

Geoscience Literature: Greater Volume – Less Access or Ignorants in the Sea of Knowledge

Peter Laznicka

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COMMENTARY

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Peter Laznicka

Consultant

[www.Totalmetallogeny.com]

64 Lochside Drive, West Lakes 5021, SA,
Australia

E-mail: plaznicka@dodo.com.au

INTRODUCTION

In 1913, when Louis de Launay published his monumental *Traité de Métallogénie*, the book that created the first factual synthesis of global ore distribution and laid the foundation for the discipline of metallogeny, he utilized at least 75% of the published global knowledge of his period, which comprised a list of references that counted only several thousand titles. The bulk of the literature was in six major European languages because there was virtually no scientific or technical writing to be found in the rest of world languages. At the onset of the 21st century we are blessed with more than four million accumulated references in the field of geology and related mining, and the list is growing at a rate of some 200-400 k/year (Fig. 1). To produce a 2007 equivalent of *Traité de Métallogénie*, would require familiarity with perhaps one million relevant references in at least thirty major languages (and eight different alphabets); this number could be reduced to some 200,000 citations if superseded and low-quality references were ignored, and further cut to a bare minimum of

10-20,000 citations to deal with the “key facts” only. In reality, however, the most recent books and databases pertaining to global metallogeny rely on 2000 citations or less. Furthermore, once a synthetic book is published, the reference list is already obsolete. Now, not many people aspire to comprehensively review global metallogeny, or any other broad subject for that matter, because there are few rewards, financial or otherwise.

Even “original research papers” are not 100% original because every piece of research has a history, including its framework, vertical and lateral relationships, transitionality, and conflicting interpretations, which is contained in the published literature.

This literature has to be collected, compiled, summarized and critically assessed before the new research increment can be added. Missing crucial facts because of insufficient literature review can invalidate new research at the very onset. “Re-discovering the wheel” is an all too common event at many seminars and conferences these days. At a recent symposium on breccias, several speakers espoused ideas that had been published decades earlier, and in greater detail, in widely available (pre-digital) publications, of which they were not aware. One might expect this from junior researchers of the digital world but even prominent experts in their respective fields are not immune, especially when the missed

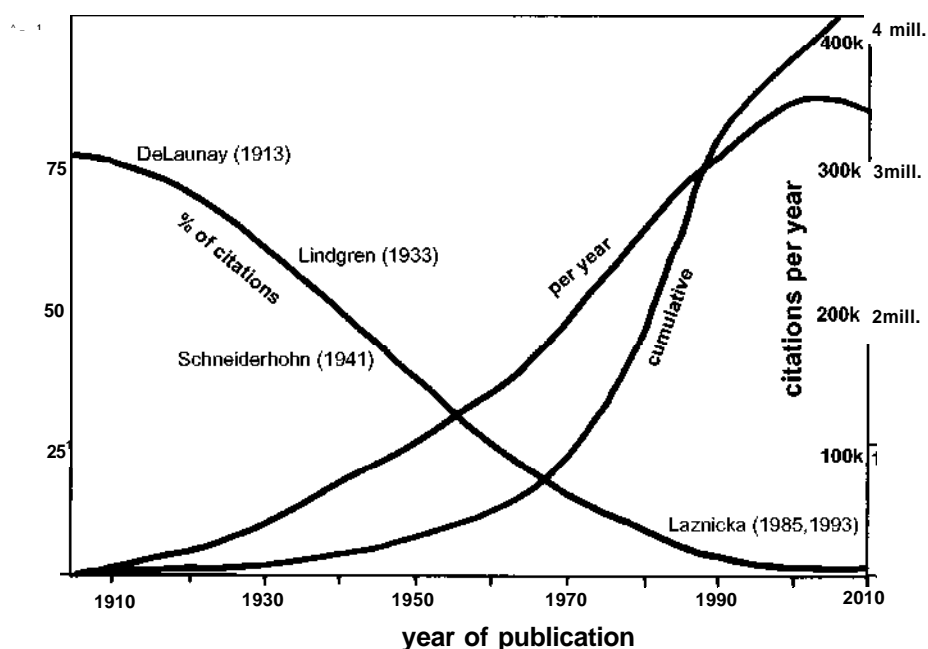


Figure 1. A graph showing an approximate relationship between the annual and cumulative growth of new scholarly citations in geosciences, and the percentage of citations out of the world’s total actually consulted by authors of comprehensive monographs on global topics, e.g. metallogeny. Although the citations utilization is clearly much higher in more restricted studies, the general trends remain the same.

components are in foreign-language literature or come from different fields of expertise.

Scholarly literature is the repository of most of the existing, accumulated knowledge that has to be studied (even before that, translated if in an unfamiliar language). To do so one has to first compile a list of references, then obtain the texts. Generating a bibliography has been greatly facilitated by electronics; however, the ability to acquire publications to read has steadily deteriorated over the past half century because the cost and time to acquire them have greatly increased. In spite of the proliferation of publications, overall availability has decreased. Increased costs have beggared the under-funded researchers and condemned many to professional semi-literacy. Although colleagues in poorer countries are the hardest hit, substantial contrasts in terms of access to literature prevail, and increase, even in the richest societies. While the volume of knowledge increases, we read less, partly because it is so frustrating to get hold of a paper or a book that just might be relevant to our research. It remains to be seen if the new technologies and new thinking will reverse this decline of professional literacy in the future.

The published professional knowledge, in print as well as in the electronic media, is heterogeneous. However, more than 50% of reports in geosciences have regional implications and are mostly published by local (national) government agencies. At least in the industrialized countries, much of this information is available at nominal, reasonable cost; furthermore, the volume of entirely free, downloadable material from government websites rapidly increases. U.S. Government agencies send (or at least used to) many of their publications to the farthest corners of the world, and they maintain open access to a number of respected information sources on their websites. This includes the Mineral Resources Data System (MRDS) database and electronic successor to the annual Minerals Yearbooks, now compiled by the U.S. Geological Survey. Government publications can generally be regarded as stable, improving and predictable. This, unfortunately, is not

the case with academic and research publishing and the rest of this article concentrates mainly on this genre.

ACADEMIC AND RESEARCH PUBLISHING

Until about 1960, most research serials were published by learned societies, academies and universities, under “gift exchange” arrangement with the authors. The publishing relied heavily on voluntary or underpaid labour driven by devotion to the cause, service to the profession and/or pride in the journal. The subscription costs approached the break-even point and were often subsidized, or free, to members. Most books, in contrast, were printed by private publishers. During the wave of Western prosperity in the 1960s, new universities were established, staff hired, and research grants initiated. Ultimately this led to the development of the now all-pervading positive feedback loop; grant-research-publish paper, which resulted in an avalanche of new papers that existing learned journals could not accommodate. The private publishers recognized a profit potential in publishing research serials, “achieving profit margins of 40% or more” (*The Economist*, 1998). The “scoundrel”, Robert Maxwell, “made his early fortune from the worthy business of publishing the scientific world’s latest discoveries” (*The Economist*, 1998). Other publishers followed and new journals of increasingly more specialized titles proliferated. The subscription prices kept increasing, devastating library budgets and almost wiping out personal subscriptions, which were still widespread with the society journals. *The Economist* (1998) described the predicament of 121 American libraries, which spent 124% more on journals in 1996 than in 1986 for 7% fewer titles. The price increases were far above the rate of inflation. As a result many of the newer journals have never been subscribed to by libraries and existing subscriptions to other journals gradually have been cancelled.

In our local library, mass extinctions have occurred; gone are the *Journal of Sedimentary Geology* (extinct since 1993), *Journal of African Earth Sciences* (1994), *Geologische Rundschau* (1994), *Lithos* (1998), *Earth Science*

Reviews (1999), *Tectonophysics* (1999), *Earth & Planetary Science Letters* (2000), *Ore Geology Reviews* (2001), *Mineralium Deposita* (2003), and many others. By 2007, virtually all the printed for-profit journals in geosciences have disappeared here and one cannot blame the library. The 2007 subscription cost of only those journals mentioned above would come to some US \$30k. The consequence is that the research published in these serials is now out of reach of the regional readers (the nearest, richer public library where some of these serials still survive, is 750 km away); hence, this research remains mostly unread and unacknowledged. The word “publish” for making information public has lost its meaning; now, information is printed and subsequently locked away from many readers, like the gold in Fort Knox. Are the contributing authors and the organizations that grant-supported their research happy?

In the 1990s, the computer revolution and the spread of the internet led to the emergence, and rapid growth, of electronic on-line journals. Initially it looked like a possible end to, or at least alleviation of, the sequestration of knowledge due to excessive subscription costs, but things returned to normal in the 2000s. In fact, a library now has a choice of subscribing to either a printed or an electronic edition of a journal, usually at the same cost (even though the electronic edition costs 30% less to produce and market), or to subscribe to both at a still higher cost. Moghaddam (2007) compared subscription prices of 4,415 electronic journals produced by the ten largest western publishers: five of them for-profit (FP), five non-profit (NP). She found, not surprisingly, that the FP publishers charge on average 2.8 times more for a subscription than the NP publishers (a very conservative multiple given my own experience). However, it is true that many of the FP journals have publication runs of several hundred copies only, compared with thousands or tens of thousands of copies for the longer established NP journals. Small print runs sharply increase the production costs. In terms of quality, expressed by the number of citations, FP and NP journals were almost equal. However, NP journals

were historically better because many former top tier NP journals, like *Geochimica et Cosmochimica Acta*, have been captured by FP publishers in the past 20-30 years. More bits and pieces from the Moghaddam (2007) paper follow:

- C The subscription price of scientific journals rose 260% between 1975 and 1995; the per-page increase between 1985 and 2003 in FP journals was 300%, compared to 50% (less than the cost of living increase) in NP journals. This caused subscription cancellations by libraries, forcing publishers to hike the costs even more (another positive feedback loop);
- C In 1999, 76% of one U.S. library budget for scientific journals went to 10 publishers (the Big Three: Elsevier [with Pergamon], Springer [with Kluwer], and Blackwell). The Big Three each published, in 2003, 69; 47; and 31 electronic journals, respectively, and the average subscriptions were US\$ 1,589; 896; and 455 (all science subjects) and US\$ 1,692; 1,090; and 448 (earth sciences only). The average subscription price of physics and chemistry journals was higher than for geoscience journals, whereas for medicine, the sky was the limit.
- C Journal subscription costs to American libraries increased annually by 8.5% between 1986 and 2001. My former Departmental Council in Canada met twice yearly to argue which subscriptions to cull.

By 2007 journal subscriptions increased further; some almost doubled. The following sampling of per year subscriptions to libraries comes from the Elsevier NL website: *Chemical Geology*, \$4,228; *Earth & Planetary Science Letters*: \$4,181; *Tectonophysics*, \$5,462. A comparison of the per-page and per-word costs in FP journals with some NP journals for the year 2000 follows. The FP journal *Chemical Geology*, Volumes 162 to 171 (representing the subscription year 2000), comprise 3292 pages and about 2.2 million equivalent words so one word is worth approximately 0.2 cents. The behemoth NP *Journal of Geophysical Research* (JGR), Volume 105 totals 29,730 pages. It has about 750 words per page, with some

22.3 million equivalent words, so one word is worth 0.01 cents. Another NP journal *Economic Geology* (EG), Volume 95 totals 1,826 pages and has 840 equivalent words per page, so one word is also worth 0.01 cents. However, EG did not have a compulsory charge to authors, which JGR had, so it represents the best value per printed word of the two journals.

The involvement of the FP publishers in research serials publishing has been a mixed blessing. It accommodated the avalanche of submitted papers throughout the 1970s and later, and in some cases provided a second tier sanctuary for papers rejected by the first tier NP journals. Some such papers have proven their worth. But the FP journals also locked away a substantial proportion of knowledge, largely generated using public money, which only the richest can now access. The FP publishers do a better job on books because they publish fast (especially on camera-ready or electronic copy basis) and they fill the gap in the review literature and conference proceedings where the NP's mostly lag behind. The FP books are expensive but the buyer has a choice to purchase or not. Fortunately NP journals still exist and some, like *Economic Geology*, are an excellent value. The *Canadian Journal of Earth Sciences* (CJES), published by a government agency that also supports much of the research, is about 3-4 times as expensive per word as EG and JGR. Several electronic journals (but none in geosciences) offer open access (Navin and Starratt, 2007), which are free to the reader, but the author (or his/her organization) has to pay the editing and publication costs. I consider this the logical way to rapidly communicate publicly funded research (e.g. by NSERC).

COPYRIGHT: THE ROADBLOCK TO KNOWLEDGE CIRCULATION

When I was a teenager, I hand-copied my favourite reference book, rarely available in the library and now out of print, and even made some copies for my rock collecting friends. I did not think that I had violated any laws then, but I would most likely now if I used time saving devices such as a photocopier or scanner. Although most western copyright laws, based on the

U.S. law [www.knowyourcopyrights.org], permit reproduction of a single article for personal scholarly use, some journals permit even more. The CJES allows reproduction of short excerpts, with author's consent, but if the author is on sabbatical or in the field consent may not be forthcoming for many months. Some organizations (like the Brazilian DNPM or the South African Chamber of Mines) give automatic reproduction consent if credit is given: a courtesy ingrained in the brains of most of us. The U.S. Government agencies (e.g. USGS) produce copyright-free publications. Copyright rules, like other regulations that slow-down communication and progress are destined to be routinely violated; just observe the goings on around a university library copier before exams. Behind the closed doors of corporate offices, guarded by receptionists and security, mass reproduction and circulation of copyrighted material is endemic. The above applies to paper copies; it is even easier and more efficient with electronic materials for those who know. The inexperienced may get caught.

Some publishers allow photocopying beyond the "single article for personal use" if credit is given. Most, however, cling to the traditional copyright rigidity, request payment via the Copyright Clearance Center, and place a hurdle of time-consuming correspondence in the way of requests for permission to use material for research or education. This slows the circulation of knowledge, if adhered to. Every student creates an anthology of photocopies of articles on a certain subject, which is legal ("personal use"), but it is an offence if a lecturer does it for their class. Notwithstanding the for profit publishers, it is hard to see why it has to take months and repeated correspondence to secure an eventually free permission to reprint a duly cited figure or graph from a publication by Canadian, Australian, or other government survey, when equivalent material from the USGS is open access.

Copyright is a two way street: it protects the intellectual property of the authors and profits of the publishers on one hand, but it also restricts the movement of knowledge on the

other hand. As an author, I want to see my work reaching others while at the same time recognizing the right of the publisher to cover costs (Moghaddam, 2007, estimated the average cost of publishing a research article at around US \$5,000- to 6,000) and earn a return on investment. However, there should be a reasonable balance between the two.

Copyright protection does not last forever (usually 50 years, or 100 years to be on the safe side) so some classic books that have shed their copyright, even entire libraries of them, are now freely available on the web. So, if you are after *Macbeth*, *War and Peace*, or *Les Miserables*, all you need is an internet access and the Google Books Library Project might deliver. You should also be able to adopt Agricola's (1556) *De Re Metallica* as your copyright-free textbook on mining geology. However, the more recent literature is mostly copyrighted and it takes time, effort and money to pass properly acknowledged ideas on to convenience-expecting audiences, in the form of handouts, notes or audio-visu-als.

KNOWLEDGE IN THE INTERNET AGE

The spread of PC computers since the 1980s allows us to use machine-searchable bibliographic (and other) databases, like Georef. Although not perfect, these databases have greatly speeded up the task of building a bibliography on any subject. The addition of short abstracts to some databases has helped to screen out non-essential reading material. In the early 2000s, the internet and high capacity servers have been revolutionizing the ways knowledge is gathered, stored and distributed. This revolution is comparable in impact with the invention of the printing press in the 15th century. Journal and book publishing is some 40% digital at present; in a few more years, printed matter will be the minority, although it is unlikely that printed books and journals will soon disappear (they actually thrive right now). The increased digitization of information is providing a respite to libraries from the never ending pressure to accommodate more and more paper volumes. Global access to information via home computer terminal has further boosted our

individualistic culture, like the widespread ownership of automobiles did forty years ago. We can now download some individual journal articles on line, from a growing list of FP and NP publishers and other providers. The cost is high and selection limited. Geoscience World [www.geoscienceworld.org], a nonprofit consortium of seven geoscientific organizations, offers access to material published by its members; so far, in English only. A one day access to a nine-page, year 2000 article comes to US \$35 (2007 price). I estimate the selection of papers available covers some 10-15% of the whole. What about the rest?

Do we still need libraries (alias knowledge/information centres)? We do. Although it would be perfectly feasible now to place our completed research on personal or institutional websites for everybody to read for free, tradition, and profit motives continue imposing serious restrictions. However, some inroads have been made and open access electronic journals keep appearing here and there. Most are funded from fees paid by the authors (Navin and Starratt, 2007). As no individual and only a few organizations can alone afford to maintain subscriptions to a number of e-journals, public libraries are gradually evolving into journal (and book) subscription agencies through which an individual can reach the electronic knowledge, without actually taking the hardcopy volumes off the shelves. The reading can be done either on-line from your living room, or from the library terminals. However, all the traditional library and readers woes, i.e. increasing costs, copyright hassles, delays, inability to read everything on your list, remain. Our individualist society has inoculated us against banding together to cooperatively and non-profitably exchange the fruits of our research.

There are some interesting technological developments that are already here or on the way. One is direct machine translation: put an article in Mandarin on a desktop, and out comes a copy in English (not yet perfect). Some freely available online resources are appearing, mostly to foster public awareness and education (e.g. the Canadian Museum of Civilization website; American Memory Pro-

ject of the Washington, D.C. Library of Congress). Google is rapidly evolving from a search engine stuffed with billions of bits and pieces of information into a provider of a more coherent knowledge. The Google Books Library Project now offers free on-line access to whole libraries of digitized (mostly classic) books, for which the copyright has expired or has been waived. Google Scholar has greater potential for an active geoscience researcher. It is basically a classified library catalogue that can also provide free access to some abstracts and entire articles, although the copyright hurdle still remains. The rapidly growing internet-based Wikipedia is an experiment in on-line populism and it provides free information on anything by means of self-help. The encyclopedic articles are contributed spontaneously by anonymous volunteers (you and me) and everyone can edit the information already there; a sort of peer control by the masses, which Chairman Mao would have loved. However, the credibility of Wikipedia-sourced facts is low, although improving. More importantly, the Wikipedia experiment suggests one possible way for the future of scholarly publishing. i.e., post a paper (as a preprint) on the internet as soon as completed by the author(s), and then subject it to review in full public view.

FINAL THOUGHTS

The convenience of one-stop literature research in a well equipped library of the 1950s-1960s is long gone. Instead, we are faced with an avalanche of papers in journals most libraries can no longer afford to subscribe to and a growing number of providers trying to sell us a restricted range of published articles on-line at an ever increasing cost. Much of the newly created knowledge thus does not reach the research community and is sequestered in out-of-reach journals. Circulation of knowledge is further restricted by copyright laws.

Scientific research has its production and dissemination phases. The former is substantially more expensive than the latter (knowledge dissemination can be achieved for free by the word of mouth or via personal website) and is mostly paid for by the public. The labouriously prepared and ref-

ereed conclusions are then given freely to journals whose production costs and profits restrict knowledge circulation. We would all be wiser if the publicly funded research producers also assumed the obligation to disseminate the peer-vetted results upon project completion, at least in a preliminary way (as open file reports), for free to the reader or at a nominal cost. Websites and the growing server capacities now make this possible. Many geological surveys are now half way there, but the research grant providers like NRC are yet to follow. There is also a pressing need to allow copyright-free circulation of the publicly funded knowledge, provided the source is properly acknowledged. I believe that the time-consuming, referee-short, and overpriced publishing process as we know it will become an add-on in the near future: nice to have but no longer indispensable as the principal means of knowledge dissemination.

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