Book deterioration - Further need for scientific research

Resume: Among many library and archives issues, book conservation is one of the fields where most energetic research efforts have been made over the decades. Nevertheless there remain still several essential problems unanswered. This paper questions general understanding of causes of paper deterioration and emphasizes further need for scientific research.

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1. Need for scientific research in book conservation

The problem of book deterioration in libraries and archives is truly crucial. A large proportion of books and documents has become brittle due to paper deterioration. The phenomenon is worldwide. In the United States, from one third to one fourth of library collections has already become brittle and is no longer usable. Survey reports from other countries also show similar serious condition of books and documents. Our written heritage is facing a crisis of annihilation.

It is recognized that the major cause of book deterioration is acidic compounds in paper introduced in the modern paper-making process. Old rag paper is stable and still in good condition today while modern wood pulp paper made since the mid 19th century is much less permanent.

A lot of research has been carried out to investigate the cause of paper deterioration. Already in the last decade of the 19th century, paper scientists and engineers tackled this problem. However it is only since the late 1950's when the problem became widely known in the library community that conservation research progressed. William Barrow, American paper conservator, published the results of his conservation experiments in 1957. His book 'Deterioration of book stock: Causes and remedies' (1) is an epoch-making report which heralded a new conservation and preservation era. Since his publication, research efforts in conservation have been widely encouraged and promoted. In fact, library conservation is one of the focuses of library research efforts in recent decades.

Yet it seems to me that library conservation is still the field where most energetic research efforts are necessary and there remains a great need of technical and technological development. Several most important questions

are yet to be answered. Our understanding of paper deterioration is not sufficient for the solution of the problem.

I will describe in this paper one example related to this keen problem; the causes of paper deterioration.

2 Why does modern paper deteriorate so fast?

William Barrow, studying the physical strength of the book papers of 1900-1939, summarized his test data as follows:

“The following estimates of the durability of books in the various categories are made:

Very Weak (39% of the samples, 1900-1939)

Such volumes can stand limited use only. Moderate use would cause them to crack, and with such use they would hardly last 25 years. If unused they might be intact after 50 years.

Low Strength (49% of the samples, 1900-1939)

It is likely that most will deteriorate to the *Very Weak* category in 25 years. Their endurance would be less than newsprint.

Medium Strength A (9% of the samples, 1900-1939)

These volumes, with moderate usage, might survive from 25 to 50 years. Group *B* (2% of the samples, 1900-1939) might be expected to last 50 years or more.

High Strength (1% of the samples, 1900-1939)

Papers of this strength should have marked durability, particularly if they show such strength a decade after fabrication.” (1)

Barrow adds “The problem presented to the librarians by this test data is formidable one. If materials should be preserved indefinitely is going to pieces as rapidly as those figures indicated, it seems probable that most library books printed in the half of the 20th century will be in an unusable condition in the next century.”(3) At the end of the 20th century where we stand today, Barrow’s warning has unfortunately become reality. In many institutions of many countries, books published in the first half of the 20th century are mostly in unusable condition.

But why does modern paper deteriorates so fast? As I mentioned earlier, it is normally understood that the acidic compound in paper is the major cause. Scientific experiments repeatedly confirm this understanding. However the reality is not quite as simple as that. Although modern paper is not very stable, the speed of deterioration or the rate of brittle books among

collections vary largely from country to country. The following data I provide you on this subject will be puzzling to many.

Graph 1 shows the comparison of the survey results of the condition of library collections in the United States and in Japan. From the US, the case of the Yale University library survey(4) is taken, while from Japan the cases are of three academic libraries namely, the National Diet Library, Keio University Library and Waseda University Library. (5) These three research libraries in Japan are all situated in Tokyo.

Graph 1: Deteriotated Book Ratios - Japan-U.S. Comparison

The large scale condition survey at the Yale University Library is highly esteemed. The results of this large and precise survey gave a general view of the critical condition of research library collections in the US. The three Japanese libraries have well over one hundred years history and are all prominent research libraries in Japan. In this comparison, in order to avoid statistical complexity, I have taken the results of samples from the foreign languages collections, mostly the European and American publications, in the

case of three Japanese surveys. By this measure the survey samples from the two countries should be comparable. In addition, this graph shows a comparison of book deterioration rate for each decade of publication. This enables a comparison of book longevity in the two countries. The historical composition of collections would differ from library to library and hence a simple comparison of the condition of collections as a whole does not allow a study of the causes of book deterioration.

What the graph indicates is clear. The surveys from the three libraries in Japan show a very similar outcome. The tendency of a high deterioration rate for books published between in in 1890s to 1900s is observed both in the US and in Japan. However the level of deterioration is significantly different. In the case of the Yale survey about 90% of books have deteriorated while in the cases of the three Japanese libraries that rate is much lower at only 20 to 30%. We estimate book deterioration rate in the library's entire collection in Japan is around 1 to 2%, a big difference from the 25 to 30 % in the US research libraries.

Why are the survey results from the US and Japan so different ? What reasons could explain this significant difference?

3 Factors affecting book longevity

Following are the four major factors which affect book longevity:

- (a) Materials
- (b) pH or level of acidity
- (c) Environment

The factors (a) and (b) are of course essential to paper longevity. We can eliminate these factors however because samples of surveys from both countries are identical. We can assume that identical books from each decade of publications are being compared here. Materials and pH level should be alike.

The remaining factor is environment. Among several environmental conditions, temperature and humidity are two most important factors to paper longevity. Table 1 indicates the importance of temperature and humidity factors to the speed of paper degradation.

Certain variations in books deterioration in different institutions have been explained by the different climatic conditions. Climatic conditions would be an appropriate reason in many cases. In reviewing another of William Barrow's publications 'The manufacture and testing of durable book papers', Lyth Hudson, well-known British paper scientist, stated as follows. "Though

the authors do not draw this conclusion, it is easy now to see why the pressure for this kind of research comes from libraries in the warmer parts of the United States. They have already found there that many books fall to pieces after about fifty years. In Great Britain, where temperatures are about 10°C lower, one would expect similar books to last 100-150 years and, as the making of books from papers other than rag is only just about a century old, the main problem may not have hit British libraries yet." (7)

Table 1

EFFECT OF STORAGE TEMPERATURE AND RELATIVE HUMIDITY
ON PAPER PERMANENCE

Average annual storage temperature		Average annual storage relative humidity							
Fahren- heit	Centi- grade	70%	60%	50%	40%	30%	20%	10%	0%
95°	35°	0.14	0.16	0.19	0.23	0.30	0.41	0.68	1.90
86°	30°	0.32	0.37	0.43	0.52	0.67	0.93	1.53	4.30
77°	25°	0.74	0.85	1.00	1.22	1.56	2.17	3.57	10.0
72.5°	22.5°	1.14	1.31	1.54	1.88	2.40	3.34	5.50	15.4
68°	20°	1.76	2.02	2.38	2.90	3.71	5.16	8.49	23.8
63.5°	17.5°	2.74	3.14	3.70	4.52	5.77	8.02	13.2	37.0
59°	15°	4.30	4.94	5.81	7.08	9.05	12.6	20.7	58.1
50°	10°	11.1	12.7	15.0	18.3	23.4	32.6	53.5	150

As Hudson stated, climatic condition plays a very important role in paper longevity. Yet in the case of what I described, this factor does not explain the curious phenomenon. Tokyo, where the three Japanese libraries are located, is situated in the Asian monsoon climate area. Tokyo is hot in summer and humid for most of the year. From the climatic point of view, Tokyo is a very bad place for book conservation.

Other environmental factors such as air pollution and optical degradation cannot explain the significant difference shown in graph 1 either. Air pollution in Tokyo is heavy and the optical factor would not differ much between Yale and Japanese libraries.

4. Air conditioning in US libraries

Examining various factors which affect paper longevity, there is no good reason to explain why paper deteriorates faster in US libraries. It is

puzzling indeed.

Upon further examination I believe the following is the key. The air conditioning in US libraries, which provides dry conditions and excessively low humidity in the book stacks in winter, has caused brittleness of books. Dry conditions cause loss of paper strength by dehydration of acidic wood pulp papers.

Table 2 is cited from the work of Arther Kimberly and his colleagues, researchers of the US National Bureau of Standards.(8) They have investigated the causes of paper deterioration in 1930s. The table demonstrates how dry the inside book stack becomes when the outside temperature goes down while the inside of building is warmed.

Table 2: Variation of Relative Humidity within a Library (8)

Day	Outside temperature	Outside humidity	Inside temperature	Inside humidity
	<i>°F.</i>	<i>Per cent</i>	<i>°F.</i>	<i>Per cent</i>
Feb. 24.....	60	42	69	38
Feb. 26.....	55	60	69	45
Mar. 5.....	40	67	60	30
Mar. 8.....	58	73	62	50

The following two graphs demonstrate dry conditions in library stacks in winter. Graph 2 is taken from the previous Yale survey report(9) and graph 3 from the study at the Columbia University Library in New York.(10) Both graphs show low humidity levels of book stacks in winter; less than 20%RH very often.

Graph 2: Weekly Fluctuation in Temperature and Relative Humidity in the Yale University Library

Graph 3: Weekly Fluctuation in Temperature and Relative Humidity
in the Columbia University Library

How does low humidity affect paper longevity? Arther Kimberly in his survey report comments "If the acid is once formed upon the sheet, its concentration varies with the moisture content (relative humidity) of the surrounding atmosphere, the acid acting as a dehydrator in a very dry atmosphere, literally burning the paper, while in a moist atmosphere it functions as an agent of acidic hydrolysis."(11) The process of paper degradation is complex but I believe that what Arther Kimberly states here should be the reason that can explain the mysterious gap shown in Graph 1.

I have discussed this subject with my American colleagues several times and the idea attracted the audience of the International Seminar in Preservation Research that was held in 1991 in New York. As Dr. Margaret Hay, visiting professor of Columbia University School of Library Services at that time, who was the rapporteur of this seminar wrote:

"Conflicting evidence was mentioned concerning the role of acidity in the 'brittle book' problem. comments were made from the floor on the differences found in the physical condition of papers from the same periods/origins, of similar pH values or acid contents, when comparing book materials found in collection in Japan, Canada, Netherlands, London, Scotland on the one hand with those in U.S. collections. I wonder whether the loss in physical integrity so noticeable in U.S. collections might not be the results of many years of over-dry storage? We know about important role played by water within the cellulose fiber and paper structure in contributing to its flexibility. Is it possible that years of over-dry storage conditions have led to an irreversible loss of moisture from within the paper structure, thus leading to the greater embrittlement of in U.S. collections?"(12)

5. Conclusion

Acidity is no doubt a major cause of book deterioration but it would be too simple to attribute the entire problem of paper brittleness to it. Without examining and identifying accurately the causes of paper deterioration, countermeasures taken to overcome the crucial problem of brittle books will not work efficiently.

This is an example of research needs. There are many other issues which need further scientific research in book conservation. Mass deacidification technology has been a focus of the conservation research and development, but little is known yet in regard of the effectiveness of this technology. A production and use of permanent paper in book publication has been another focus for book preservation. Yet there is not much information about the actual use of permanent paper in each country. Research need for the preservation of information is needless to mention. They are only few I could name. Although research and development is important in any field of library services, it is indispensable for preservation solutions.

On that respect, beside stressing the importance of preservation research, I would like to add one thing, which is the need of communication. Verner Clapp, leading American librarian over the decades, once traced the history of the brittle book problem. He observed that a fair amount of studies have been carried out in the past, and yet, prior to 1960s, fruits were scarce. He wrote later in that work, "How could such a weight of protest and investigation have failed to bring reform? The answer lies partly in economics, partly in the state of chemical knowledge, and partly in communication." (13)

What Clapp pointed out holds true still today. A good communication is vital for the progress of research. An inter-professional communication is particularly essential in research and development. It is another important key for the solution of the library and archives preservation problems.

Notes

- (1) Church, Randolph W. ed. 'Deterioration of book stock - Causes and remedies; two studies on the permanence of book paper/conducted by W. J. Barrow' Virginia State Library publication, No.10, 1959.
- (2) ibid, p.15.
- (3) ibid, p.16.
- (4) Walker, Gay et al. 'The Yale survey: A large scale study of book deterioration in the Yale University Library' College & Research Libraries 46(2) p.111-132(1985) Unpublished data are also obtained from Gay Walker.

- (5) Data are taken from the followings: 'Paper deterioration and the conservation of library collections' Toshokan Kenkyu Sirizu, No.24, p. 209-232(1984), Okuzawa Misa 'The condition survey in Keio University Library' Ronshu Toshokangaku Kenkyu no Ayumi, No.5, p. 117-148(1985) and Toshokan Kiyo Henshu linkai ed. 'Report of the survey in Waseda University Library' Waseda Daigaku Toshokan Kiyo No.32, p.1-34(1990)
- (6) Smith, Richard W. 'The nonaqueous deacidification of paper and books' Doctoral dissertation. The University of Chicago. 1979.
- (7) Hudson, F.Lyth. Paper Technology 2(1) p.21(1961)
- (8) Kimberly, Arthur R. et al. 'A survey of storage condition in libraries relative to the preservation of records' Miscellaneous Publication. Bureau of Standards. No.128, p.6 (1931)
- (9) op cit. Walker et al., p.125.
- (10) Adamitis, Vicky et al. 'Monitoring project' 1985 (Unpublished)
- (11) op cit. Kimberly et al. p.4.
- (12) Hay, Margaret, 'Rapporteur's report on the International Seminar on Research in Preservation and Conservation, Columbia University School of Library Services, May 25-28,1991' (Unpublished)
- (13) Clapp, Verner W. 'The story of permanent/durable book-paper, 1115-1970' Restaurator, Supplement, No.3 p.23 (1972)