Geoscience Canada

Hamilton Harbour Remediation: The Role of Environmental Geology

N. A. Rukavina and J. P. Coakley

Volume 21, Number 1, March 1994

URI: https://id.erudit.org/iderudit/geocan21_1con03

See table of contents

Publisher(s)

The Geological Association of Canada

ISSN

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

Explore this journal

Cite this article

Rukavina, N. A. & Coakley, J. P. (1994). Hamilton Harbour Remediation: The Role of Environmental Geology. *Geoscience Canada*, *21*(1), 34–36.

density of geochronologic information greater than that found in many orogenic belts or individual greenstone belts in the Superior Province; not all these ages are geologically consistent. In the past, the tendency has been to reinterpret geologic relationships in terms of the geochronology. One unanswered question of the session is how much do we really know about the systematics of many isotopic systems during high-grade metamorphism, or repeated metamorphism? Can we always recognize igneous *versus* metamorphic zircons or partial resetting? Perhaps a little more skepticism and caution is needed. Then again, maybe our difficulty in interpreting the geochronological data reflects a lack of understanding of the geological relationships in the area.

4. Geophysical information is becoming more significant in interpretation and modelling, especially seismic reflection images. Geophysical data were very influential in many of the studies presented, even though this influence was not apparent in the titles of the scheduled talks. In future sessions, organizers should encourage greater involvement by geophysicists, perhaps by ensuring that a geophysicist serves as a session organizer.

5. Terrane definition and analysis in the Central Metasedimentary Belt has been based primarily on the classical methods or on recognizing distinctive stratigraphic packages bounded by faults or shear zones. Within the Central Gneiss Belt, however, more latitude has been used, including isotopic signatures (U-Pb, Nd-Sm, systems), timing and age of regional metamorphism, structural history, and potential field maps. In the case of the Central Gneiss Belt, this usage is similar to the broadening of terrane-defining characteristics being discussed in the Cordillera (see Johnston *et al.*, this volume).

The session was successful in bringing together much of the current research within the Grenville Province, and providing all concerned with a snapshot of a work that is still in progress. The only drawback is that the setting of the GAC–MAC Annual Meeting made discussion and debate difficult, compared to the atmosphere found at more focussed meetings, such as Friends of the Grenville workshops. This is in spite of the fact that many speakers, especially the students, gave properly timed talks that allowed for in-session questioning. True, many informal discussions occurred over meal times and during the field trip, but these were only accessible to a few. If GAC–MAC Annual Meetings are to continue to be relevant forums, methods of fostering in-session discussion (at least in some circumstances) need to be pursued. Then again, perhaps these types of issues can only be resolved in a different type of setting (*e.g.*, a NUNA conference).

Session abstracts are published in the Geological Association of Canada–Mineralogical Association of Canada, Program With Abstracts, v. 19, 168 p. A field trip guide for the meeting, titled Terrane Boundaries and Lithotectonic Assemblages within the Grenville Province, Eastern Ontario, 89 p., is available from the Department of Earth Sciences, University of Waterloo, Waterloo, Ontario N2L 3G1. Cost is $16. Cheques should be made payable to "Waterloo '94."

REFERENCES

Easton, R.M., 1992, Revised Terrane Subdivision and Observations on the Tectonic Assembly of the Central Metasedimentary Belt, Ontario: Geological Society of America, Program with Abstracts, v. 24, p. 94.

Howell, D.G., 1989, Tectonics of Suspect Terranes: Chapman and Hall, New York, 232 p.

Johnston, S.T., Hart, C.J.R. and Mihalynuk, M.G., 1993, NUNA conference report: the Northern Intermontane Superterrane: Geoscience Canada, v. 21, p. 27-30.

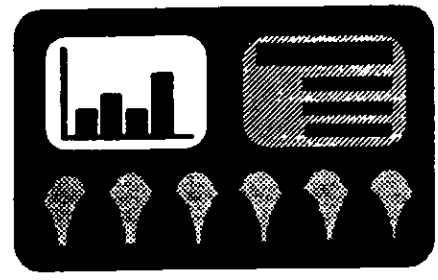
Moore, J.M., 1982, Stratigraphy and tectonics of the Grenville Orogen in eastern Ontario: 1982 Grenville Workshop, Rideau Ferry, Abstracts, p. 7.

Rivers, T., Martingole, J., Gower, C.F. and Davidson, A., 1989, New tectonic subdivisions of the Grenville Province, southeast Canadian Shield: Tectonics, v. 8., p. 63-84.

Willet, S., Beaumont, C. and Fullsack, P., 1993, Mechanical model for the tectonics of doubly vergent compressional orogens: Geology, v. 21, p. 371-374.

[1]GSC Contribution Number 51094

Accepted 3 October, 1994.



Hamilton Harbour Remediation: The Role of Environmental Geology

N.A. Rukavina and J.P. Coakley
National Water Research Institute
867 Lakeshore Road
Burlington, Ontario L7R 4A6

In the mid 1980s, the International Joint Commission identified Hamilton Harbour as one of 42 "Areas of Concern" in the Great Lakes with severely degraded water quality and toxic contamination. The harbour occupies a natural bay at the western end of Lake Ontario in the midst of an urban-industrial complex and is one of the busiest ports in the Great Lakes. For more than 150 years, it has served as the equivalent of a secondary-sewage treatment plant for industrial, municipal and agricultural waste. The task of clean-up and restoration of the harbour has now been assigned to a local stakeholders group charged with setting up and implementing a "Remedial Action Plan" (RAP). Clean-up is to be based on an ecosystem approach that takes into account the results of research on the processes and materials of the harbour.

Environmental research in the harbour is a fairly recent activity. Most of the studies have been done within the past 20 years by the Ontario Ministry of the Environment, the federal National Water Research Institute (NWRI) in Burlington, Ontario, and local universities. Work has been accelerated recently by the federally-sponsored Great Lakes University Research Fund (GLURF) and by a sizeable NSERC grant to McMaster University. At this stage, some perspective on what has been accomplished and its relevance to the RAP program was identified as useful in specifying and assessing future

research needs. This was the rationale for a special session at the May 1994 Geological Association of Canada–Mineralogical Association of Canada meeting in Waterloo sponsored by the Environmental Earth Sciences Division of GAC entitled, "Hamilton Harbour Remediation: The Role of Environmental Geology."

The session was organized and chaired by Norm Rukavina and John Coakley of NWRI and consisted of a full day of presentations and posters on a wide range of harbour science and engineering topics. Some attempt was made to structure the session so that it proceeded from environmental history to general geology and limnology, contaminant distribution, and finally, to a discussion of RAP needs and the mediation procedures designed to address them. To broaden the scope of the session and benefit from the experience of others with the same problems, we invited speakers to report on the situations in Halifax and Boston Harbours and to discuss our approach.

SUMMARY OF PRESENTATIONS

Dale Buckley (Atlantic Geoscience Centre) led the session with a presentation on the status of contaminant research in Halifax Harbour. The harbour is severely contaminated as the result of a long history of accumulation of metals and organic compounds. Untreated sewer outfalls and secondary contamination by leaching and surface runoff are the major sources of contaminants, and the inner harbour is the major sink. Geochemical and hydrodynamic studies have been helpful in identifying the sources, sinks and pathways of contaminants and in guiding the efforts at remediation.

The research on Hamilton Harbour was introduced with two papers tracing its environmental history over the past several thousand years and setting the stage for the discussion of its present status. Both studies were based on paleoenvironmental analysis of a long core from Hamilton Harbour with a base dated at 8800 years BP. Yang and Duthie (U. of Waterloo) analyzed the diatoms in the core and were able to distinguish four stratigraphic zones indicating a succession of shallow depth and isolation from Lake Ontario, gradual deepening, connection with the lake during the Nipissing Flood, and finally, increasing eutrophication and pollution after 270 BP. The companion study by Denis Delorme (NWRI) on the ostracode stratigraphy of the same core showed similar trends in bathymetry and sediment quality.

Norm Rukavina (NWRI) then summarized the current status of data on the bottom sediments and bottom features of the harbour. The surficial sediment pattern is a fairly simple one in which texture is related to water depth and wave exposure, but the stratigraphy of the uppermost sediments (0-1.5 m) is very complex, particularly along the industrial south shore. Coring and side-scan sonar surveys show this complexity to be the result of considerable modification of the harbour bed by shipping, dredging and dumping. The recognition of sediment disturbance as an important factor will clearly have an impact on both future research on harbour processes and the procedures used for remediation.

Paul Hamblin (NWRI) looked at the problems of water exchange between the harbour and the lake, an important factor in assessing remediation strategies. Direct measurements of exchange through the shipping canal are complicated by the presence of ship traffic. Paul demonstrated that it is now possible to use new acoustic-doppler equipment to measure flow remotely and to collect data on the exchange rate and the concentrations of suspended sediment carrying the contaminants.

After the mid-morning break, the session changed focus to look at sediment dynamics in the harbour. The key speaker for this section was Marilyn Bucholtz ten Brink of the United States Geological Survey at Woods Hole. She described her work and that of her colleagues on sediment contamination in Boston Harbour and Massachusetts Bay. Like Halifax Harbour, Boston Harbour has been receiving vast quantities of contaminants for centuries. Massive remediation efforts are now being planned, making it the site of the most expensive ($4.5 billion) remediation project under the United States Environmental Protection Act (EPA) Superfund initiative. The study combines physical and chemical characterization of sediments with water movements (circulation due to waves and tides) and studies of sediment transport, and applies these parameters to proposals for changes in outfall siting and dredge spoil disposal.

Murray Charlton, with Mike Fox, brought the discussion back to Hamilton Harbour with a presentation of NWRI research on sediment-trap data. Their data show higher settling fluxes and lesser resuspension in the harbour than in Lake Ontario, and that contaminant levels depend on proximity to industrial sources. There is some evidence that trap samples are now slightly less contaminated than bed sediment, but continued monitoring will be necessary to confirm that trend and to track the future progress of the clean-up efforts in the harbour.

John Coakley (NWRI) reported on a co-operative study with McMaster University of contaminant dispersal in the harbour from the Hamilton and Burlington sewage-treatment plants. Analysis of the spatial concentration patterns of a number of natural tracers, including coprostonal, $\delta^{15}N$, $\delta^{13}C$ and selected trace metals, was used to infer sediment pathways. The best results were obtained with coprostonal, which has its source only in sewage treatment plants (STPs). This shows a pattern of alongshore movement and eventual discharge to the lake through the ship canal, which is in good agreement with simple models of nearshore circulation.

The theme of sediment transport trends was continued by Ken Versteeg and co-authors (McMaster University and NWRI) in a presentation of the use of magnetic-susceptibility profiles for mapping the spread of contamination in the harbour. The profiles show an order of magnitude increase after settlement which can be associated with related increases in trace metals and polycyclic aromatic hydrocarbons (PAHs). When the data are plotted as a series of time? slices, they show an advancing front of susceptibility (and presumably contamination) across the harbour from the south shore.

In the closing paper of the morning session, Tanya Mayer and colleagues at NWRI examined the transport of particle-associated contaminants in the harbour by measuring phosphorus, heavy-metal and PAH levels in water and in suspended and benthic sediments. They found evidence of input from the steel industry marked by high-hematite and wüstite and high-P input associated with point sources.

The theme of the afternoon session was the remediation of Hamilton Harbour and new technologies for contami-

nant stabilization or removal. Keynote speaker Keith Rodgers of NWRI reviewed various aspects of the Hamilton Harbour RAP from his perspective as its former co-ordinator. Current plans include research to facilitate wetlands renewal, control contaminant sources, and quantify the various contaminant/biota relationships.

Tom Murphy (NWRI) then described his innovative system for *in-situ* stabilization of toxic sediments that uses a ship-mounted device for mechanical injection of a proprietary mixture of oxidants and nutrients. The mixture was designed and tested in the laboratory to optimize bacterial decomposition of toxic organics such as PAHs and oil/grease complexes. The results of field trials in the harbour in 1992 and 1993 (48-86% biodegradation of organic contaminants, 98% precipitation of the porewater iron) suggest that the procedure should be useful in selected sites where the alternatives of dredging and confinement are too costly or disruptive.

Another remediation technique aimed at isolating areas of contaminated sediments from contact with the water column was described by Alex Zeman of NWRI. This is a capping technique that involves covering polluted sediments with a clean find sand cap up to 50 cm thick. It has been used successfully in the United States and Japan; Alex is responsible for organizing a demonstration progect on a 1-hectare site in Hamilton Harbour. The advantages of the procedure are its low cost and minimal disruption of contaminated sediments.

The final paper by Ken Versteeg (McMaster) described a joint McMaster and NWRI investigation of a fast and inexpensive procedure for the measurement of contaminant distribution in cores. The study compared non-destructive measurements of magnetic-susceptibility in cores with PAH measurements determined by conventional sub-sampling and chemical analysis. Results showed a close correlation of magnetic and PAH profiles and the potential for using magnetic data as a rapid and cheap proxy for identifying contaminated sediments in this particular environment.

The poster presentations continued the theme of sediment characterization introduced in the morning sections. Edwards and Cieslewicz (U. of Waterloo) illustrated the use of stable isotopic ratios from fossil cellulose in long cores from the harbour to corroborate some of the paleoenvironmental changes suggested earlier in Yang and Duthie's presentation. Water level changes and the changing influence of the open lake, in particular, were clearly identified by trends in the isotope profile. The use of side-scan sonar as a tool for remote characterization of bottom features was the theme of two posters. Brown and Scott (U. of Toronto) used a computer display to illustrate the advantages of digital side-scan sonar data for areal and profile analysis of bottom features and for creating a mosaic of images to produce high-resolution bottom-feature maps. Rukavina and Zeman (NWRI) and Keyes (McQuest Marine) summarized the results of a detailed side-scan survey of the entire harbour in a number of CAD-generated maps showing large areas of surface-sediment disturbance by anchor-dragging and dredging operations. The final exhibit co-authored by Harvey, Rudolph and Frape (U. of Waterloo), Novakowski (NWRI) and Lee (Atomic Energy of Canada Ltd.) was concerned with preliminary data from a study of groundwater flow in the the harbour floor and its implications with respect to contaminant dispersal.

IMPACT

Following the presentations, the keynote speakers were invited to comment on the current status of the harbour work and possible future research directions. They acknowledged that the studies to date do provide a useful background for remediation efforts, but also recognized that data gaps remain in a number of areas: the geochemistry of sediments, sedimentation rates, sediment re-suspension and transport and sediment budgets. It was also clear that there are problems still to be addressed in the integration of data and in improving access to a considerable volume of unpublished data.

The special session was clearly a successful addition to Waterloo '94. It was well attended, and interest was high enough to sustain discussion through the coffee breaks and lunch and into the poster session. The multidisciplinary focus on a well-known problem area proved to be useful to both the scientific community and those interested in applying the research to remediation problems. It was particularly helpful in showing how environmental geology fits into the design of remedial initiatives for the harbour and in suggesting areas for future research.

Accepted 26 October 1994.