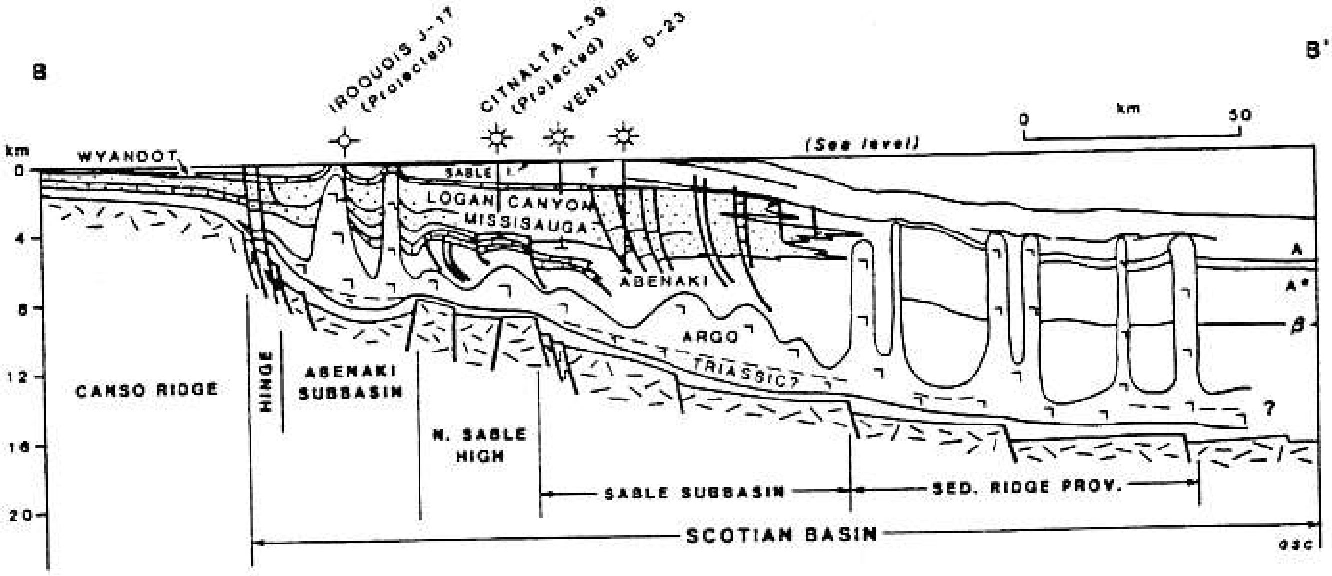



**Figure 3.40 Structure section (B-B') across Scotian Shelf**

(Wade, in Procter et al., 1984)

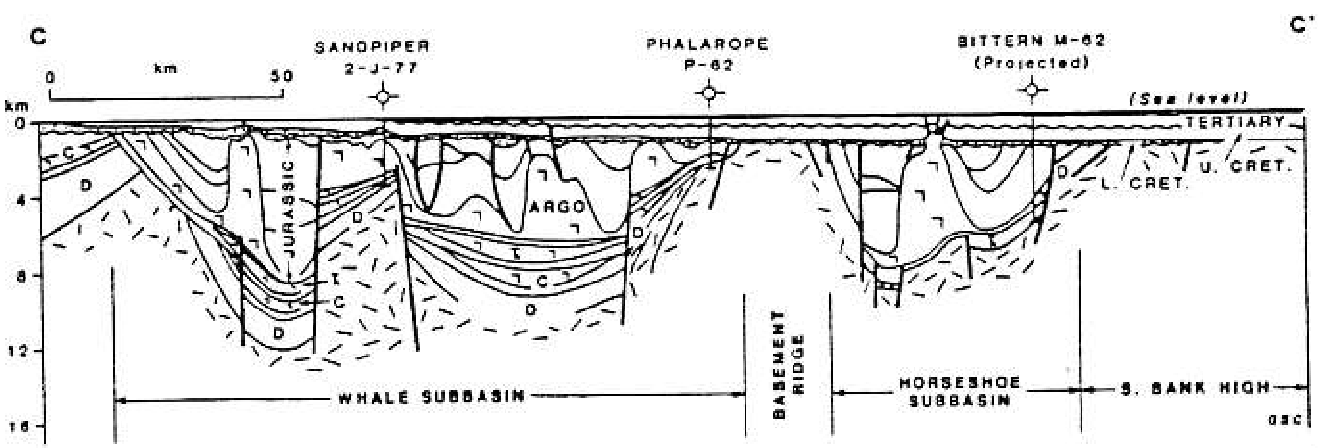



**Figure 3.44 Structure section (C-C') through the Whale and Horseshoe subbasins** (Grand Banks)

(Wade, in Procter et al., 1984)

East coast, Offshore.

Microfossils and their zonations have been described from the east coast offshore for the Early Jurassic (Exton and Gradstein, 1984) and Jurassic-Cretaceous boundary (Ascoli et al. 1984). Of particular interest is the mixed boreal and Tethyan microfauna at the Jurassic/Cretaceous boundary. The cores yield very rare ammonites and bivalves.

## TAXONOMIC STUDIES

### Palynology and Micropaleontology

Progress in Canadian Jurassic palynology is continuing, and several publications can be expected in the near future (Ricketts and Sweet, 1986; R. Fensome; E. H. Davies). In particular, the Late Jurassic interval and the Jurassic-Cretaceous boundary are now reasonably well characterized palynologically in the East Coast offshore, the Brooks-Mackenzie Basin, the Western Canada Basin, and Sverdrup Basin, and progress is continuing in the difficult Williston Basin. Middle Jurassic palynomorphs are less well understood but suites have been described from the Sverdrup Basin and Brooks-Mackenzie Basin. Lower Jurassic palynology in Canada, and particularly the Triassic/Jurassic boundary interval, remain poorly understood, although progress is being made in Sverdrup Basin, Brooks-Mackenzie Basin and the Western Canada Basin.

Microfossils are now reasonably well known from all parts of the Jurassic and zonations have been published or are being developed in the various marine basins of Canada (W. K. Braun, M. M. Brooke, B.E.B. Cameron, E. Carter, A. Hedinger, J. H. Wall).

Correlation of the Boreal and Tethyan successions of the Latest Jurassic and the Jurassic/Cretaceous boundary interval may be aided by further consideration of the east coast offshore palynomorph, foram, ostracode, and calpionellid assemblages which contain representatives of both faunal realms in association or interbedded. A recent search of samples from this interval in southwestern British Columbia, where possibly mixed Boreal/Tethyan Buchia and ammonite assemblages are known failed to produce any calpionellids. Only a few poorly preserved radiolaria were discovered. Radiolaria continue to permit recognition of Jurassic units in otherwise poorly fossiliferous terranes of western British Columbia. In certain parts of British Columbia they can be well controlled by associated ammonite faunas, so that a radiolarian zonation can be expected.

### Macropaleontology

Ammonites, and Buchia bivalves in the Late Jurassic, continue to be the major basis for age determinations in areas where the Jurassic outcrops (up to date reference lists can be found in papers in the volume edited by G. Westermann, 1984). Ammonites and bivalves are plentiful in many areas, although most have not yet been described. Future work will concentrate on developing regional zonations for the Lower Jurassic of Taseko Lakes area and Queen Charlotte Islands (H. W. Tipper, P. Smith and students) and the Western Canada Basin (E. T. Tozer) and the Middle Jurassic of central B. C. and Sverdrup Basin, as well as descriptions of more local interest. Middle Jurassic zonations for southern B. C. and Queen Charlotte Islands, and northern Yukon are now available (Hall and Westermann, 1980; Poulton, in press). Faunal provincialism and the implications for plate tectonics in British Columbia remain major interests. Bivalves are still being described; some have important biostratigraphic and biogeographic implications. The belemnites are under study by J. A. Jeletzky. A new teuthid was recently described from the Toarcian of the western Canada Basin (Hall, 1985). Other studies include brief reports on a (age) bryozoan from British Columbia (Henderson, 1981) and Canadian Jurassic corals (Beauvais and Poulton, 1980; Beauvais, 1982). Additional comments were published in Newsletter 3 (January, 1986) of the IGCP Project 171 (Circum-Pacific Jurassic).

Vertebrates

There is an exciting recent discovery of a diverse reptile fauna of possible Early Jurassic age in Newark Supergroup equivalents in Nova Scotia (Bower, 1985). They are considered by the finders to post-date the great end-of-Triassic extinction event, which is the only great extinction event to co-incide with known meteorite impact swarms worldwide.

Dinosaur footprints in the Late Jurassic beds of the Kootenay Group, and a Toarcian fish (Neuman and Wilson, 1985) add to the list of Jurassic vertebrates from the western Canada Basin summarized by Poulton (1984). A plesiosaur skeleton has been excavated from the Middle Jurassic Wilkie Point Group of Melville Island, Sverdrup Basin, by Dale Russell (in Harrison et al., 1985).

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