Geoscience Canada

Report from Vancouver

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Volume 2, Number 3, August 1975

URI: https://id.erudit.org/iderudit/geocan2_3con01

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Publisher(s)

The Geological Association of Canada

ISSN

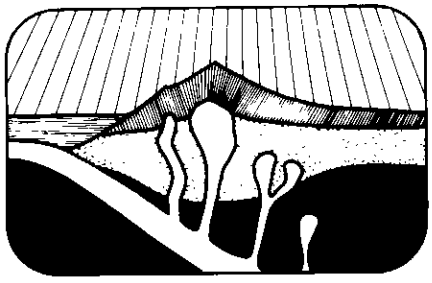
0315-0941 (print)
1911-4850 (digital)

Explore this journal

Cite this article

Armstrong, R. L. (1975). Report from Vancouver. *Geoscience Canada*, *2*(3), 150–153.

Conference Reports



Report from Vancouver

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The Cordilleran Section of the GAC held its annual meeting in Vancouver on February 7 and 8, 1975, under exceptional circumstances - with several inches of snow on the ground. Those who came for balmy weather were disappointed! But this did not cool the interest of the 650 attendees who spent two full days at the symposium devoted to the topic "Intrusive Rocks and Related Mineralization of the Canadian Cordillera". Following established tradition the topic was introduced and reviewed in many facets by a series of invited speakers. The program was deliberately structured to provide a broad view of the topic but to focus repeatedly on the Canadian-Alaskan Cordillera and specific newly studied and well-studied examples from that context. Speakers ranged from internationally known experts to graduate and honours students, each with an appropriate contribution to make.

The outlines of today's view of the plate tectonic setting for magma genesis were lucidly presented by P. J. Wyllie in an opening lecture that set the standard for the meeting in eloquence and visual sparkle. He reviewed the significant igneous rock associations and abundances, underlining the predominance of granodiorite-granite in the igneous spectrum, and it was largely with these more abundant rocks that the symposium was concerned. There are potentially several ways to produce a granitic magma and the relative roles of each process cannot yet be stated. Some magma undoubtedly comes from the mantle either by melting at hot spots or by melting of slabs of crust pushed down into the mantle or by mantle melting triggered by water and frictional heat from those same crustal slabs. The melting of deep crust in areas of tectonic thickening or where heat and fluids are injected from below must also be significant. Indeed, some workers in the Coast Mountains consider this the dominant process. It is not a question of choice between alternatives because a multiplicity of processes contribute to the creation of igneous rocks.

H. J. Greenwood discussed several quantitative aspects of the partial melting process, principles which apply whether the melting occurs within the mantle or crust. Partitioning of trace, and many economically significant, elements between melt and solid phases is an effective enrichment process if the amount of melt is small and observed data on such fractionations are consistent with derivation of many common magmas from the mantle. The extraction of small percentages of melt from the mantle, however, requires the intervention of a process such as intense shear deformation as may be the case in subduction zones.

T. H. Brown briefly described the results of theoretical and computational models of the interaction between ore bearing solutions (brines with low concentrations of many elements and a plethora of chemical species) and different rock types. We are approaching the point of being able accurately to explain and predict deposition and reaction sequences as observed in contact aureoles and ore bodies. In the examples presented, a change in wall rock chemistry, and nothing else, converted a copper-only to a copper-lead-zinc deposit. The interactions are complex and not intuitively obvious but managable today with large digital computers and improved calculation techniques.

The topic that was once a bitterly disputed focus of the granite controversey, the emplacement process, was touched on only briefly and agreeably by N. Rast. There is a general consensus now that intrusive igneous rocks are derived from fluids - something in the spectrum from complete melt to crystal mush with interstitial melt - fluids that were under pressure and of much lower viscosity than their host rocks. Rast reviewed recent work in the field of dyke and sill emplacement with special emphasis on the studies of Pollard and Ramberg. A curious observation, no doubt related to the emplacement process, was the conclusion, derived from geophysical data by C. A. Ager, that several well studied batholiths (Guichon, Iron Mask, Hogem) are all funnel shaped bodies that pinch out downward, rather similar to some Coast Mountain pluton shapes described several years ago by Hutchison.

Further insight into the emplacement mechanism and its economic significance was provided in the discussion of Vancouver Island plutons by D. Carson and others who described mineralization associated with several laccolithic bodies whose emplacement was stratigraphically controlled.

The tectonic setting of intrusive rocks was reviewed on a variety of scales. P. Bateman began with a quick tour of the Circumpacific plutonic belt, emphasizing the variety of local settings and plutonic types. He noted, particularly, the segmentation of the batholith belts along strike, and the classification of granitic rocks into I and S types proposed by the Australians Chappell and White (I being the low-Al, typically non-foliated, granitic rock with xenoliths of more mafic granitic rocks and S being high-Al, typically foliated, two-mica granitic rocks with xenoliths of sedimentary rock). H. Gabrielse focused attention closer to home in a review of the tectonic setting of intrusive rocks in the Canadian Cordillera. There igneous rocks occur in all possible environments - bits of ocean floor, volcanic arcs in continental margin, intermontane, and craton-edge settings, and volcanic centres associated with rifting and floods of mafic lava. Only carbonatite and kimberlite magma types are poorly represented.

One key to unravelling relationships and associations is chronology and this was the subject of many presentations at the symposium. Gabrielse's introductory overview, in the form of a blended classification combining tectonic setting and age, and the papers by P. C. Bateman (Circumpacific), M. A. Lanphere (Alaska - U.S.), N. C. Carter and P. A. Christopher (Canadian Cordillera), D. J. T. Carson, J. E. Muller, and K. E. Northcote (Vancouver Island), T. Hudson and G. Plafker (southeastern Alaska), J. G. Smith (Alaska Panhandle), and D. J. Tempelman-Kluit (Yukon Crystalline Belt) developed the topic in a variety of directions. An overall impression is that the history of pluton emplacement was a complex one that defies generalization in a few words. In any given area pluton emplacement was distinctly episodic with relatively few episodes represented. But if one attempts to view the whole Cordillera the episodes blur and merge in such fashion as to make generalization a matter of disagreement, even between contributing geochronologists.

Although five distinct episodes have been proposed for California a conservative analysis such as outlined by M. A. Lanphere will only distinguish two broad culminations (late Jurassic and mid Cretaceous) and traces of earlier activity (back to late Triassic time). The story has become one of the irregularly shaped regions of igneous activity - continually waxing and waning in intensity, shifting geographically, with gradual or sudden inception and equally gradual or sudden local cessation of activity. Figures 1, 2 and 3 attempt to summarize the shifting patterns as now known and presented at the symposium. Only two periods in the Mesozoic are, on present evidence, times of significantly diminished intensity - minima of date frequency, and no concordant dates, occur in early Cretaceous (about 132 m.y. ago) and mid to lower Jurassic time (180 to 190 m.y. ago) but available isotopic dates form a complete continuum since about 220 m.y. ago (maxima occur in late Jurassic - early Cretaceous and mid to upper Cretaceous time). Many of the dates are probably discordant due to later heating or a variety of other possible alteration processes, and thus cannot be accepted unsceptically in speculations on magmatic history. In-depth studies pinning the ages of single plutons by a variety of independent techniques are just beginning. Most available information is in the form of K-Ar dates, many without concordancy checks, a lack bemoaned by several speakers. Thus one can take the view expressed by M. A. Lanphere that "the spacing and duration of intrusive epochs are not yet well established" or view the brighter side - that we do have lots of data and have gained real knowledge about pluton timing in most parts of the Cordillera, admitting that there is an opportunity for much future work. In addition to the two culminations of activity already cited, the Canadian Cordillera preserves a stratigraphic plus geochronologic record of late Triassic - early Jurassic, and early to mid Eocene magmatic episodes - both of considerable economic importance.

G. H. Eisbacher focused his wit and sedimentological eye on one aspect of tectonic history involving plutonic rocks that has consistently been neglected, in spite of its potential information content - the igneous and metamorphic rock debris in Mesozoic and Cenozoic clastic rocks. The problem, as he pointed out, is not just one of creating these rocks, but of disposing of huge volumes of them as uplift and erosion bring the crystalline complexes we study today back to the earth's surface from depths as great as 15 km. At present we lack an identified clastic accumulation that corresponds to denudation of the Coast Mountains during the past 50 m.y. - this does not mean that the interpretations of erosion depth and history are wrong but it reminds us that a review of the evidence is called for and that may lead to new insights or at least confusion at a higher level of sophistication!

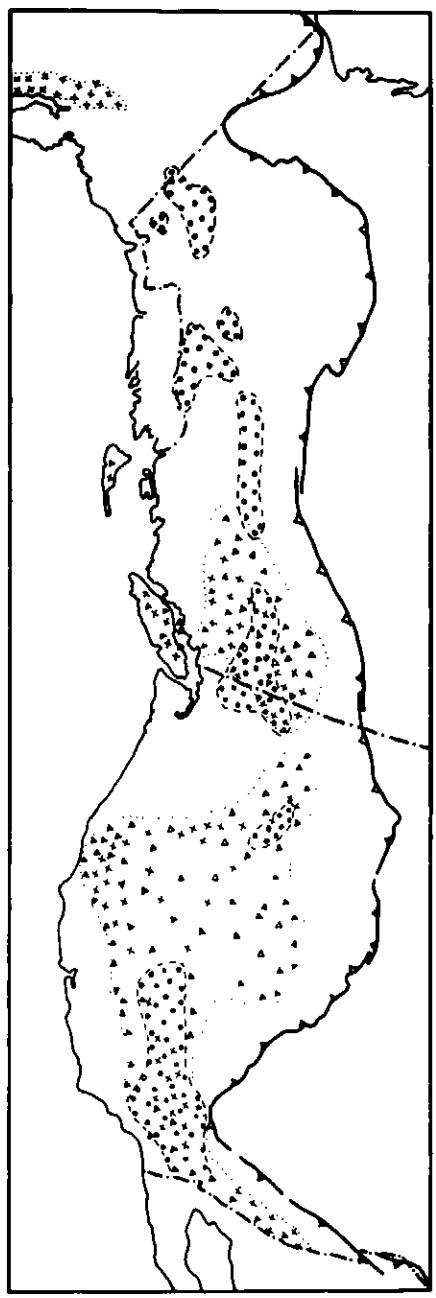


Figure 1
Western North America showing areal distribution of intrusive rocks of Late Triassic-Early Jurassic age (225 to 195 m.y. shown as circles) and Jurassic and earliest Cretaceous age (195 to 160 m.y., shown as crosses and 160 to 135 m.y. shown as triangles).

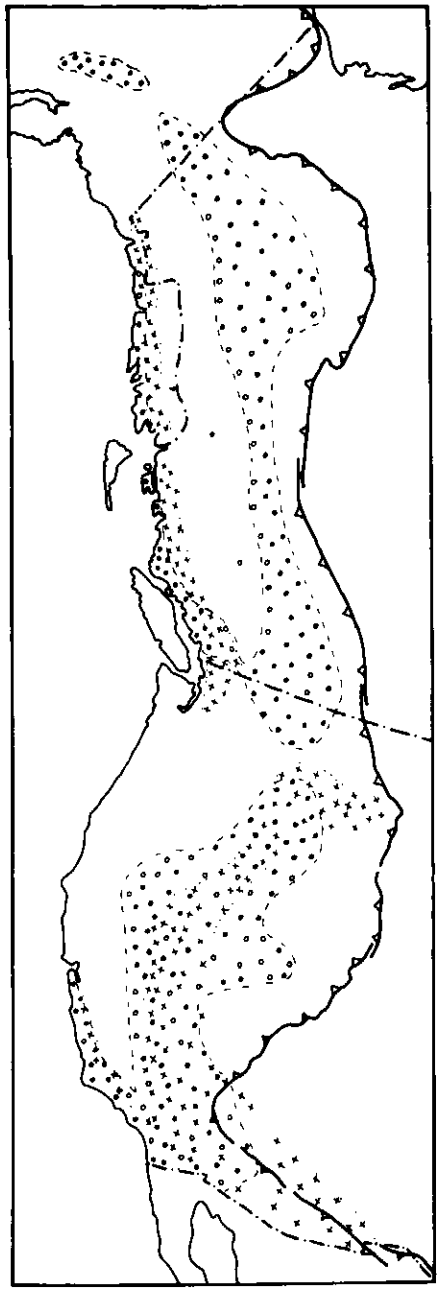


Figure 2
Western North America showing areal distribution of intrusive rocks of Cretaceous age (135 to 95 m.y. shown as circles, 95 to 65 m.y. shown as crosses).

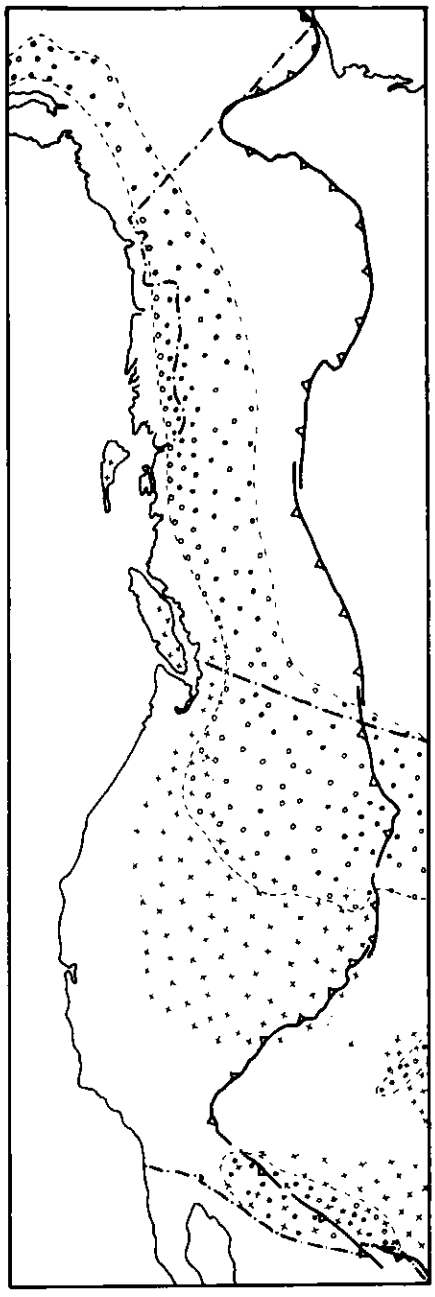


Figure 3
Western North America showing areal distribution of intrusive rocks of latest Cretaceous and early to middle Cenozoic age (65 to 40 m.y. shown as circles, 40 to 25 m.y. shown as crosses). The irregular and unpredictable changes in pattern demand a complex and intricate tectonic evolution that is unique for each narrow sector of the Cordillera.

A modest amount of attention was focused on mafic and ultramafic rocks but there was no attempt to deal exhaustively with this topic which has been frequently worked over at other meetings. Attention focused on newly studied bodies in British Columbia. K. C. McTaggart reviewed the results of three UBC theses by R. C. Wright, A. Elliot and J. Nagel on the Pioneer, Mitchell, and Shulaps bodies, respectively. All three bodies are intensely deformed, extensively serpentinized, and variously metamorphosed periodotites in which bits of original layering are preserved. Most direct evidence of genesis is lacking - supporting their classification as alpine-type bodies.

The Polaris ultramafic and Axelgold gabbroic plutonic complexes, described by T. N. Irvine, are, in contrast, clearly intrusive. Many characteristics of the Polaris body indicate that it has been considerably modified by tectonic deformation during solidification. The Axelgold pluton turns out to be strikingly similar to the Skaergaard Complex. The Turnagain River zoned ultramafic complex, a deformed blob, with an unusual whiff of nickel sulfides, was described by T. Clark and the nickel-copper-bearing Giant Mascot ultramafic body, a mega-inclusion in a younger Coast Mountains pluton, was the subject of a joint presentation by P. A. Christopher and J. A. McLeod.

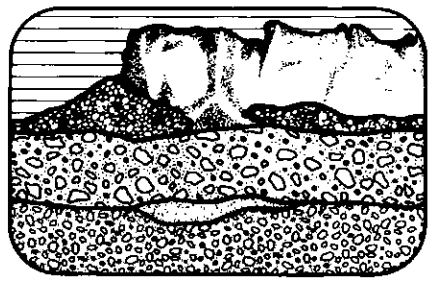
A normal expectation of the Vancouver symposia is attention paid to economic mineral deposits and this meeting was no exception. Mineralization was discussed by almost every speaker but the attention devoted to the topic varied considerably. Several of the papers concerned with geochronometry dealt as well with the association of plutons and ore bodies, or at least the ages of ore bodies - topics that are inescapably intertwined as virtually every major ore body in the Cordillera has some association with igneous rocks. Two review papers neatly summarized a wealth of information on the porphyry deposits of the Cordillera. A. E. Soregaroli and R. V. Kirkham discussed Cordilleran porphyries in general and concentrated on the point that they are complex rock assemblages resulting from multistage histories - complex permutations of intrusion, alteration, fracturing and mineralization events - that can be worked out by detailed studies. J. M.

Allen presented a paper by V. F. Holister, J. M. Allen, S. A. Anzalone, and R. H. Seraphim on the Highland Valley deposit - one of the giants, and gradually becoming a classic case history. A number of other papers provided a cross section of ore-pluton associations in the Canadian Cordillera, and reviewed mineral deposits of pneumatolytic origin, alkaline rocks, and geochemical studies of plutonic bodies.

Any erroneous impression that the problems had all been solved was effectively and humorously put to rest by D. Strong in his off-the-cuff "with a few slides I just happened to have in my briefcase" postmortem of the two days of talks. Well aimed blows were struck at classification schemes, anthropomorphic descriptions of processes, and the perversity of natural systems . . "you can't really trust nature". He pointed out that nearly all the papers avoided speculation on source or genesis of plutonic rocks, perhaps for good reason. The granite controversy of past decades may not be dead but its metamorphosis has been radical - the impact of plate tectonic ideas, experimental petrology, geochemistry, quantitative structural geology, and vastly improved maps and descriptive information has dispelled many problems and recast the statement of others.

These symposia are among the least structured, and simply run, yet among the largest geologic meetings in North America. In spite of the minimum of frills - no business meetings, no field trips, no commercial displays, no ladies activities - and perhaps because of the focus - no concurrent sessions, and two days maximum length - they continue to attract a large and devoted audience. The attendance remained full to the very end.

MS received April 3, 1975.



Interdisciplinary Till Symposium

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The uses of Till in engineering and mineral prospecting, and its significance in top-soil formation, were reviewed against an appropriate geological background at an interdisciplinary symposium held in Ottawa, Canada, on February 17 and 18, 1975. Sponsored by the Royal Society of Canada and the Canadian Geoscience Council, as well as by the individual member organizations of this Council, the meeting attracted about 260 participants for two days of review and discussion.

Four invited keynote papers set the scene for more detailed papers which were presented, in summary, and discussed in the other three half-day sessions. These eighteen papers were selected from more than 60 proposals for papers received by the organizing committee, a number that is mentioned to indicate the widespread interest in this major glacial deposit in North America and elsewhere.

Since almost all of Canada has been glaciated, it has probably the greatest extent of glacial soils of any country. It was appropriate, therefore, for the symposium to start with a general review of the geological origin and the properties of Tills. This was presented by Professor Aleksis Dreimanis of the University of Western Ontario who reviewed the dependence of all Tills upon the processes by which they were deposited, their pre-depositional erosive histories and the modes of transport that led to their present location.

In a broad-ranging review, Professor Dreimanis suggested desirable recognition of three major genetic classes - ablation till, with two varieties; basal till, with at least three varieties; and waterlaid till, even though some workers regard such material as a true sediment. Dr. John S. Scott then summarized some of the recent field studies by the Geological Survey of Canada, suggesting regional syntheses which demonstrated the great amount of work still to be done in developing accurate correlations. He pointed out that about three-quarters of Canadian surficial deposits are Till; surface soil maps are therefore useful aids in till studies.

Dr. Raimo Kujansuu of the Geological Survey of Finland described corresponding field investigations of his Survey, now in progress over an area of 100,000 square kilometers, close to 70°N. Special attention is being given to determination of ice-flow directions, five different directions having been observed in one location. It is clear that Finland and Canada share many of the complexities of Till. One special Canadian phenomenon described in another paper was the formation of thrust-moraine ridges as surface evidence of glacial thrusting, the 'stacks' so formed often containing bedrock as well as Till.

Three more detailed geological papers presented results of the applications of methods now used for stratigraphic correlation of Tills in central and western Canada and an analysis of the variability of till composition aided by statistical methods. Professor Paul Karrow of the University of Waterloo reviewed such methods in general and the significance of their recent development, suggesting that wider use of such detailed investigations can be anticipated. In discussion, the continuing importance of detailed field studies was likewise stressed, both approaches being clearly desirable in the future with proper inter-relation.

Professor R. J. St. Arnaud of the University of Saskatchewan (and currently President of the Canadian Soil Science Society) presented the main review of the pedological aspects of Till. From a wide variety of sources he discussed the influence of till type on the formation of soils developed from them and their relationship, in turn, to soil fertility and other land use considerations. He described the main soil types of Canada but used as more specific illustrations the soils of western