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Human Resources Needs in Earth Sciences in Canada

A preliminary Survey

September 2008

CFES 2008-1

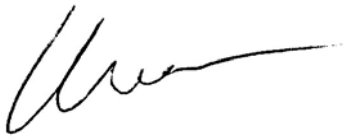
Today's demographic situation will result in increasing labour shortages across the board in Canada. This survey estimates current work force composition and anticipated challenges for all sectors of Canadian Earth Sciences. Significant shortages are anticipated and lead to a series of recommendations

Foreword

CFES/FCST is pleased to present to you the first ever survey on future human resources needs in the entire Canadian Earth Sciences discipline. Our field is core to Canada's future in managing the natural environment, in mitigating natural disasters and in exploiting our wealth of earth resources. The survey indicates that all sectors will face difficulty in finding sufficient and sufficiently qualified staff in the near future. CFES/FCST remains committed to advocating about the Earth Sciences in order to raise awareness and increase recruitment of students majoring in Earth Science in our universities. CFES/FCST will also continue to push for increased research funding for all sectors of the Earth Science discipline, for improving cross-provincial mobility and for increasing the numbers of qualified immigrant professionals.

We want to thank especially our special advisor for this project, Simon Hanmer, for initiating the work. We thank especially the Canadian Council of Professional Geologists (CCPG) for sharing data with us and allowing us to quote them in this survey. We also thank our administrative assistant Catherine Barrett for an immense amount of data manipulation and Lisa Griffith and Elisabeth Kosters for final editing. Most importantly, we want to thank the representatives of all the companies, geological survey organizations and academic departments for spending precious time to fill out and submit this survey.

September 2008



Ian Young, President

Bill Mercer, president-elect

About the Canadian Federation of Earth Sciences CFES/FCST

CFES-FC`ST is an umbrella organization of 15 professional and learned geosciences societies and interest groups, representing about 15,000 Canadian geoscientists. CFES-FCST, as the unified voice for Earth Science in Canada, facilitates communication and processes internally across the Canadian geoscience community with its member societies and externally to all Canadians.

To the general public, CFES/FCST raises awareness of the importance of Earth Science in Canadians' everyday lives. It enhances society's understanding and appreciation of the role of Earth Sciences in environmental, natural hazard and climate studies. CFES also advocates for the fundamental role of Earth Sciences in securing and responsibly developing Canada's energy, mining and water resources. It seeks to influence science-based policy and public opinion, acting as the principal contact and point of reference for the public with regards to information, advice, and advocacy on matters of concern to the Earth Sciences.

Within the community of Earth Sciences, CFES-FCST facilitates the sharing of data, knowledge, and evolving ideas among the sectors of Canada's Earth Sciences.

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Executive Summary

The issue of an impending shortage of highly qualified professionals (HQP), including Earth Scientists, is a challenge we face in Canada as well as in the rest of the western world. Of the different sectors of the Earth Science community in Canada, it is mining industry that has repeatedly called upon all levels of government to address this emerging human resources deficit. But government agencies and universities across the country are also experiencing serious difficulties finding sufficient and sufficiently trained personnel. These anticipated shortages will have consequences not only on the economic vitality of the mining and petroleum sectors, but also on Canada's ability to face future challenges. These challenges are currently addressed by earth scientists in the public and academic sectors and include energy, water and material needs and short and long term natural hazards.

This report summarizes the results of a comprehensive multi-sector survey, addressing a) the skills required of highly qualified personnel (HQP) in the Earth Sciences, and b) magnitude of the anticipated geoscience human resources deficit. The conclusions are based on a questionnaire distributed among five Earth Science sectors representing 117 organizations and approximately 4000 working earth scientists.

Our data indicate that there is no "one size fits all" solution: the HR profiles and the HR Challenge is sector-specific within the Earth Science community. This is because there are differences in the demographics of the earth scientist community between sectors, but also in hiring practices as some sectors hire more contract staff and others more permanent staff. In industry, there are differences between domestic or international practice and exploration vs production. The environmental sector has a dynamic all of its own. It should be noted that some sectors appear to underestimate the shortage of earth scientists by their implicit assumption that a shortage of in-house Earth Science expertise will be supplied by on-demand external contractual expertise – without consideration of the sustainability or source of the contractors.

Because there is no single solution to the Earth Science HR Challenge and because the need for specifically skilled personnel varies across the sectors, we recommend a variety of approaches aimed at increasing numbers of Earth Science BSc graduates, well versed in the fundamentals of Earth Science. It goes without saying that outreach activities about the role of the Earth Sciences in society remain essential. Additionally, changes to facilitate the recognition of the qualifications of immigrant Earth Science professionals must be supported.

Background

The Canadian Earth Sciences faces a dearth of highly qualified personnel. Several reports and briefs are referenced here to illustrate the history and breadth of the problem.

- 2002 - Engineers/Geologists. *"2002 National Survey of Professional Engineers"*, which included geologists as a partial subset.
- 2004 - Petroleum. An energy sector report published by the Petroleum Human Resources Council (PHRC): *"Strategic Human Resources Study of the Upstream Petroleum Industry: the Decade Ahead",* which concluded that there would be less need for geoscientists in the future as industry moved away from exploration

- 2005 - Mining. A comprehensive report entitled *"Prospecting the Future: meeting human resource challenges in the Canadian minerals and metals industry"*, published by the Mining Industry Human Resources council (MiHR; formerly MITAC, the Mining Industry Training and Adjustment Council). According to this report, the cumulative gap in HQP required by the Mining sector for the coming decade is greater than 70,000.
- 2006 – Mining. Based on the 2005 report above, the Mining Association of Canada (MAC) cited the human resources deficit as a challenge facing Canadian mining, and called upon all levels of government to mobilize to address this emerging gap in a brief to the Mines Ministers Conference (MMC). Similar issues were raised by the Prospectors and Developers Association of Canada (PDAC) at the same MMC.
- 2006 - Academic. The Council of Chairs of Canadian Earth Science Departments presented statistics in its *"Enrolment Report for 2007"* (http://ace.acadiau.ca/cccesd/rep2006.html)

In other words, the worsening highly qualified personnel (HQP) capacity gap in the earth resource sectors has been well articulated by the sector associations, but these reports do not refer to Earth Science as a whole, but rather focus on the broad spectrum of skills, trades, and professions associated with various industries. Until now there has been no public information for HQP requirements of the other Earth Science sectors such as government (e.g. geological surveys, water management agencies, energy regulators) and the (private) environmental/geotechnical sector.

Method: the CFES HQP Questionnaire

An evaluation of the entire Earth Science discipline was hence deemed necessary in order to enable governments, academia and industry associations to address the Earth Science HR Challenge in a meaningful way, as the basis for their strategies and for the investment of their resources.

The CFES/FCST survey presented here is a preliminary contribution to the ongoing analysis of the specific requirements of each of the Earth Science sectors. It is a snapshot of the current perception of HQP requirements, and as such is certainly subject to change given our quickly shifting political-economic world.

The data were gathered between June 2007 and June 2008 in response to a Questionnaire sent out to five Earth Science sectors: Government, Academia, Petroleum, Mining, Environmental & Geotechnical.

The respondents represent a population of some 4000 people working in 117 organizations (Figure 1). Additional data compiled by the Canadian Council of Professional Geoscientists (CCPG), representing approximately 8600 people, is included. A bulleted summary of the responses is provided in the Appendix.

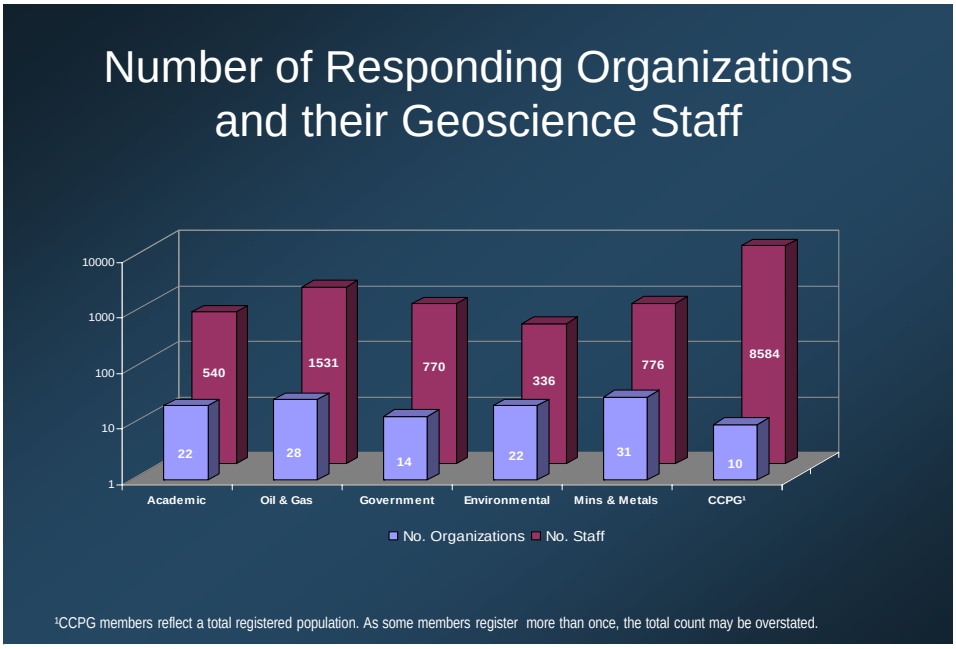

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Figure 1

The questionnaire was designed to elicit information on current and future demographics and on required expertise. It was constructed in two parts: (i) general demographics and projections into the coming 2-5 years, and (ii) a simple prioritization (low / medium / high) of specific expertise in the event of future hiring. To allow sector-specific aspects of the demographics to be captured, and to enable comparison of the data between sectors, the basic questionnaire template was then tailored to each of the sectors of the Earth Science community.

Quantitative Demographics

Figure 2 presents current demographic data from the five surveyed Earth Science sectors. Added are data from the Canadian Council of Professional Geologists (www.ccpg.ca), representing both engineers and geologists professionally registered across all provinces in Canada (engineers outnumber geologists in this population.), a figure for the total Canadian population and a figure for the total of geoscientists. The responses have been standardized by converting them into percentages. The observations can be summarized as follows:

- Academic and Government. The infamous "Grey Bulge", a marked high percentage of workers in the 40-60 demographic in contrast to low percentages in the under 40 brackets, is well defined in both the government and academic sectors with some variation in the older range of age at which the bulge declines. In each of these sectors, the under-40 group is represented by only 20% of the total population. In both academia and government this trend is exacerbated by a hiring preference for MSc and PhD degrees, delaying hiring age until about 30. The "Grey Bulge" may also reflect episodic mass hiring in times of economic

upswing, coupled with a lack of mobility related to tenure or its equivalent and attractive pension plans. Both sectors can provide mentors and experienced scientific leadership to younger staff. There is both room and need for expansion of the under-40 to ensure ongoing renewal of capacity. This concern is not unique to Canada: in Australia's Geological Survey Organization, only 16% of staff is under 30 and no less than 16% over 55[1].

- CCPG. The demographics for CCPG members are indistinguishable from those of academia, and very similar to those of the government sector, rather than mirroring the trends in petroleum and mining. This probably relates to the fact that a minimum experience level is required before one can apply to be a registered geologist (P.Geo.), hence professionals delay this step. Young professionals often start in large companies where there is no initial need for professional status. In addition, the trend may reflect the situation where professionals register once they start working as independents, which is often in a later phase in their career.
- Mining, Petroleum. The "Grey Bulge" is not well defined in the mining and petroleum industries. The Mining sector is principally staffed by geoscientists whose demographic numbers are quite flat in the 20-50 age range, followed by a steep decline at 50+. The Oil & Gas sector shows extended flat demographics up to 60, followed by decline. These numbers suggest that the Oil & Gas sector is holding onto its most experienced personnel, more so than the Mining sector, possibly through the mechanism of vested options held by employees. In addition, the Oil & Gas sector includes a significant number of geotechnical professionals, who show a marked (+50%) bulge in the 40-50 age range. This trend may reflect an artefact created by differences in classifications of geoscientists over time.
- Environmental/Geotechnical. The Environmental/Geotechnical sector is the only sector with a significant percentage of young workers. The trend is probably the effect of its relatively recent status within the Earth Science discipline and also of the tendency of younger generations to prefer the environmental sector over the resource sector.
- Total Geoscientists. The Earth Science sector reflects the gross working population trends for Canada as a whole, thereby suggesting that our data are robust.

Two possible discrepancies in the mining data can be flagged

1. the acquired statistics for the 20-50 age range in the Mining sector may mask short wavelength fluctuations that might be predicted by variations in the numbers of BSc graduates in Earth Sciences over the past 30 years (Figure 3), assuming that a significant proportion of those graduates entered and remained within the resource sector job market. However, because downturns in degrees often trend with job market conditions, periods of low employment may have induced geoscientists to seek employment in other sectors, even well after graduation. Figures for the United States, for example, indicate that about 50% of BSc-level graduates in Earth Sciences work outside their profession (Keane, 2007 at www.geoscience.ca/census.html). If such a career-change were numerically important, it would significantly reduce the difference in amplitude between the flanking peaks and the central downturn in Figure 3 with respect to retention of highly qualified personnel within the Earth Science community.
2. The drop in numbers after 50 years of age in the Mining sector occurs too early in our data. This trend may be explained in part by migration into independent consulting, a group that was possibly underrepresented in the survey.

[1] http://www.innovation.gov.au/Documents/Ch6_geoscienceaust_0607_20071025160826.pdf

Further investigation will be required to settle the apparent demographic discrepancy in the Mining sector, as well as to determine if it also applies to the Oil & Gas sector.

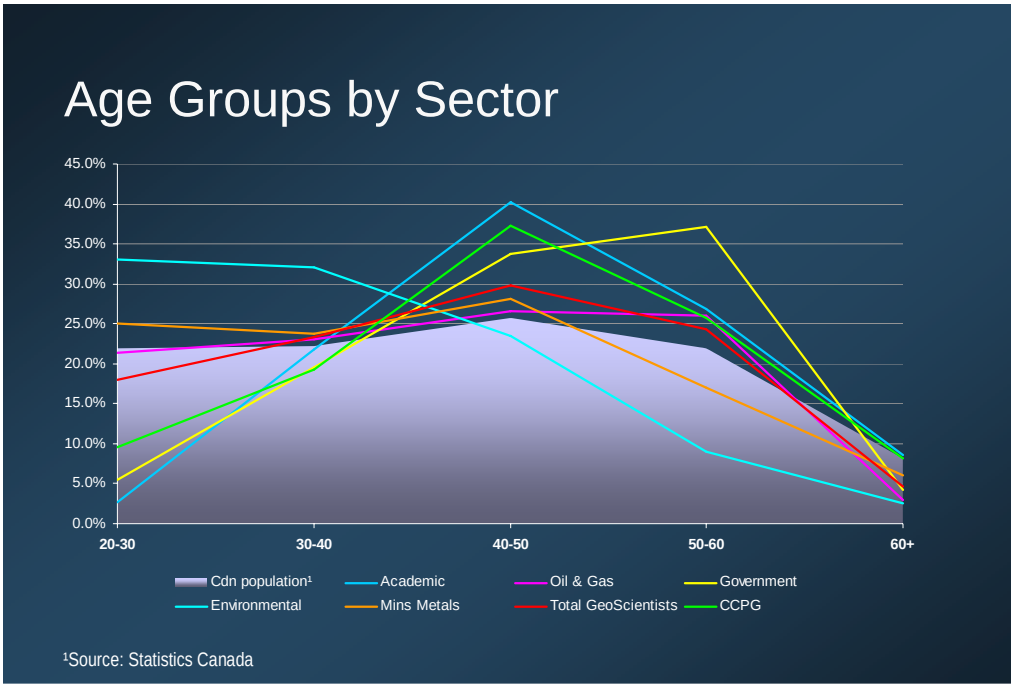

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Figure 2

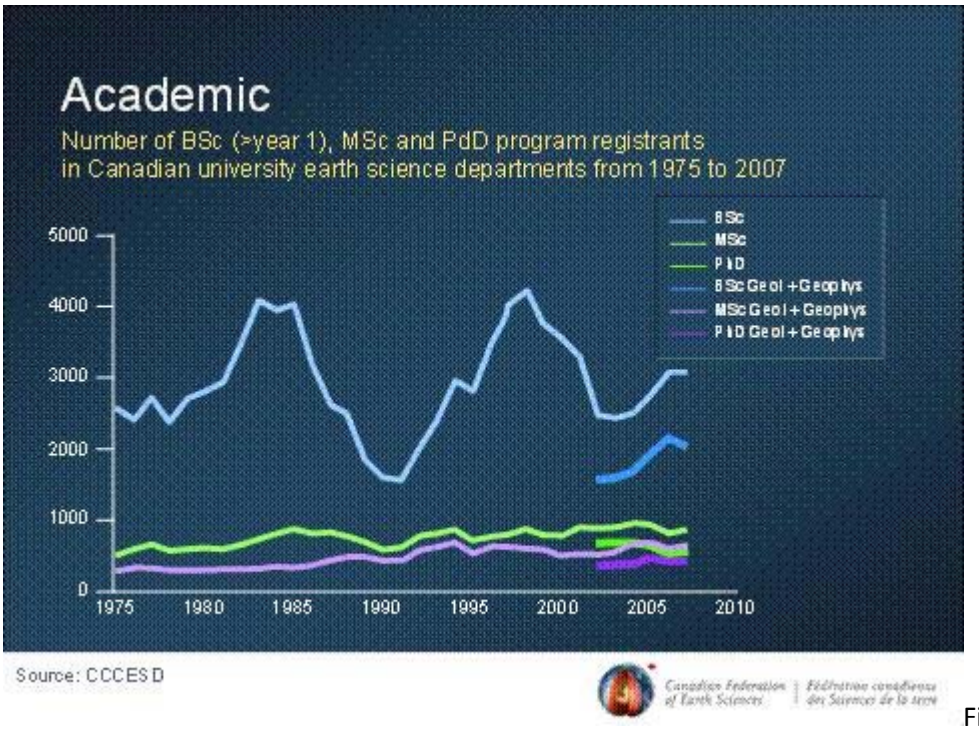

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Figure 3

Contract staff (Figure 4) account for 40% of personnel working in the Mining sector. This stands in stark contrast to the numbers reported from the other sectors: 5% in Oil & Gas, 10% in government, and 10-20% in academia (teaching and technical support, respectively). In the Environmental & Geotechnical sector this figure is 20%.

Predicted net change in number of staff marks another clear distinction between the Mining and Environmental & Geotechnical sectors and others. Both of these sectors predict a ~30% staff increase over the coming 5 year period (Figure 5). The other sectors predict increases in the 5% range. In Mining, this increase likely reflects the upsurge in confidence in the mineral exploration sector, and the inherent financial volatility that characterizes the junior companies that now account for the majority of exploration activity. Note that this increase is predicted to occur just as the population peak for Mining (40-50 year olds) will be entering the historical precipitous decline in numbers. Are 50+ year olds migrating to independent consulting, or are they leaving the industry? In contrast, the strength of predicted growth in the Environmental & Geotechnical sector likely reflects a growing demand for E&G services.

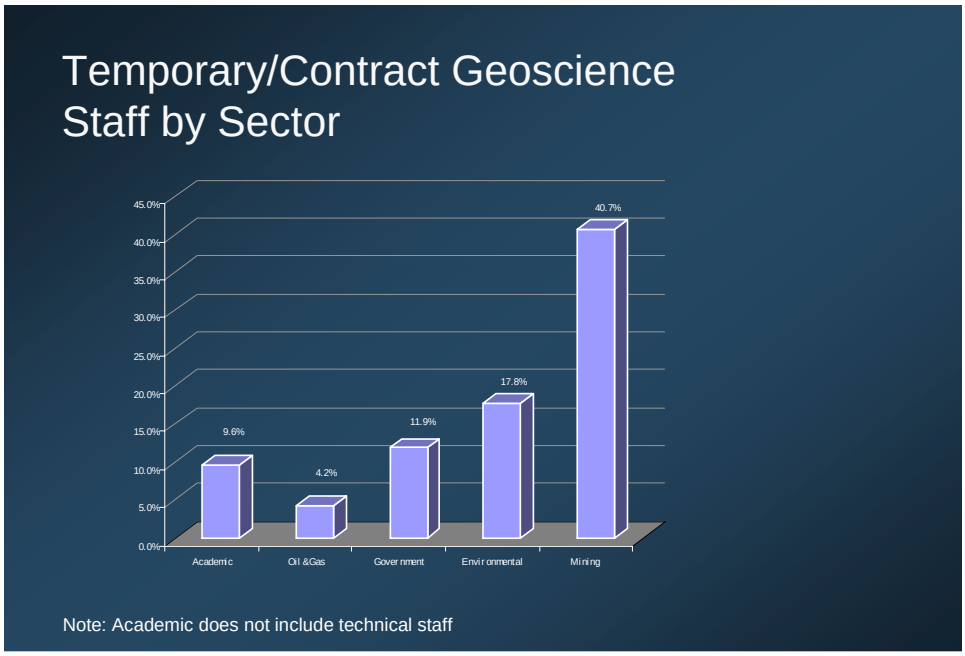

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Figure 4

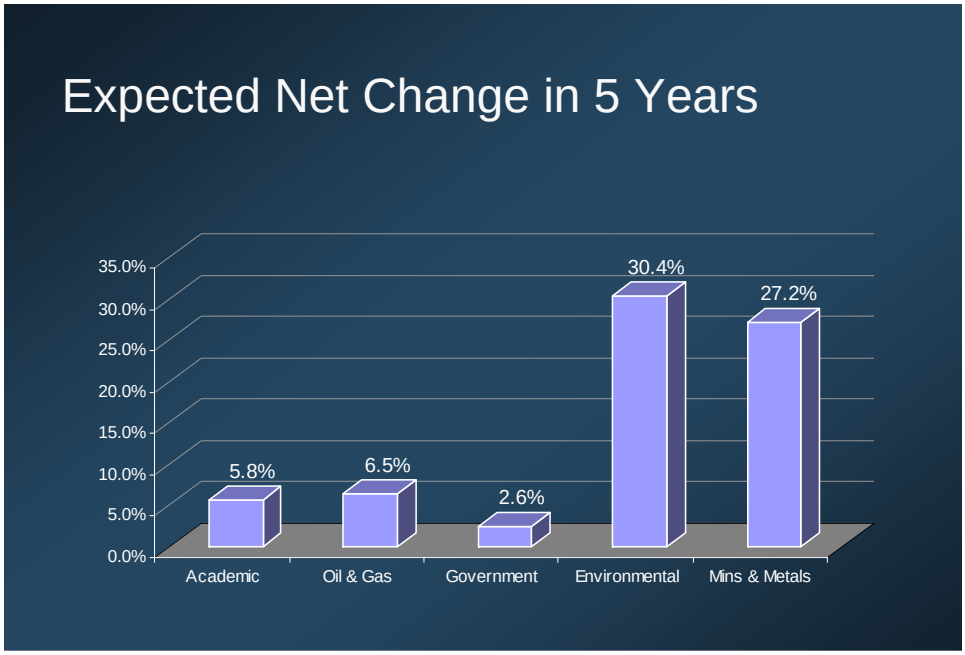

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Figure 5

Marked differences occur in sectoral education requirements (Fig. 6). Academia requires a PhD, Oil & Gas overwhelmingly seeks a minimum BSc for new hires (suggesting that in-house training is important), other sectors more frequently an MSc-minimum.

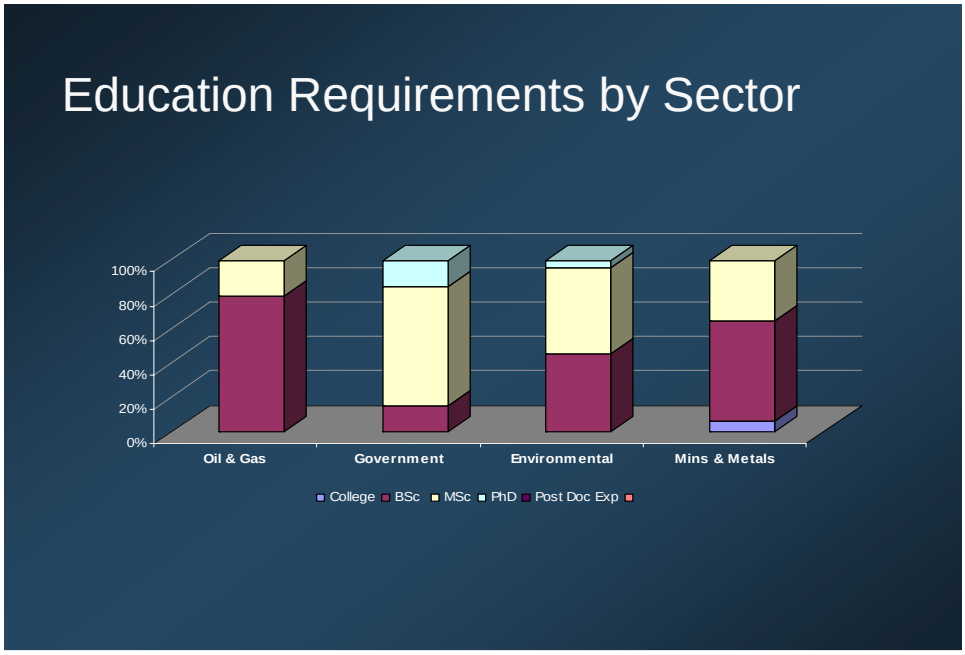

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Figure 6

Expertise requirements

Qualitative aspects of a poll are more complex to compare, contrast and interpret than quantitative ones. Nonetheless, a number of broad comparisons reflecting the anticipated future demand of geoscientific expertise of each sector can be made.

- The Oil & Gas sector places a clear emphasis on development and production of established reserves/resources, ranging broadly from conventional to unconventional oil and gas. If the current scenarios for increases in oil sands production are validated, unconventional oil will become a major factor for this sector. Not only is the emphasis thoroughly domestic, but the Western Canada Sedimentary Basin continues to dominate the Oil & Gas sector at present.
- The Mining sector emphasis is divided between frontier exploration outside of Canada and domestic exploration and development, all related principally to base and precious metals, plus subsidiary diamonds and uranium.
- The Environmental & Geotechnical sector, not surprisingly, clearly emphasizes groundwater and reclamation, followed by waste disposal, principally in domestic areas serviced by infrastructure, followed by frontier areas.
- Government Surveys predictably maintain a broad scope of activities related to domestic geoscience, with a slight emphasis on bedrock-related activities in support of mineral exploration. The latter is somewhat surprising given the importance of surficial deposits to exploration in general, to shallow gas, and to multiple environmental aspects of land-use.
- Academic faculty ideally strive to achieve a balance between research (40%), teaching (40%) and administration (20%). The fact that their research-related sphere of operation emphasizes regions close to existing infrastructure within Canada is likely a reflection of financial constraints within academia. The numbers indicate that scientific interests range widely from fundamental to applied research.

Future expertise requirements

The results of this questionnaire regarding priorities for future hiring in each sector are significant

- The Oil & Gas sector places a clear hiring priority on petroleum geology, stratigraphy/sedimentology, and geophysically-based subsurface mapping, plus structural geology and 3D visualisation and modeling. Surprising is the low priority explicitly accorded to all geochemistry, geotechnical geosciences and groundwater despite the fact that this expertise is needed in the industry. This apparent discrepancy may indicate that the sector typically outsources this expertise to consultants.
- The Mining sector places its hiring priorities on some aspects directly related to its mandate, including bedrock mapping, mineral deposits, GIS in general, regional geochemistry and vectoring to buried/hidden mineral deposits. It places medium priorities on regional metallogeny, 3D visualisation and modeling, geophysics and till geochemistry. It does not appear to emphasize surficial mapping, which is key to many aspects of mineral exploration. Given the importance of rock properties to 3D visualisation and modeling based on geophysical data, it would appear that this sector too counts on someone else (consultants / geological surveys) to deal with these facets.
- The Environmental & Geotechnical sector places its hiring priorities in the geological aspects of groundwater, habitat restoration, soil mechanics and engineering. Surprisingly, the sector either places a low priority or disregards industrial minerals, stratigraphy, geothermal

geology, 3D modeling, all geophysics, all geochemistry other that related to water, coastal geology, and climate change. The sector also appears to be equivocal regarding prioritization of the interpretation of chemical data and cold region geotechnology.

- Government hiring priorities are broadly spread from mapping of all kinds, via petroleum systems, to groundwater and climate change. To some degree, these priorities do indeed cover some of the aspects of geoscience upon which the private sector appears to have explicitly placed a low hiring priority. What is surprising is the low priority placed by government surveys on mineral deposits, volcanology, indicator minerals, 3D visualisation and modeling, and geophysics in general, not to mention habitat restoration. Given the numeric bias in the data toward the provincial and territorial surveys and geoscience agencies, this trend may reflect an expectation by the provinces and territories that the federal geological survey will provide this key public geoscience across the country, which is in line with the division of tasks between provincial and federal surveys.

Summary

The foregoing evaluation is preliminary. However, it does highlight marked differences across our discipline: The 'grey bulge is less apparent in the resource sector than anticipated. Several sectors appear to focus on core tasks, underscored by the low priority accorded to certain expertise:

- **For Oil & Gas -** Chemistry, geotechnical, groundwater
- **For Mining -** Surficial mapping, rock properties
- **For Environmental & Geotechnical -** Surficial industrial minerals, geothermal geology, geophysics, geochemistry, coastal geology, climate change
- **For Government -** Mineral deposits, volcanology, industrial minerals, geophysics, habitat restoration

Does the apparent low amplitude of the "Grey Bulge" in the resource sectors negate the perceived HQP gap? The PHRC report (see *Background*) concluded that there would be less need for geoscientists in the future, but our survey predicts a net increase in geoscience requirements in both resource sectors. In other applications of our discipline, climate change and related natural hazard mitigation will require growing numbers of geoscientists in the environmental sector.

Each sector requires specific policies to meet their HR Challenge. This is illustrated, for example, by the high proportion of contractual staff in the Mining sector *vs* the BSc-minimum entry level requirement of the Oil & Gas sector. Given the broad range of required skills in the different sectors and the fickle nature of the job market, universities must continue to focus their undergraduate programs on broad fundamental training. Much cooperation exists between universities and Federal and Provincial authorities (geological surveys, environmental departments, resource regulators), resulting in opportunities for student training..

Canadian Earth Science needs more students. Attracting them requires outreach to educate the public (parents and policy makers) regarding the societal role, economic opportunities, and intellectual challenge inherent to Earth Science when students are making important decisions regarding their future. In addition – as in other professions – immigration of qualified professionals must be made more attractive.

Appendix: Abbreviated CFES HQP Questionnaire Summaries by Sector

Priorities within a Sector decrease from higher-level to lower-level bullets

Oil & Gas

- Broad spread of company size
- Mostly geologists and geophysicists - flat 20-50, then mild bulge at 50-60
- Geotechnologists - flat, except for clear bulge at 40-50
- ~5% contract staff
- ~5% net staff increase in 5 years
- Seeking BSc in 5 years
- Most time spent on Development/Production, and on-trend exploration
- Conventional oil and gas, tight gas, and unconventional gas
- Domestic WCSB
- **Priorities** - staggered according to priority level
    - Petroleum geology
    - Stratigraphy/Sedimentology
    - Subsurface mapping
    - Seismics
    - Borehole geophysics
        - Structural geology
        - 3D visualisation and modeling
            - Geochemistry, including Petroleum Systems
            - Groundwater not indicated
            - Geotechnical

Mining

- Spread of company size
- Mostly geologists - flat 20-40, then mild bulge at 40-50, decrease at 50-60
- 33% contract staff
- ~40% next staff increase in 5 years
- Seeking BSc-MSc in 5 years
- Most time spent on Exploration /Development
- Base metals, precious metals
- Foreign and domestic in brown and greenfields
- **Priorities** - staggered according to priority level
    - Bedrock mapping
    - Mineral deposits
    - GIS
    - Interpretation of MT and electrical data
    - Regional geochemistry
    - Mineral deposit vectoring
    - Interpretation of chemical data
        - Regional metallogeny
        - Structural geology
        - Indicator minerals
        - 3D visualisation and modeling
        - All Geophysics
        - Interpretation of potential field data
        - Till geochemistry
        - Trace element and tracer isotope geochemistry
        - Soil mechanics
        - Hydrogeology
        - Engineering geology
        - Rock mechanics
            - Metamorphic petrology
            - Paleontology
            - Rock properties
            - Seismic interpretation
            - Other Geochemistry, including Geochronology
            - Groundwater

Environmental & Geotechnical

- Spread of company size
- Mostly geologists, technologists/engineers - flat 20-540, then decreases
- 20% contract staff
- 30% next staff increase in 5 years
- Seeking BSc-MSc in 5 years
- Most time spent on development/application
- Groundwater and reclamation, followed by waste disposal
- Domestic with infrastructure, followed by domestic frontiers
- **Priorities** - staggered according to priority level
    - Aquifer geology
    - Interpretation of chemical data
    - Habitat restoration
    - Groundwater
    - Soil mechanics
    - Geoenvironmental
    - Hydrogeology
        - Bedrock mapping
        - Subsurface mapping
        - GIS
        - 3D visualisation
        - Interpretation of potential field data
        - Groundwater geochemical surveys
        - Engineering geology
        - Rock mechanics
        - Geosynthetics
            - Petroleum geology
            - Industrial minerals
            - Structural geology
            - Stratigraphy/sedimentology
            - Geothermal geology
            - 3D modeling
            - All geophysics
            - All other geochemistry
            - Coastal geology
            - Climate change

Government

- Moderate size plus federal
- Geologists - clear bulge at 40-60
- ~10% contract staff
- ~2% next staff increase in 5 years
- Seeking MSc in 5 years
- Most time spent on Minerals & Metals
- Polyvalent, skewed to bedrock and management
- Domestic greenfields, plus brownfields
- **Priorities** - staggered according to priority level
    - Bedrock mapping
    - Surficial mapping
    - Petroleum geology
    - Aquifer geology
    - GIS
    - Regional geochemistry
    - Mineral deposit vectoring
    - Petroleum systems
    - Chemistry
        - Regional metallogeny
        - Structural geology
        - Stratigraphy/Sedimentology
        - Till geochemistry
        - All Geophysics
        - Till geochemistry
        - Groundwater
        - Climate change
            - Mineral deposits
            - Volcanology
            - Indicator minerals
            - 3D visualisation and modeling
            - All Geophysics
            - Habitat restoration

Academia

- **Need analysis of sub-disciplines**
- Broad spread of dept size
- Sedimentology, geochemistry, geophysics, paleontology are >30
  - Next is Environmental geology @ 24
  - Hydrocarbons, oceanography, geotechnical are < 10
  - Next is GIS @ 10
  - Clear bulge at 40-50, so lots of leadership potential, but only 25% of bulge is 50+, so replacement potential limited
  - 30-40 is 50% of bulge, so room for expansion
- ~10% contract teaching, 20% tech support staff
- ~5% next staff increase in 5 years
- Seeking PhD in 5 years
- 40% Research, Teaching 40%, Admin 20%
- Minerals and Environment, then Oil & Gas, then Hydrogeology
- Domestic, close to infrastructure - financially determined?
- **Priorities** - staggered according to priority level
  - Mineral deposits
  - Petroleum geology
  - GIS
  - Seismic interpretation
  - Tracer and isotope geochemistry (includes geochronology)
  - Groundwater
  - Climate change
    - Bedrock mapping
    - Structural and metamorphic geology
    - Stratigraphy/Sedimentology
    - Aquifer geology
    - Subsurface mapping
    - 3D visualisation and modeling
    - Groundwater geochemistry
    - Meteorology
      - Regional metallogeny
      - Paleontology
      - Volcanology
      - Indicator minerals
      - Marine geology
      - All other Geophysics
      - Other Geochemistry
      - Habitat restoration
      - Oceanography