



# **MEASURING THE ECONOMIC IMPACTS OF GEOSCIENCE WORK BY GÉOLOGIE QUÉBEC**

**Charles Maurice, Daniel Lamothe and Charles Roy**

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## Introduction

The Direction générale de Géologie Québec of the Ministère des Ressources naturelles et de la Faune (MRNF) is responsible for the development of geoscience knowledge on Québec's territory and its mandate was reaffirmed and clarified in June 2009 within the scope of Québec's Mineral Strategy (Government of Québec, 2009). Géologie Québec's mission is to acquire, process, and disseminate geoscience knowledge on the mineral resources of Québec, in order to assess and promote the mineral potential of its regions in a sustainable development perspective. Géologie Québec acquires new geoscientific data across Québec, integrates data acquired by the mineral exploration industry, in order to fully exploit and disseminate the latter. These data, accessible via Québec's Geomining Information System (SIGEOM: <http://www.mrnf.gouv.qc.ca/english/products-services/mines.jsp>), are used by the mineral exploration industry to make strategic decisions pertaining to their work. Private companies then acquire new data on targeted terrains, which are in turn also integrated into SIGEOM when assessment work reports are filed. This model for geoscientific data integration has been in place for many years now and has led to the construction of a public data bank that is constantly evolving and that provides a global and up-to-date portrait of the current level of knowledge, which can be used to assess the mineral potential of Québec and to develop its mineral resources.

Monitoring of mining title acquisitions and exploration investments in the mineral exploration industry are two ways to measure the impact of work programs to acquire new geoscientific data and mineral potential assessment studies performed by Géologie Québec. In this document, we discuss indicators that are used to quantify the short-term and medium-term impacts of this work. Although it is difficult to establish a direct link between Géologie Québec's work and mining discoveries, which often occur many years later, these indicators illustrate the relevance of investments made by the government of Québec in this sector.

## Impacts of Regional Geoscience Activities

Géologie Québec conducts work to acquire new geoscientific data across Québec, in order to improve the level of knowledge. This work can then serve to stimulate the search for new orebodies by providing new data and new exploration models for industry. Expanding our knowledge base is strategic as it helps make exploration investments more efficient, especially in more remote, lesser-known areas.

In order to promote the mineral potential of Québec, Géologie Québec focuses its activities in regions where mineral exploration activity is weak and geological knowledge is limited. These regions often correspond to areas with little or no access infrastructure. It is therefore difficult to acquire new data in these regions, which requires ambitious projects with complex logistical needs, specific know-how and substantial investments. To demonstrate the importance of continuous acquisition of new geoscience data, it is critical to measure the impacts of such work on the activities of exploration companies. This task is however complicated by various factors, namely the level of knowledge in a given territory, access to road infrastructure, and strength of economic markets. Figure 1 nevertheless shows the evolution over time of knowledge acquisition investments made by Géologie Québec and exploration investments made by industry in two vast regions, the Baie-James region (Figure 1a) and the area covered under the Far North Program (Figure 1b).

Despite sustained efforts by many mineral exploration companies in targeted areas of the Baie-James region in the early 1990s, geoscience knowledge in this region remained limited. The government's willingness to better assess the mineral potential of this vast region provided the impetus to launch the "Near North" Program (Beaumier *et al.*, 1994; Chartrand and Gauthier, 1995). Launched in 1995, this program led to the publication of 15 geological reports covering 34 map sheets at a scale of 1/50,000 and four map sheets at 1/250,000 (see references included in: Lamothe *et al.*, 2000; Simard and Gosselin, 1999; Goutier *et al.*, 2002;

**Editing:** Charles Gosselin  
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Moukhsil *et al.*, 2003). Annual investment levels by the mineral exploration industry in this region remained relatively stable from 1997 to 2001, *i.e.* during the years that Géologie Québec conducted mapping in the area (see Table 1; Figure 1a). Then, as Géologie Québec left the region, mineral exploration investments steadily increased until 2003. From 2004 onward, favourable economic conditions and the discovery of the Éléonore deposit had a major impact on annual investments by the mineral exploration industry, which rapidly exceeded the \$100M mark. This rapid increase in exploration investments is probably due largely to the discovery of the Éléonore deposit. However, the sustained efforts of Géologie Québec to develop geoscience knowledge and geological expertise in the Baie-James region were critical to promote the mineral potential of this region. Public investments stimulated and supported aggressive exploration strategies by the private sector. Whereas in 1997, a mere 7.7% of exploration investments across Québec were recorded in the Baie-James region, this figure reached 22.1% in 2008. Since 1997, the mineral exploration industry has invested \$421.9M in this region, whereas Géologie Québec has invested \$22.0M; this represents a ratio of 19:1.

Simultaneously with the Near North Program, Géologie Québec launched a mapping program in Northern Québec (Figure 1b). This program, conducted in a region devoid of road infrastructure, was to become one of the most ambitious ever attempted in Canada. Under the "Far North" Program from 1997 to 2003, the first lake-bottom sediment survey conducted in partnership with industry was carried out (MRN, 1998); 21 geological reports and maps at 1/250,000 scale were published; and a geological synthesis of the entire region was released (Simard *et al.*, 2008 and references therein). From 1987 to 2008, public investments in geoscience knowledge acquisition totalled \$40.7M in this region (\$35.7M by Géologie Québec and \$5.0M by the GSC), whereas investments by the mineral exploration industry reached more than twice this amount, at \$92.9M (Table 1; Figure 1b). From 1987 to 1996, total annual investments by the public and private sectors remained below \$1.5M, whereas during the Far North Program, from 1997 to 2003, this level stood between \$5.9M and \$13.3M. Finally, growing investments by the mineral exploration industry after the passage of Géologie Québec in this area (Figure 1b; up to \$24.9M in 2007) outlines the significant contribution of geoscience activities on the level of exploration in Northern Québec.

In the case of the Near North and Far North programs, public investments in knowledge acquisition work were made before the mineral exploration industry eagerly flocked to these regions (Figure 1). Since interventions by Géologie Québec predate those of the industry, they

clearly have tangible leverage to stimulate and support mineral exploration in Northern Québec. Even after the end of the Near North and Far North programs, the level of geological knowledge in these regions remains relatively limited (Figure 2). As stated in Québec's Mineral Strategy (Government of Québec, 2009), new investments in geological data acquisition will be required in order to preserve and stimulate the level of economic activity in Northern Québec.

### **SIGEOM: The Geomining Database**

The level of geoscience knowledge in Québec is a function of the public documents and data kept in Québec's Geomining Information System (SIGEOM, Figure 2). This system contains geoscientific data derived from work conducted by Géologie Québec, by exploration and mining companies, and by universities. On the one hand, the system contains both raw data of a geological (descriptions of outcrops, deposits, drill holes), geophysical (electromagnetic, magnetic or gravity), or geochemical (rock or sediment) nature, as well as elements interpreted by geologists (contacts, folds, faults, etc.). On the other hand, the documentary database (SIGEOM-Examine) provides access to all the geoscientific documentation for Québec, whether it be derived from the work of Géologie Québec (geological reports and studies, geological maps, mineral potential assessment maps), or from exploration work conducted by industry (assessment work reports including results of mapping, drilling, geochemical and geophysical surveys).

From August 2001 to August 2009, access to SIGEOM-Examine has resulted in 88,667 orders for complete or partial reports, whereas access to SIGEOM generated 21,552 orders for GIS products. In recent years, the Abitibi region, where the level of knowledge is high (Figure 2), has seen a high order rate for related reports (Figure 3) and products (Figure 4). In contrast, the Far North region has a much lower level of knowledge (Figure 2). This region has nevertheless seen a relatively significant number of orders for reports (Figure 3) corresponding to the recent mapping and promotional efforts of Géologie Québec under the Far North Program. Despite a relatively low level of knowledge (Figure 2), the Near North region has also been the object of widespread dissemination of data and reports (Figures 3 and 4), spurred by recent discoveries by the mineral industry and knowledge acquisition efforts by Géologie Québec. Finally, the Saint Lawrence Lowlands have seen a strong demand for documents and data, linked to the search for natural gas. Monitoring of orders made via SIGEOM is a useful means to follow the evolution of exploration work in Québec and thus measure the impact of interventions made by Géologie Québec.

Once they have been integrated in SIGEOM, raw data, reports and maps become available to everyone and constitute a geoscientific heritage for which the replacement value has been estimated at more than 2.5 billion dollars. Integrating this heritage into a single database makes it possible to search for information, to analyze and process it in an effective manner. It also makes it possible, among other things, to produce mineral potential maps to identify new exploration targets in unstaked areas.

## **Impacts of Mineral Potential Assessment Studies**

In order to make good use of the data available in SIGEOM, generate targets and stimulate mineral exploration, Géologie Québec began producing mineral potential assessment maps a few years ago. To build such maps, first an exploration model for one or many commodities must be evaluated over a given study area. Factors deemed favourable to the deposit model are then weighed based on their spatial association with known deposits. Values obtained for each of these factors are combined on a final map to delineate high-favourability zones likely to host other deposits of the same type. Unstaked portions within these zones represent “new targets” favourable for mineral exploration. The easiest way to measure the short-term impact of this type of work consists in quantifying the number of new mining titles registered on these targets following publication. Figure 5a shows the number of new mining titles staked in areas covered by four mineral potential assessment projects conducted from 2005 to 2008. These figures show that the latter projects had a genuine impact on the mineral exploration industry.

While variations in the number of mining titles provide an instant portrait of the impact of potential assessment studies, a compilation of exploration investments on staked targets provides an appreciation of the financial impact of this work in the medium term. Since assessment work reports are filed by industry only two years after mining titles are issued, compiled data for mineral potential maps published in 2005 and 2006 provide a more complete portrait (Figure 5b). Thus, these two projects have generated

to date exploration investments of \$0.85M and \$1.67M respectively, i.e. about 12 times the financial resources allocated for their production. In addition to stimulating mineral exploration in neglected areas, the production of mineral potential maps is a way to fully exploit all of the data integrated into SIGEOM and contributes in disseminating widely accessible information.

## **Conclusion**

Through its mission to stimulate mineral exploration, Géologie Québec acquires, processes, and disseminates geoscientific data which is then archived in the Geomining Information System (SIGEOM). A comparison of investments in knowledge acquisition work related to two large-scale mapping programs (Near North and Far North programs) versus investments from the mineral exploration industry shows that interventions by Géologie Québec lead, in the short and medium term, to a significant increase in exploration investments from the private sector. These results suggest that geoscience knowledge acquisition activities conducted by Géologie Québec are useful to better constrain areas of economic interest and enhance the efficiency of investments by the mineral exploration industry. In doing so, Géologie Québec stimulates in a measurable way the strength of the mineral exploration sector. Subsequent processing of geoscientific data acquired by Géologie Québec and industry namely results in the production of mineral potential assessment maps and the identification of new exploration targets. Later-stage investments in exploration on these targets also provide another way to measure the impact of work by Géologie Québec. The ever-growing value of SIGEOM, as well as a concerted long-term commitment involving Géologie Québec, geological research groups and the mineral exploration industry, are essential to facilitate the future discovery of new mineral resources in the remote areas of Northern Québec.

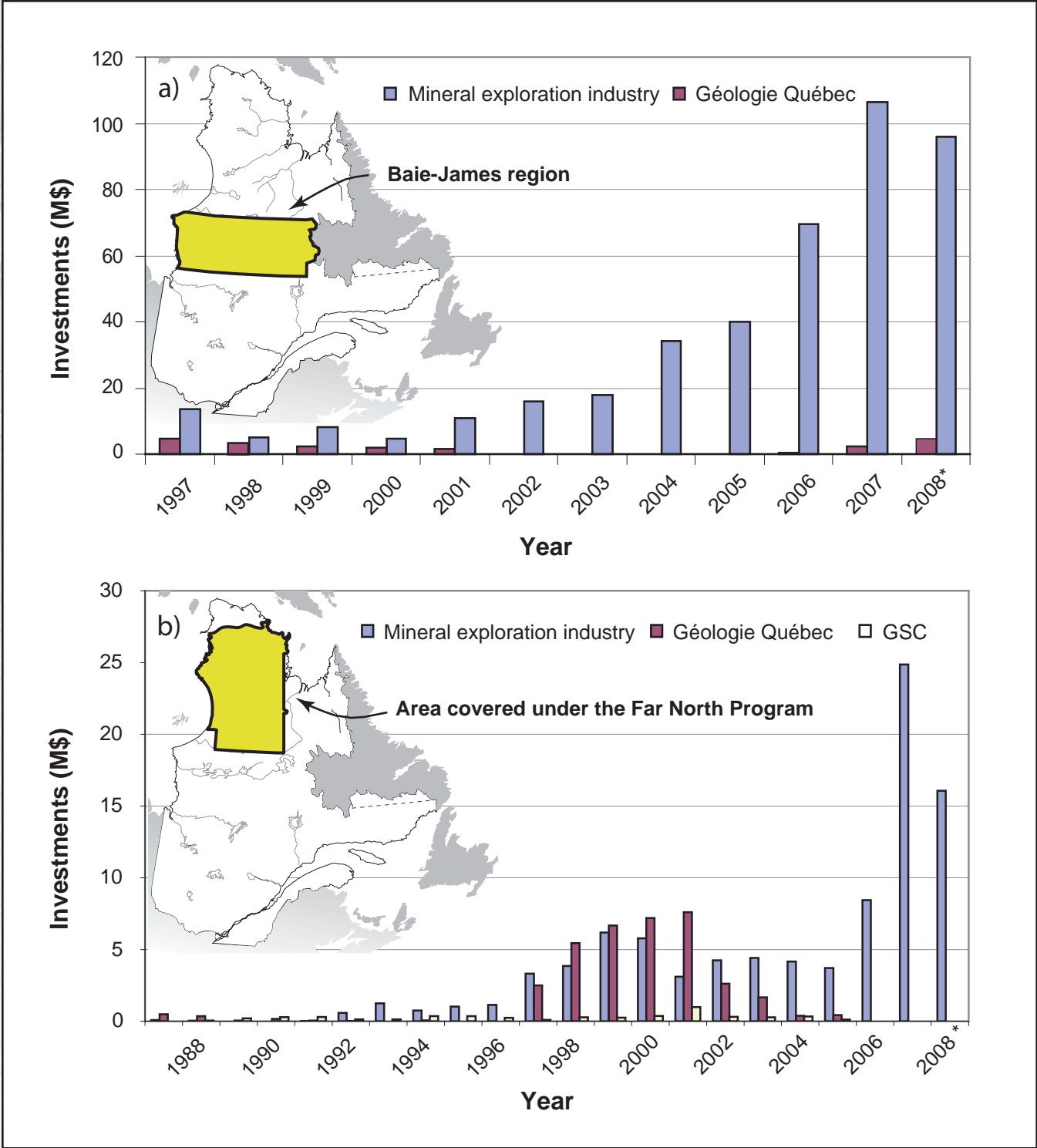
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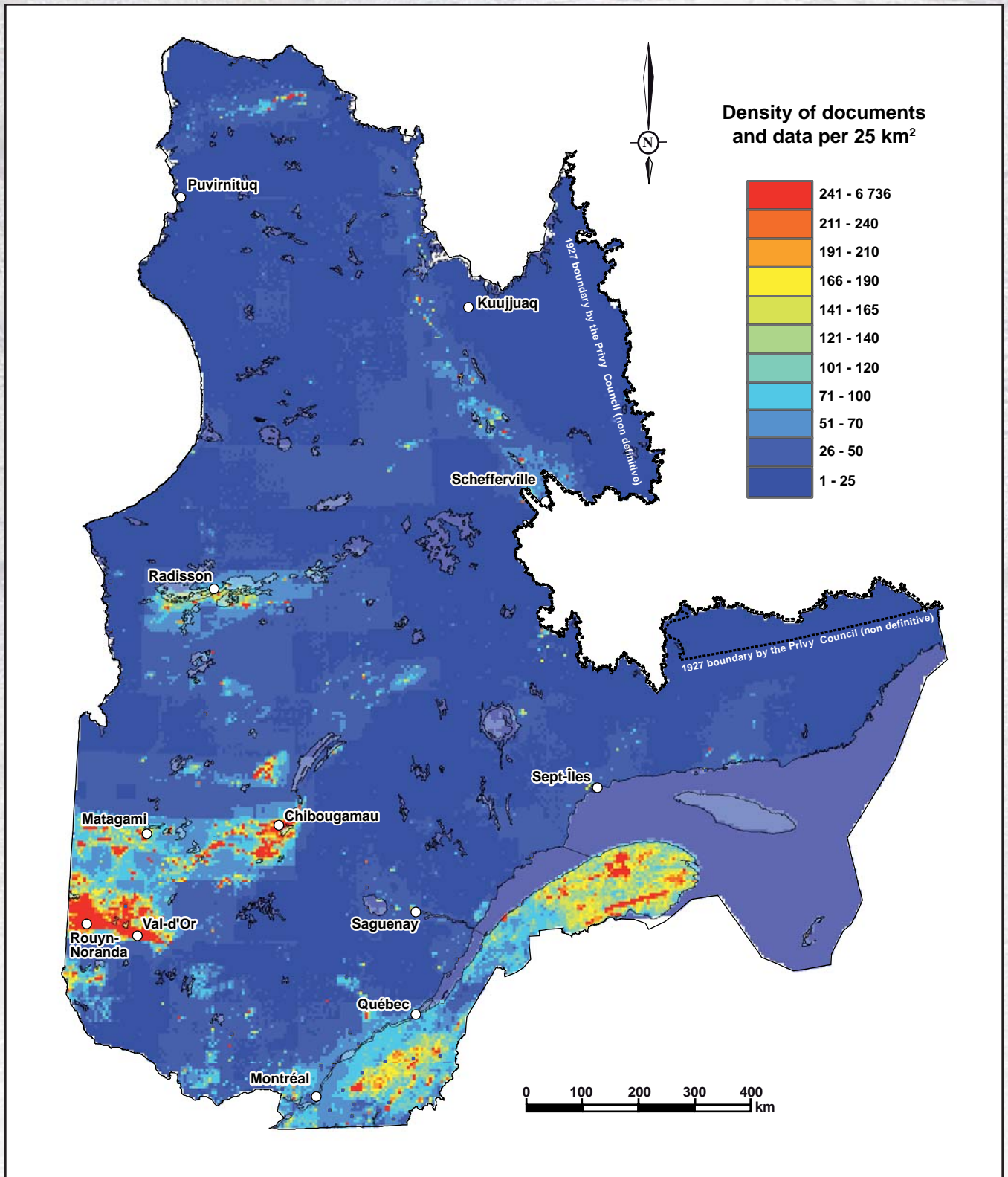
1- The SIGEOM database contains 135,000 drill holes averaging 155 m depth. Assuming a replacement cost at \$75 per metre, this amounts of \$1.6 billion solely for the drill holes, notwithstanding the administrative costs of field campaigns. There are 23,000 ground-based geophysical surveys and 1,650 airborne surveys; these two elements combined are estimated at \$165 million. The 11,000 geological surveys are estimated at \$320 million. All these figures are fairly conservative and show that the SIGEOM database constitutes a first-class information heritage for the mineral industry and for society in general.

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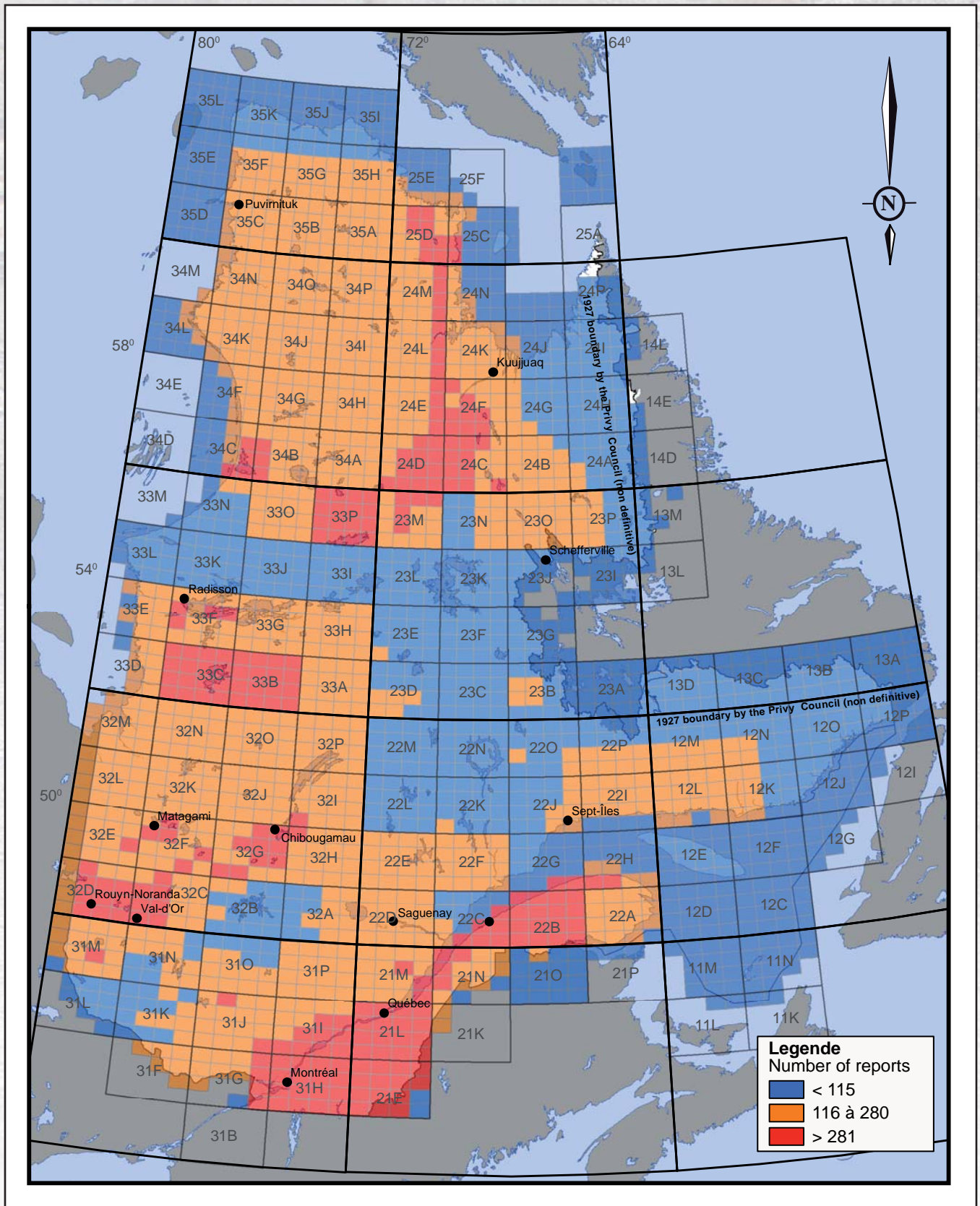
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**Figure 1** - Comparative evolution of investments made by the mineral exploration industry, Géologie Québec, and the Geological Survey of Canada (GSC): **a)** in the Baie-James region from 1997 to 2008; **b)** in the area covered under the Far North Program from 1987 to 2008 (sources of data in Table 1; Figure 1b modified after Leclair *et al.*, 2006).



**Figure 2** - Current level of geoscience knowledge across Québec. The image shows the density per 25 km<sup>2</sup> of documents in SIGEOM-Examine combined with the density of point data available in SIGEOM (drill holes, geochemical analyses, INPUT data, outcrop descriptions, etc.).



**Figure 3 -** Distribution per 1/50,000 scale NTS sheet of the 88,667 complete or partial reports ordered through SIGEOM-Examine, from August 2001 to August 2009.

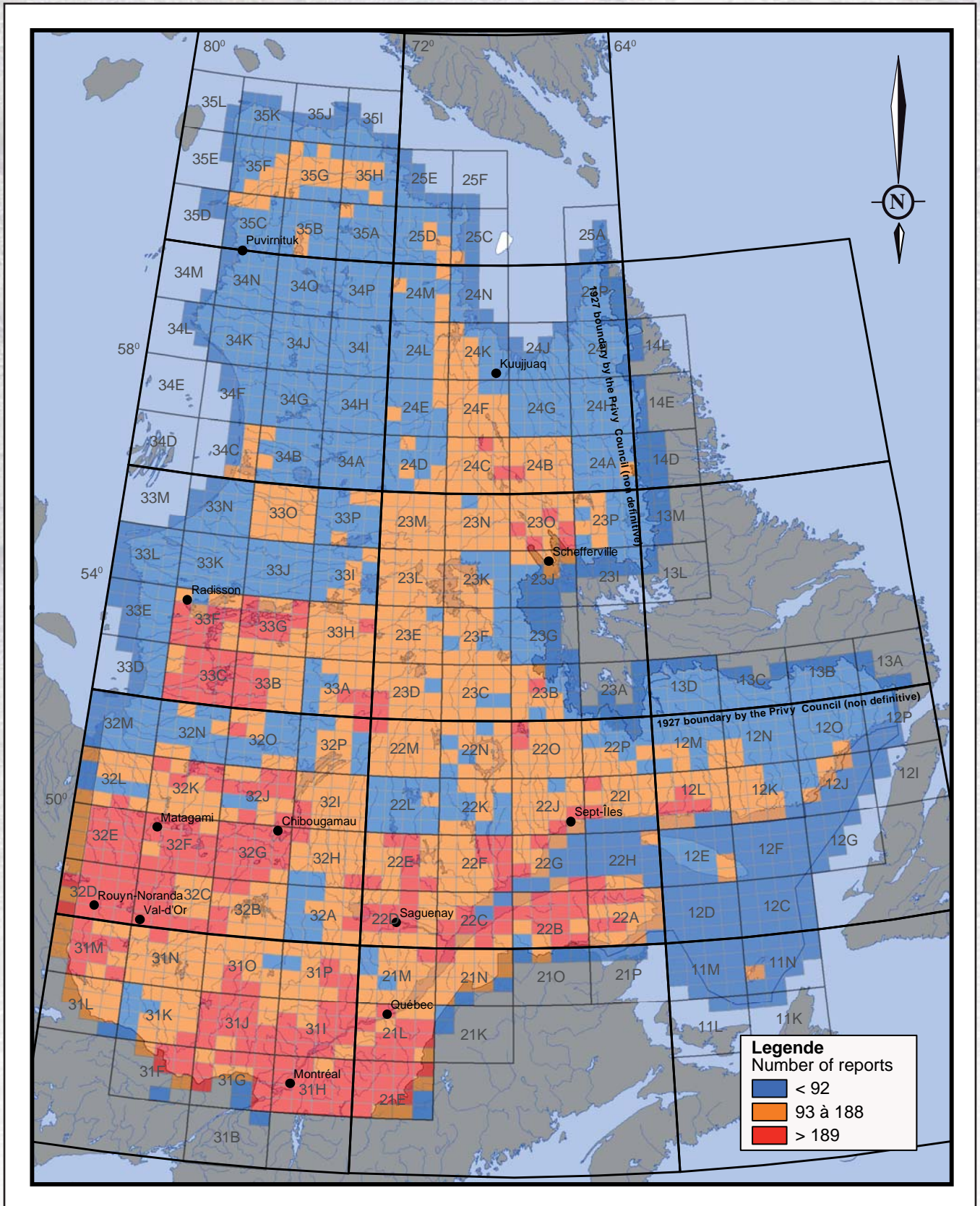
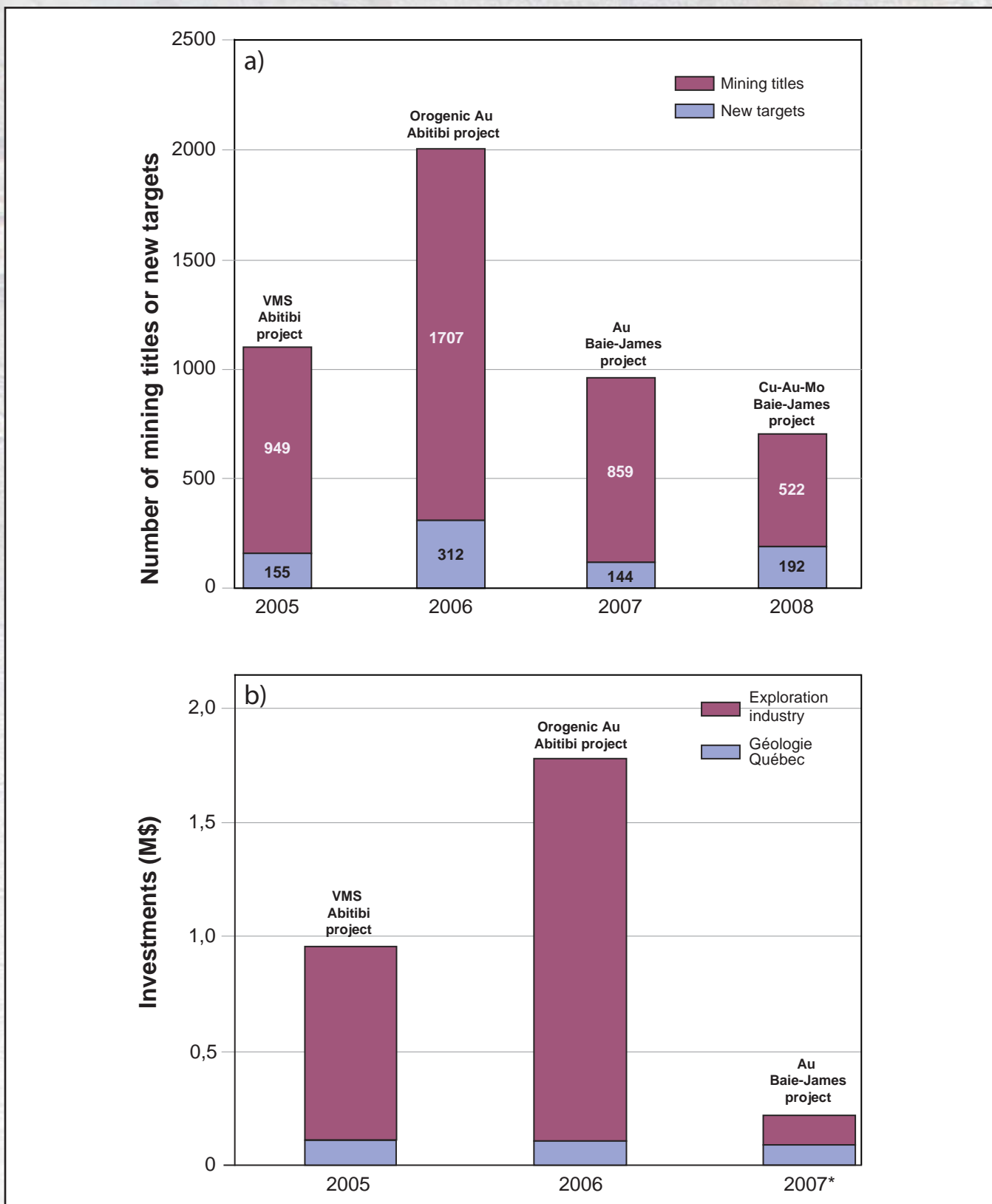


Figure 4 - Distribution per 1/50,000 scale NTS sheet of the 21,552 GIS products ordered through SIGEOM, from August 2001 to August 2009.



**Figure 5** - Histograms showing: **a)** the number of mining titles requested on new targets generated and the number of new targets generated during mineral potential assessment projects in 2005 (VMS / Abitibi project; Lamothe *et al.*, 2005), 2006 (orogenic Au / Abitibi project; Lamothe and Harris, 2006), 2007 (Au / Baie-James project; Lamothe, 2008), and 2008 (Cu-Au-Mo / Baie-James project; Lamothe, 2009); **b)** exploration investments on new targets generated, compared to resources allocated by Géologie Québec to complete each mineral potential assessment project (\*: data for 2007 industry investments are partial).

**Tableau 1** - Investments in mineral exploration by industry and in geoscience knowledge acquisition by Géologie Québec and the Geological Survey of Canada (GSC) in the Baie-James region from 1997 to 2008, and in the Far North region from 1987 to 2008. Data for the years 1987 to 2001 are from the Institut de la Statistique du Québec (compiled by R. Beullac). Data for the years 2002 to 2008 are from the MRNF (compiled by P. Roy). The location of targeted areas is shown in Figure 1.

Year	Baie-James (\$)		Grand Nord (\$)		
	Exploration industry	Géologie Québec	Exploration industry	Géologie Québec	GSC
1987	N.C.	N.C.	80 197	493 361	0
1988	N.C.	N.C.	39 563	353 080	45 000
1989	N.C.	N.C.	—	52 043	206 000
1990	N.C.	N.C.	—	163 296	285 000
1991	N.C.	N.C.	10 000	43 093	292 000
1992	N.C.	N.C.	587 423	17 075	135 000
1993	N.C.	N.C.	1 244 799	—	125 000
1994	N.C.	N.C.	751 862	60 028	355 000
1995	N.C.	N.C.	1 019 363	—	360 000
1996	N.C.	N.C.	1 138 858	—	235 000
1997	13 403 218	4 818 875	3 319 001	2 501 586	100 000
1998	4 932 727	3 593 172	3 852 497	5 446 598	269 000
1999	8 314 718	2 412 936	6 184 406	6 666 250	255 000
2000	4 627 532	2 083 478	5 775 933	7 188 628	368 000
2001	10 714 475	1 415 135	3 099 259	7 602 122	985 000
2002	15 943 905	66 094	4 240 908	2 610 000	308 000
2003	17 939 376	32 165	4 409 199	1 660 000	270 000
2004	34 169 892	6 168	4 157 225	375 000	330 000
2005	39 903 223	0	3 710 861	425 000	115 000
2006	69 406 677	555 000	8 444 630	0	—
2007	106 519 040	2 305 113	24 867 147	0	—
2008 *	96 050 926	4 689 771	16 067 868	0	—

N.C.: not compiled

—: no data

\*: partial preliminary compilation

