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> Without educated brain and skilled hands, the fertile soil, the timbered land, water-power and mineral deposits, must lie idle or be ignorantly squandered. (Ontario Royal Commission on University Finances, 1921)

Since the seminal works of Harold Innes, natural resource exploitation has been among the central concerns of Canadian historians (see Peter J. George, 'Classical Writings in Canadian Economic History: the Role of Natural Resources in Canadian Economic Development,' in Deborah C. Poff, ed., Research Tools in Canadian Studies (Ottawa: ACS/ICCS, 1988), 19-32). Many of the outstanding names of the profession, past and present, have written on aspects of that topic. With regrettably few exceptions, however, the technology of resource industries has formed at best a very minor part of these studies. Thus it is encouraging to see a growing literature emerging to fill that lacuna. For its part, the Canadian Historical Association included a session on 'Staple Production and Technology in North America' at its 1989 annual meeting in Québec. This review discusses three very different books with very different foci, all of which look at the resource sector and all of which have technology central to their arguments.

Along among these three authors, Dianne Newell is an historian of technology. Her book looks at the changing technology of mining in Ontario between 1840 and 1890. The bulk of this short volume consists of three case studies: hardrock mining in the Upper Great Lakes (Lake Superior shore, Sudbury basin), Southeastern Ontario (including iron ore, gold and lead mining) and petroleum and salt extraction in Southwestern Ontario. Historians of mining in Ontario will not find a great deal that is new in these studies. They do however represent welcome summaries showing the place of technology in three contrasting settings.

Of greater interest are her chapters on 'the 19th century revolution in mining.' Newell looks first at innovations, mostly mechanical, then at the means of diffusion. She shows that the sources of innovation were diverse, including lone inventors, equipment manufacturers and borrowings from other industries. The largest part of the technology by far had its proximate origins in the United States, with additions from the UK and Europe as well as Canada. The question of origin is however of little importance when placed against the increasing internationalization of mining technology. More and more, mining professionals accessed a common pool of technical knowledge. They then brought that knowledge to bear on the site-specific problems associated with particular ore bodies in particular locations, a process which demanded a high degree of technological creativity.

Equally diverse were the mechanisms for the diffusion of technology. Technical knowledge travelled with managers and skilled workers. Trade catalogues, technical journals and monographs poured off the presses in an astonishing volume. Government bureaux, professional associations and mining schools had their parts to play. Individuals moved not only geographically, but among sectors. Newell mentions the example of W. H. Merritt (grandson of the canal promoter) who was variously an Eastern Ontario mining consultant, a member of the Ontario Royal Commission on Mineral Resources and lecturer on mining engineering at the School of Mines at Kingston. All of this formed part of a new approach to mining know-how. Much of the mystery fell away from this craft as knowledge became more public, more a common property resource than a proprietary good.

Ian Radforth is a labour historian looking at changes in the technology of pulpwood logging in Ontario during the course of the twentieth century. He observes that problems in terrain and the extreme heterogeneity of this workplace long resisted mechanization. The skill and judgement of workers remained supreme as late as the Second World War. In the third of a century after that conflict, however, the situation underwent a radical

transformation. Radforth sees the transformation as motivated by changes in the labour market, pressure from lower cost areas and the need for a reliable year-round flow of materials to the mills for continuous process production. I would place more stress on the third of these factors than has the author, and would also ask about the changing nature of the forest and of forestry practice.

The sources of new mechanical technology included the workers themselves, equipment manufacturers and individual inventors. In addition, the logging industry borrowed extensively from other industries, recombining off-the-shelf technology for new purposes. New developments originated both in the United States and Canada. Radforth correctly identifies the crucial role played by the Woodlands Section of the Canadian Pulp and Paper Association as an agent of technological change. The Section brought together not just competing pulp and paper firms but also their suppliers in an effort to seek solutions to a set of technical problems which they faced in common.

A new workforce emerged from this transformation, one with a new set of skills. These were mechanical skills, not bush skills. In addition, mechanical and forest engineers played expanded roles in the productive process, a factor which must be kept in mind when assessing the net level of skill in the industry in different periods.

Ferguson's study demonstrates that the story of attempts to exploit the tar sands is a story of industrial research. His is a clear and lucid account of a complex set of relationships. He shows how the shifting alliances among two levels of government and diverse private concerns intersected field, laboratory and pilot scale investigations. In different periods, perceptions varied as to the likelihood of economic exploitation of this resource and the shape which that exploitation would take. Would the sands yield fuel or be suitable as a road surfacing material? Would some variant of conventional drilling technology be successful or technology borrowed from open pit mining?

Government, academia and business were involved cooperatively right from the start. The Geological Survey of Canada, a chemist at the Royal Military College in Kingston and a private refiner in Southwestern Ontario shared in the first nineteenth century efforts to understand how the sands might yield their bounty. By the post-World War Two period, those involved in the research efforts included the University of Alberta, US and Canadian engineering consulting firms, operating companies, potential consumers, equipment suppliers, the Federal Mines Branch and the Research Council of Alberta. Most technical knowledge was public, not proprietary. The crucial question: who would be best equipped to deal

with the knowledge, to bring it to the point of production and implement it? Ferguson is especially strong on governments' need to gain the ability to assess new science-based industrial technology.

These three works show how far the history of technology in Canada has progressed since J. J. Brown. No longer are credible historians exercised by the search for winners and losers or simplistic categorizations of 'our' technology versus 'their' technology. Instead the eclectic nature of the sources of technological knowledge, the multiplicity of foci and the importance of procedures for managing that knowledge are recognized. Historians are beginning to explicate the complexity of systems for acquiring, evaluating and applying technical knowledge in production. They have identified key mediators in this process: government scientific services, academic experts and technical associations. A fascination with patents is giving way to a greater appreciation of the scope and significance of increasingly public or commonly held technical knowledge. All of these are important themes and all merit further exploration in other industrial settings.

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