EXPLORATION TARGETS IN THE UPPER EASTMAIN RIVER AREA, BAIE-JAMES, QUÉBEC:

INTERPRETATION OF A NEW GEOPHYSICAL SURVEY

PRO 2011-04

Québec

Editing : Charles Gosselin
Translation : Venetia Bodycomb
Compilation of data : Isabelle d'Amours
Graphic art : André Tremblay

www.mrnf.gouv.qc.ca/produits-services/mines.jsp
Dépôt légal – Bibliothèque et Archives nationales du Québec, 2011

Exploration targets in the upper Eastmain River area, Baie-James, Québec: interpretation of a new geophysical survey

Isabelle D'Amours

Pro 2011-04

Introduction

The *Ministère des Ressources naturelles et de la Faune du Québec* announces the publication of new geophysical data (D'Amours, 2011). Pursuing its objective to outline strategic areas for mineral exploration work, Géologie Québec carried out a new magnetic and gamma-ray spectrometry survey in the Baie-James region in 2010 (Figure 1). The survey covers 13 map sheets at a scale of 1:50,000 (32P16, 33A 01 to 08, 33B01, 33B02, 33B07 and 33B08; Figure 2), for a total surface area of 12,500 km^2. This new publication comes with a report describing all the technical aspects of the survey, a set of 130 geophysical maps at 1:50,000 scale, and all related digital data (available as document number DP 2011-01 at the following address: http://www.mrnfp.gouv.qc.ca/english/products-services/mines.jsp, via "**E-Sigeom (Examine)**".

Since 2007, Géologie Québec has completed a series of extensive geophysical surveys across the Baie-James region. These surveys aim to provide high-quality geophysical coverage in an area where the level of exploration has increased considerably, namely the area surrounding three advanced mining projects: Renard (diamonds), Éléonore (gold) and Coulon (zinc, copper; Figure 1). This document describes the two quantitative interpretation techniques for this survey—the Keating coefficient method for magnetic data and distribution histogram analysis for equivalent uranium concentrations and U/Th ratios—and proposes 120 targets for mineral exploration.

Regional geological setting and mineral potential

Despite the efforts of a few mineral exploration companies in some of the target areas in the Baie-James region during the early 1990s, the level of geoscientific knowledge for this region remained limited. The "Near North" Program was eventually launched in response to the government's wish to better assess the mineral potential of this vast region (Beaumier *et al.*, 1994; Chartrand and Gauthier, 1995). This program led to the publication of fifteen geological reports covering 34 maps at a scale of 1:50,000 and one report at a scale of 1:250,000 (see references included in Simard and Gosselin, 1998; Goutier *et al.*, 2002; Moukhsil *et al.*, 2003). Recent MRNF mapping efforts focused on the area near the Opinaca Reservoir, in the vicinity of the Éléonore project (Figure 2; Bandyayera *et al.*, 2010), and along the northern contact between the La Grande and Opinaca subprovinces (Bandyayera *et al.*, in preparation; NTS 33G07 and 33G10).

The area covered by the new geophysical survey (D'Amours, 2011) lies mainly within the southern part of the Opinaca Subprovince (Figure 2; Card and Ciesielski, 1986). This subprovince primarily consists of migmatitic paragneisses and diatexites of the Laguiche Complex and late felsic to intermediate intrusive suites. The eastern part of the surveyed area covers the western portion of the sedimentary Monts Otish Basin and the Upper Eastmain River Volcanic Belt (BVRES, Figure 2). Among the known mineralized showings, the most important are the MacLeod Lake Cu-Mo-Au deposit and the Eastmain Au-Cu mine. A number of uraniferous showings have also been recorded along the edge of the Monts Otish Basin in the southeast corner of the survey.

The western part of the area (33B01, 33B02, 33B07 and 33B08; Figure 2) was covered by a regional mapping project at a scale of 1:250,000 by Simard and Gosselin (1998). The MRNF never performed any geological work over the central part (33A03 to 33A06), but the eastern part was covered by regional mapping in the 1970s (Hocq, 1975, 1976 and 1985). Finally, note that not a single mining claim or mineral showing has been registered in the central part of the area, which thus remains entirely open to exploration.

Diamond exploration targets defined using magnetic data

Targets possibly representing vertical kimberlite pipes were identified based on roughly circular magnetic anomalies visible on the total residual magnetic field map. These anomalies were identified using an algorithm developed by Keating (1995), which is based on a vertical cylinder model of infinite length and known radius (Figure 3). Magnetic anomalies for which the absolute value (positive or negative) of the correlation coefficient with the model is greater than 0.92 (Table 1) are illustrated on the first vertical derivative map as circles with radii proportional to the correlation coefficients (Figures 4, 5 and 6). Negative correlation coefficients represent reversely magnetized anomalies, a common feature observed in kimberlite pipes in the Northwest Territories (Keating and Sailhac, 2004). Parameters for the cylinder are selected based on the grid cell size (60 m), so that the size of the modelled response will be similar to that of the analytical window (480 m or 81 cells). The size of the latter must be sufficient to generate statistically significant correlations. Considering these elements, a cylinder with a diameter of 200 m is the minimum size that may be used for this survey. All modelling results are illustrated without any geological interpretation. For example, anomalies corresponding to Proterozoic gabbro dykes are also presented. The parameters used in the calculations are listed in Table 2. The distance to the top of the cylinder was set at 115 m despite a nominal flight altitude of 80 m. The average flight altitude was 115 m over the entire survey due to topographic prominences that had to be avoided by the plane. Although it can be assumed that the plane was able to maintain the nominal 80-m flight altitude over flat areas, these are often underlain by thick Quaternary deposits which would add to the distance between the plane and the bedrock, thus justifying the decision to use 115 m as the height of the cylinder.

This theoretical model has been successfully applied in the past in the Kirkland Lake area, where five of the seven known kimberlite bodies were successfully modelled (correlation > 0.85; Keating, 1995).

In the study area, however, no Keating anomalies correspond to the Beaver Lake deposit (Figure 6). One possible explanation is that the model is based on a body with a diameter of 200 m, whereas Beaver Lake mainly consists of dykes and a chimney, creating an anomaly with a diameter of less than 75 m based on soil survey results (Brack, 1998). Anomalies generated using the Keating coefficient method nevertheless remain a useful tool when combined with other types of data (apparent resistivity, geochemistry, indicator minerals...).

The area covered by the new survey is cut by NW- to NNW-trending and NE-trending diabase dykes corresponding to linear magnetic highs. These dykes, and the intersections between dykes, may represent favourable sites for the ascent of kimberlitic magmas (Wilkinson *et al.*, 2001). The association of Keating anomalies with such sites make the targets even more interesting.

Uranium exploration targets defined using spectrometry data

The interpretation of gamma-ray spectrometry data requires a good understanding of geomorphology and Quaternary deposits, since most of the measured gamma radiation comes from the upper 30 centimetres of ground (International Atomic Energy Agency, 2003). It is therefore very important to understand the relationship between surface materials and bedrock. The use of gamma-ray spectrometry for mapping and target definition requires an integrated approach that combines image enhancement techniques (ternary imagery of radioactive elements, ratios and standardization) and statistical analysis techniques (cluster analysis, mean difference, supervised classification), as well as the integration of other types of airborne geophysical data such as magnetic and electromagnetic maps.

Our work defines exploration targets (Figures 7, 8 and 9; Table 3) that represent the zones with the highest concentrations in equivalent uranium, *i.e.* above 2.5 ppm (more than 99.75% of the survey values, the survey average being 0.51 ppm with a standard deviation of 0.4) and with eqU/eqTh ratios above 0.28 (more than 90% of the survey values, the survey average being 0.16 ppm with a standard deviation of 0.17). These values may seem very low, but we must take into account the fact that for an airborne survey at an altitude of 100 m, less than 40% of the measured radiation emanates from a source within a 100-m radius below the sensor and more than 20% of the measured photons for an infinite source come from lateral distances of more than 300 m. Consequently, the "field of measurement" contributing to each reading is much wider than the sample spacing which is 80 m (International Atomic Energy Agency, 2003). Most targets in the study area are located on land covered by active mining titles, and some of these correspond to known uranium showings (Figure 9), although the central and western parts remain completely open to exploration. Despite being poorly known, the latter are underlain by migmatitic paragneisses and diatexites, which is fairly similar to the geological setting further west (NTS 33B14) on the Upinor project belonging to Dios Exploration (http://diosexplo.com/upinor.php). The work by Dios describes uranium mineralization associated with granitic injections in the Laguiche Complex. Several samples yielded grades above 0.05% U_3O_8, including one sample grading 0.23%.

References

BANDYAYERA, D. – RHÉAUME, P. – MAURICE, C. – BÉDARD, E. – MORFIN, S. – SAWYER, E.W., 2010 – Synthèse géologique du secteur du réservoir Opinaca, Baie-James. Ministère des Ressources naturelles et de la Faune, Québec; RG 2010-2, 50 pages, 1 plan.

BANDYAYERA, D. – BURNIAUX,P., – MORFIN, S., en préparation – Géologie de la région du lac Brune (33G/07) et de la baie Gavaudan (33G/10). Ministère des Ressources naturelles et de la Faune, Québec.

BEAUMIER, M. – CHARTRAND, F. – SIMARD, A., 1994 – Vers une meilleure connaissance du potentiel minéral du territoire de la Baie de James. Ministère des Ressources naturelles, Québec; PRO 94-05, 7 pages.

BRACK, W., 1998 – Magnetometer surveys in the Beaver Lake area, Otish Mountains Project. Ministère des Ressources naturelles et de la Faune, Québec : GM 56613, 41 pages.

CHARTRAND, F. – GAUTHIER, M., 1995 – Cadre géologique et potentiel minéral des roches archéennes du bassin de La Grande Rivière, Baie James. Ministère des Ressources naturelles, Québec; PRO 95-06, 10 pages.

CARD, K.D. – CISIELSKI, A., 1986 – Subdivisions of the Superior Province of the Canadian Shield. Geoscience Canada; volume 13, pages 5-13.

D'AMOURS, I., 2011 – Levé magnétique et spectrométrique aéroporté dans le secteur sud de LG4, Baie-James, Québec. Ministère des Ressources naturelles et de la Faune, Québec; DP 2011-1, 14 pages, 130 plans.

GOUTIER, J. – DION, C. – OUELLET, M.-C. – DAVIS, D.W. – DAVID, J. – PARENT, M., 2002 – Géologie de la région du Lac Guyer (33G/05, 33G/06 et 33G/11). Ministère des Ressources naturelles, Québec; RG 2001-15, 53 pages.

HOCQ, M., 1975 – Géologie de la région du Lac Campan (Nouveau-Québec). Ministère des Ressources naturelles, Québec; DP 331, 14 pages, 9 plans.

HOCQ, M., 1976 – Géologie de la région du Lac Cadieux (Nouveau-Québec). Ministère des Ressources naturelles, Québec; DPV 433, 17 pages, 1 plan.

HOCQ, M., 1985 – Géologie de la région de la région des lacs Campan et Cadieux, territoire du Nouveau-Québec. Ministère des Ressources naturelles, Québec; ET 83-05, 188 pages, 4 plans.

INTERNATIONAL ATOMIC ENERGY AGENCY., 1991 – Airborne Gamma Ray Spectrometer surveying. IAEA–TECDOC-323, Vienna, 97 pages.

INTERNATIONAL ATOMIC ENERGY AGENCY., 2003 – Guidelines for radioelement mapping using gamma ray spectrometry data. IAEA–TECDOC-1363, Vienna, 173 pages.

KEATING, P., 1995 – A simple technique to identify magnetic anomalies due to kimberlite pipes. Exploration and Mining Geology; volume 4, pages 35-41.

KEATING, P. – SAILHAC, P., 2004 – Use of the analytical signal to identify magnetic anomalies due to kimberlite pipes. Geophysics; volume 69, pages 180-190.

MOUKHSIL, A. – LEGAULT, M. – BOILY, M. – DOYON, J. – SAWYER, E. – DAVIS, D.W., 2003 – Synthèse géologique et métallogénique de la ceinture de roches vertes de la moyenne et de la Basse Eastmain (Baie-James). Ministère des Ressources naturelles, Québec; ET 2002-06; 57 pages.

SIMARD, M. – GOSSELIN, C., 1999 – Géologie de la région du lac Lichteneger (SNRC 33B). Ministère des Ressources naturelles, Québec; RG 98-15, 25 pages, 1 plan.

WILKINSON, L. – KJARSGAARD, B.A. – LECHEMINANT, A.N. – HARRIS, J., 2001 – Diabase dyke swarms in the Lac de Gras area, Northwest Territories and their significance to kimberlite exploration: initial results. In: Current Research, Part C; Geological Survey of Canada; Paper 2001-C8, 17 pages

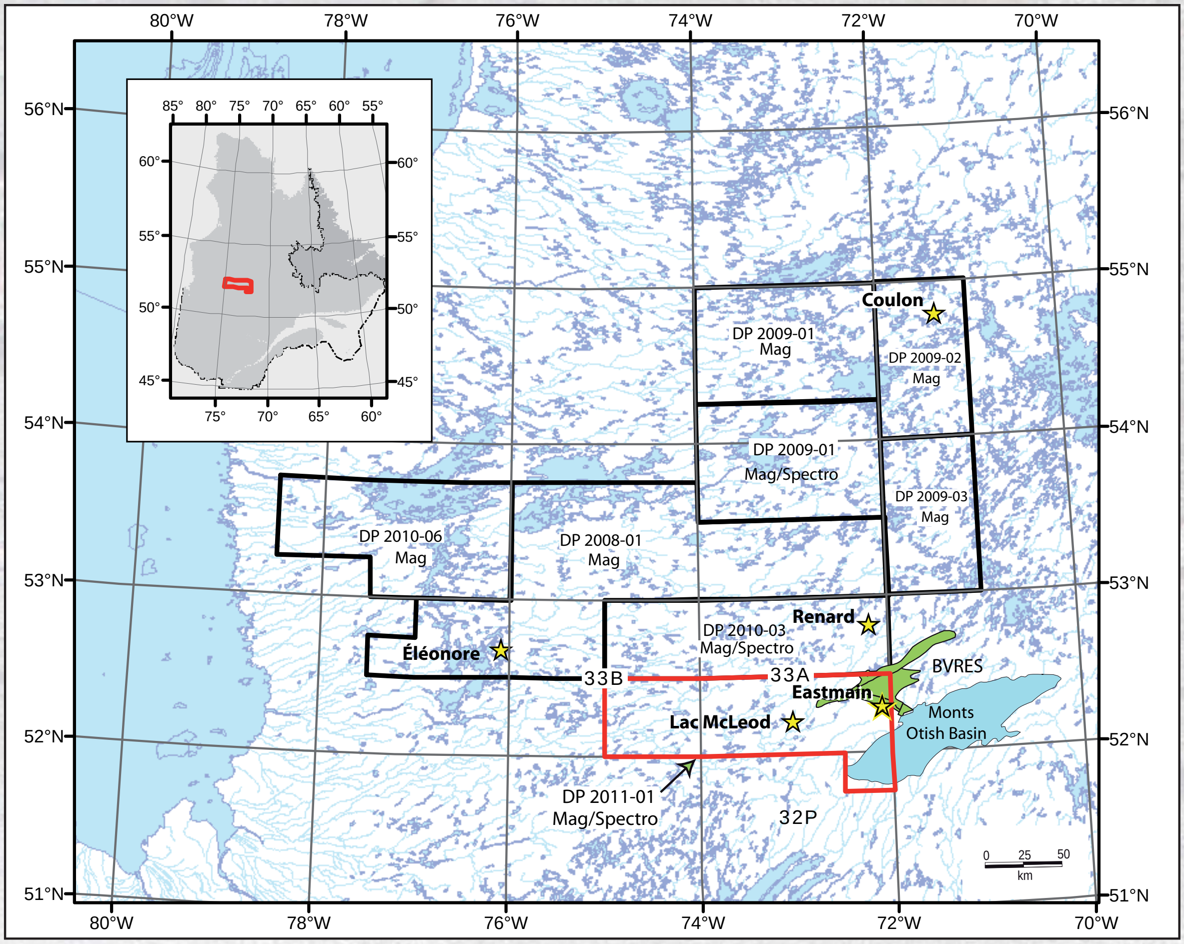

Figure 1 – Location of the new survey and previous high-resolution geophysical surveys carried out since 2007 in the Baie-James region.

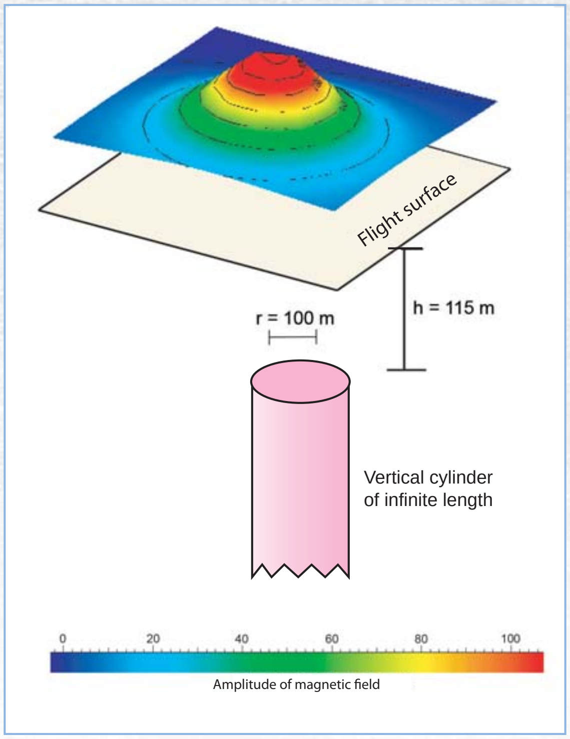

Figure 2 – Theoretical model used to calculate the Keating correlation coefficient (Keating, 1995).

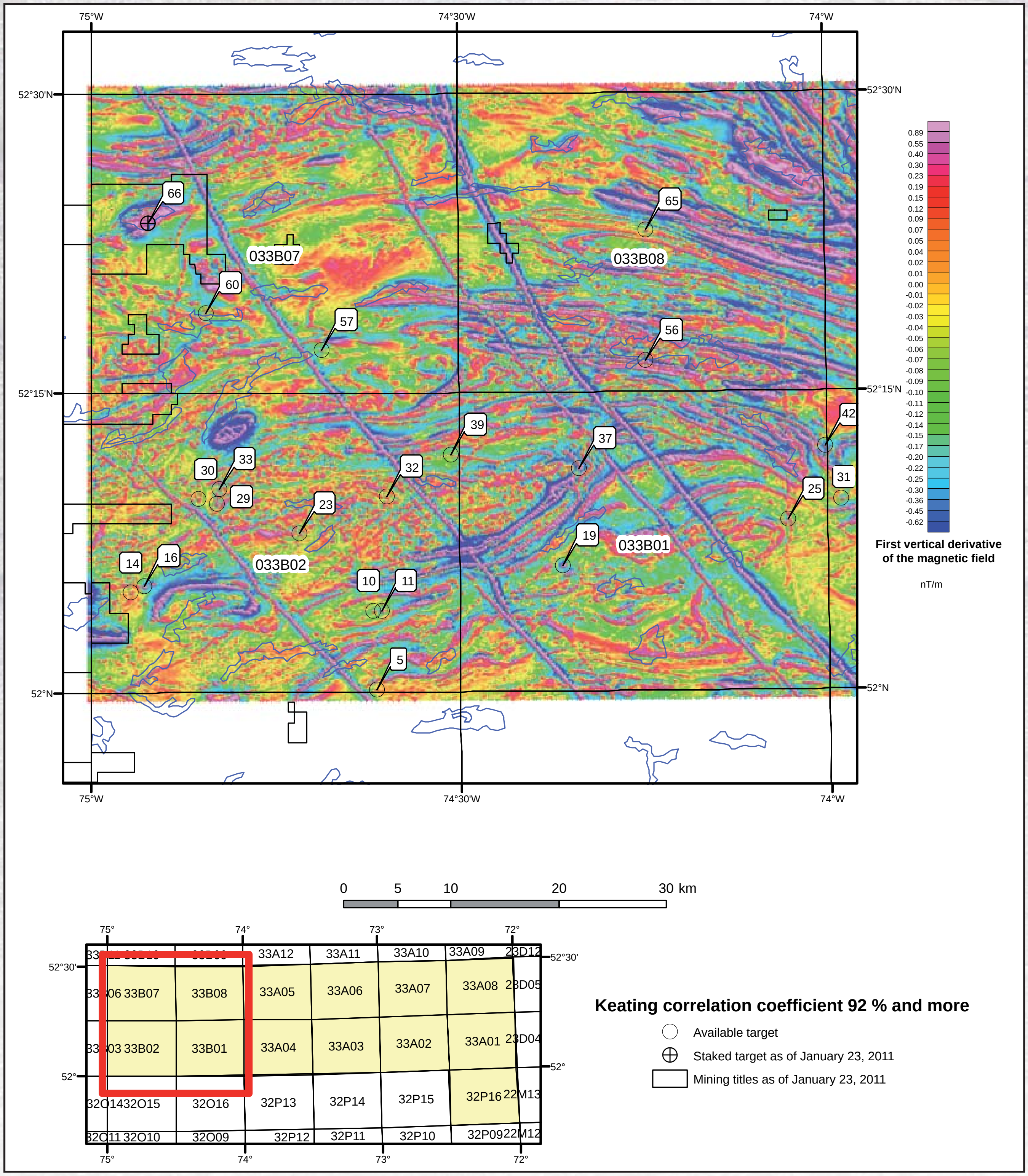

Figure 3 – Map showing the first vertical derivative of the magnetic field and diamond.

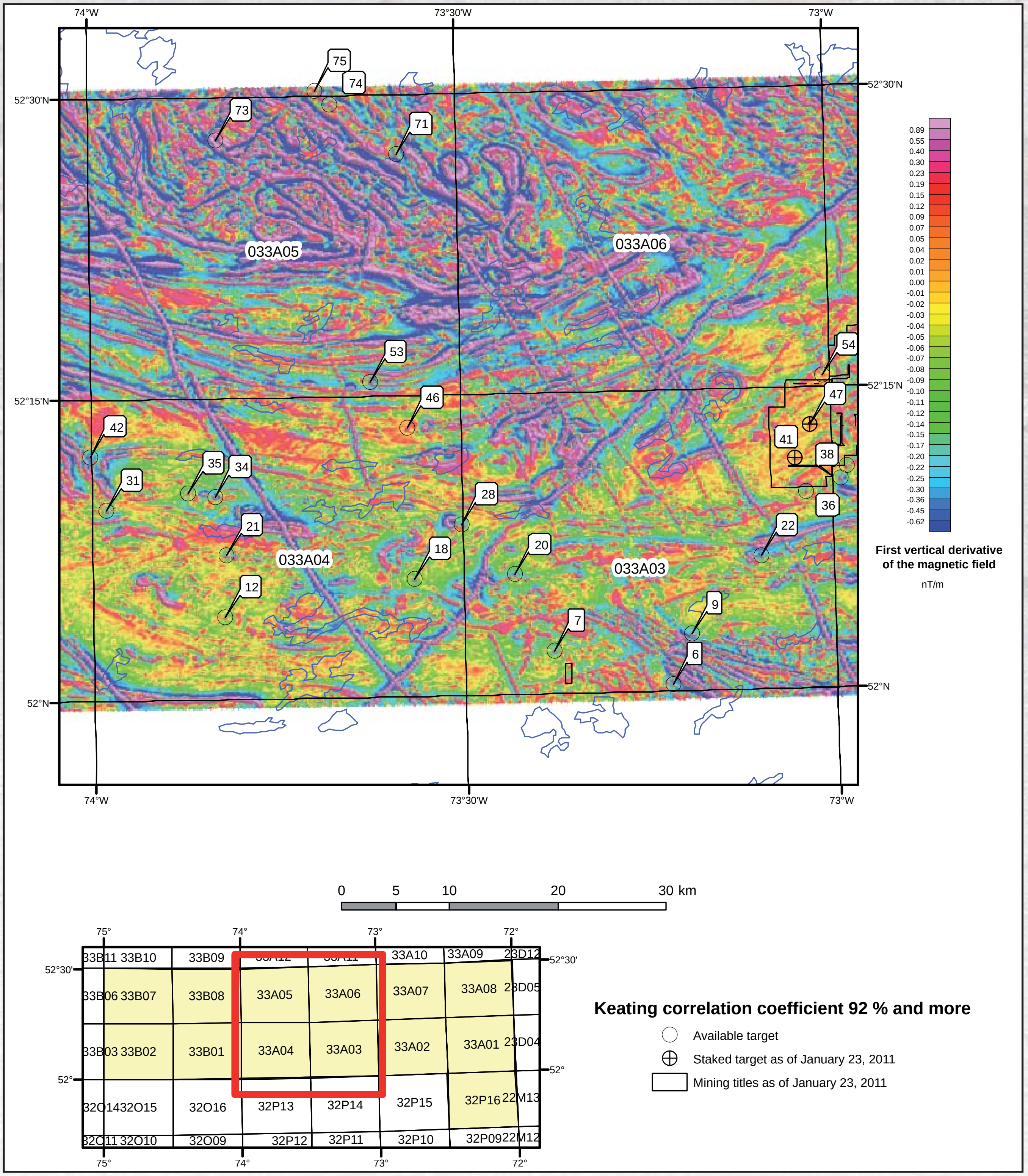

Figure 4 – Map showing the first vertical derivative of the magnetic field and diamond exploration targets established using the Keating coefficient in the central part of the survey..

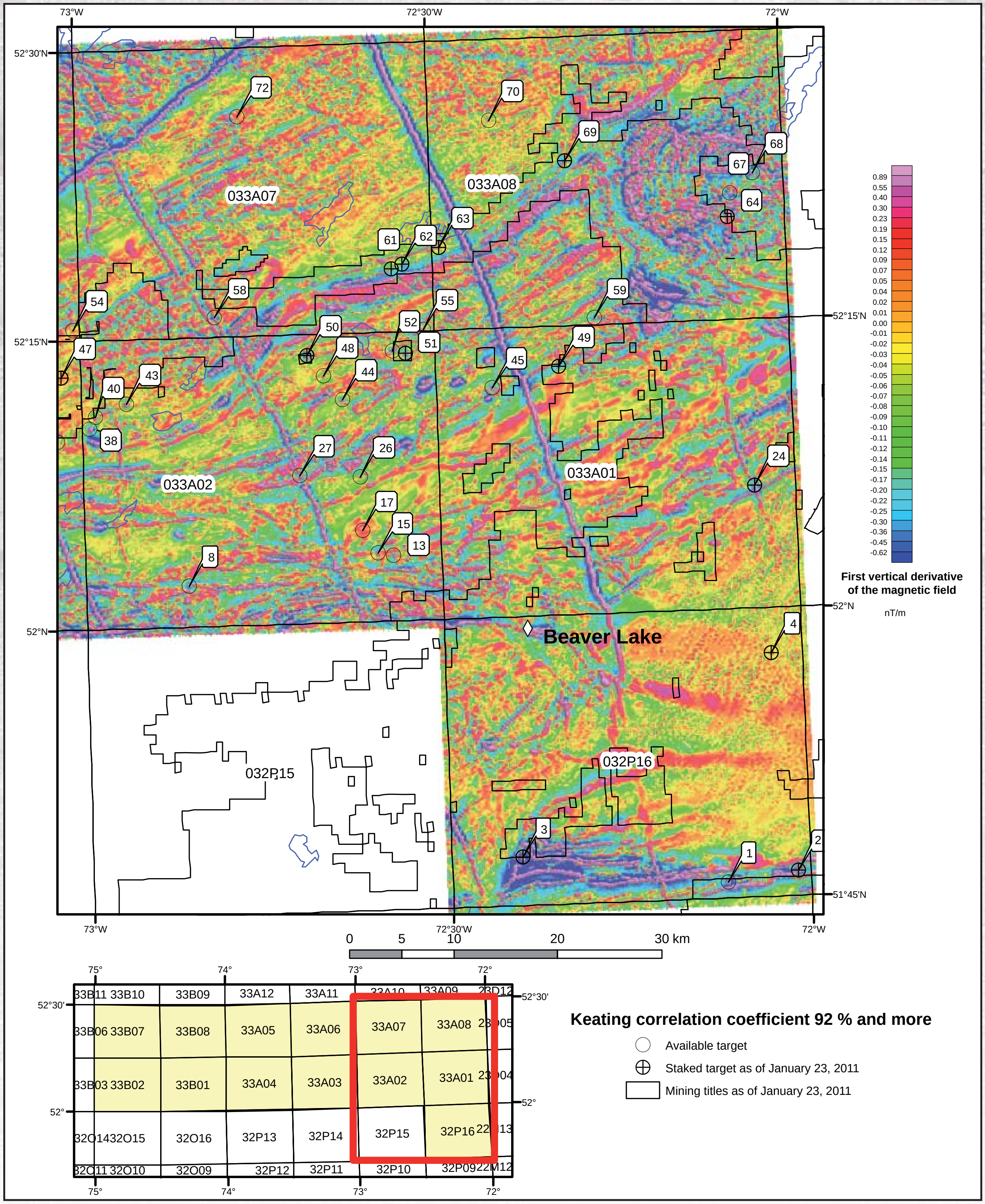

Figure 5 – Map showing the first vertical derivative of the magnetic field and diamond exploration targets established using the Keating coefficient in the eastern part of the survey..

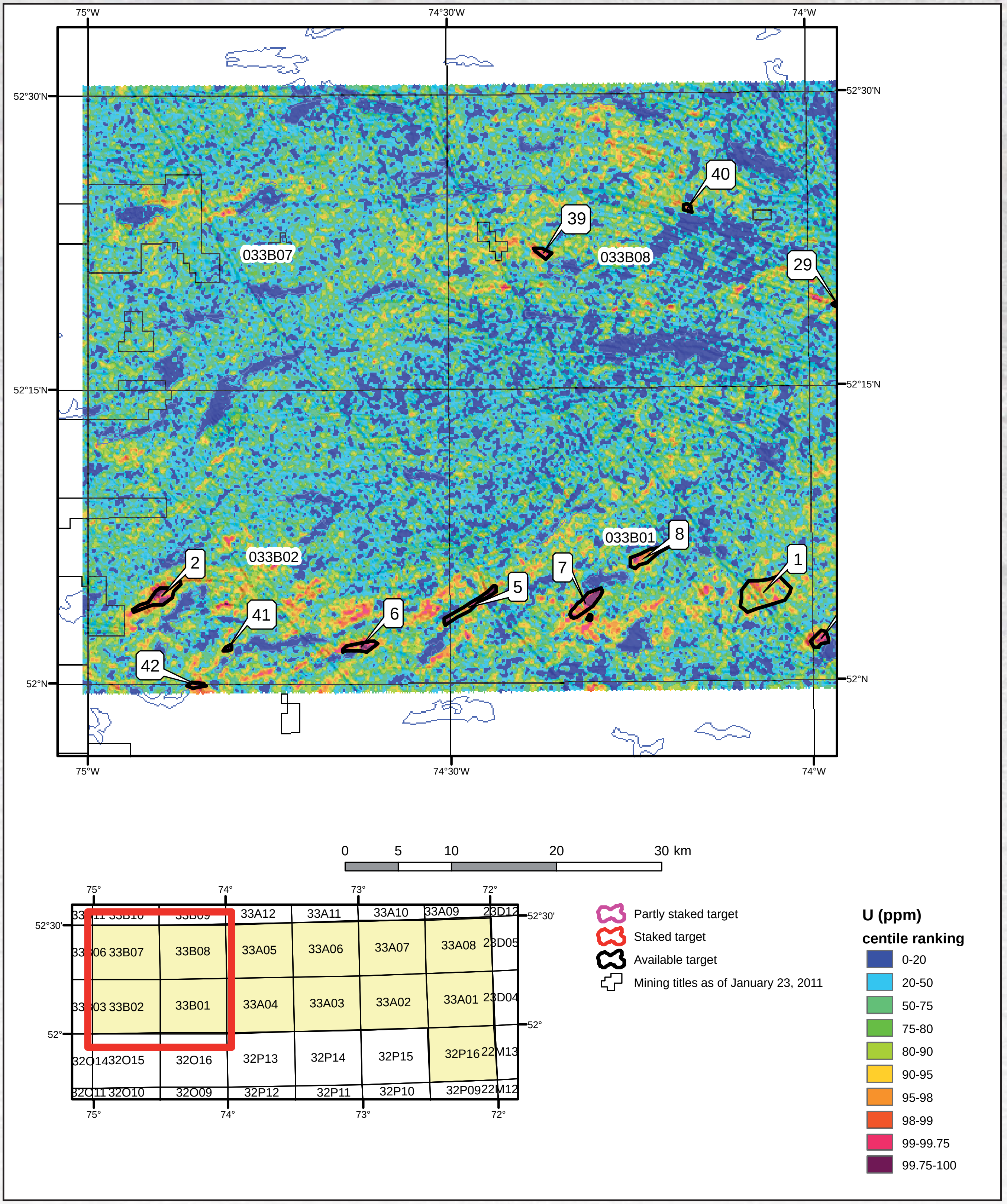

Figure 6 – Map of equivalent uranium (ppm) overlain on the shaded relief of the first vertical derivative of the magnetic field and uranium exploration targets in the western part of the survey.

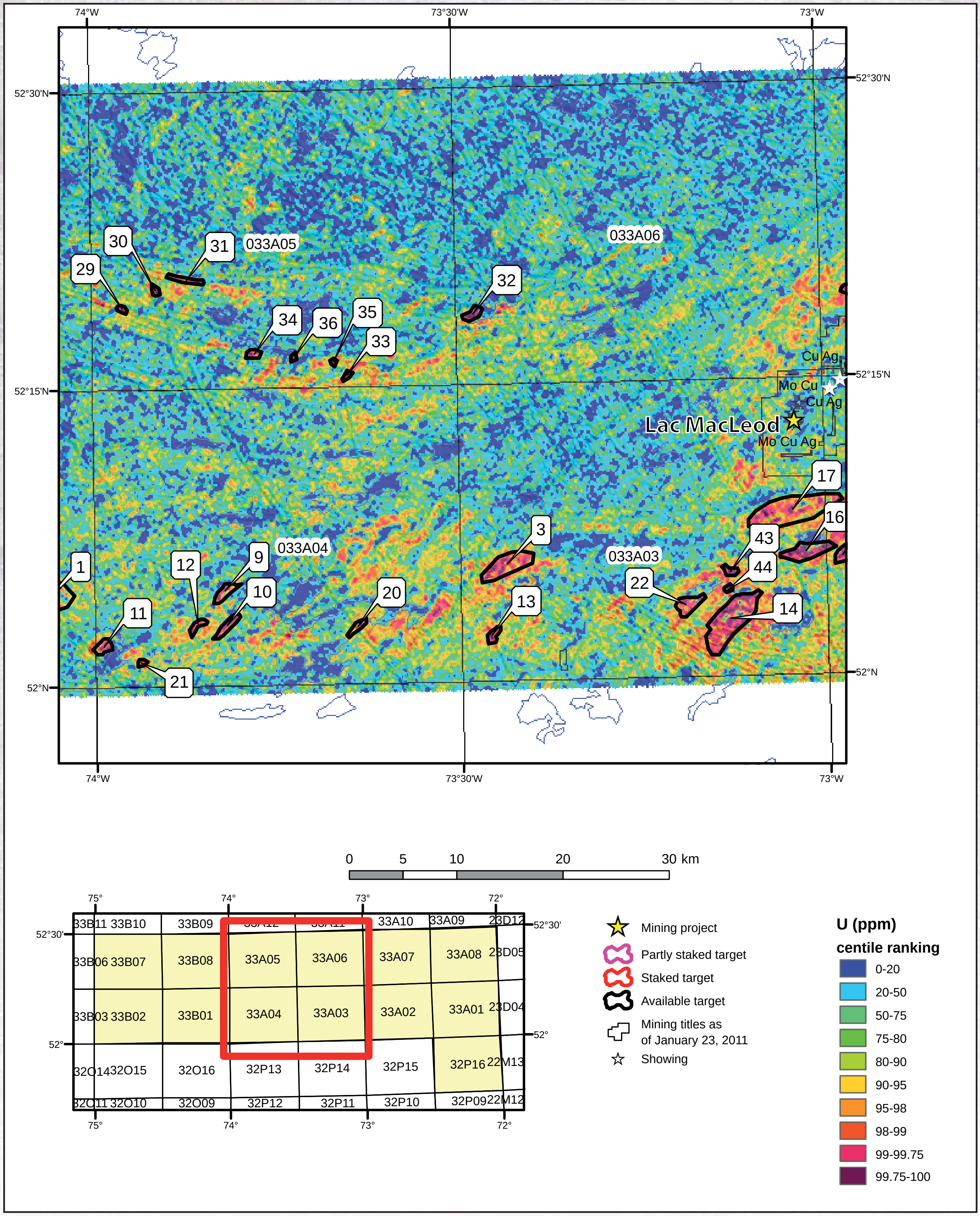

Figure 7 – Map of equivalent uranium (ppm) overlain on the shaded relief of the first vertical derivative of the magnetic field and uranium exploration targets in the central part of the survey.

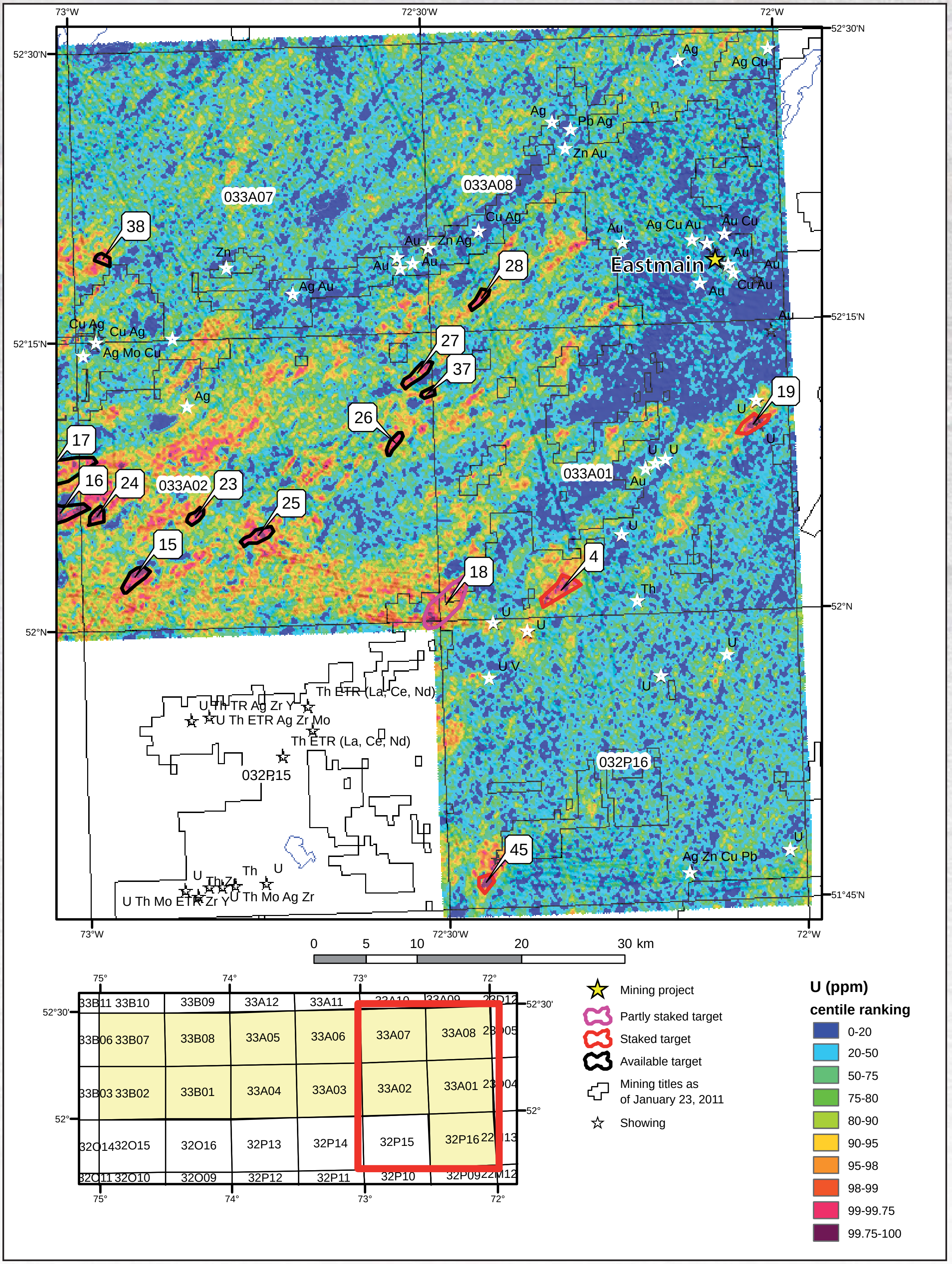

Figure 8 – Map of equivalent uranium (ppm) overlain on the shaded relief of the first vertical derivative of the magnetic field and uranium exploration targets in the eastern part of the survey.

TABLE 1 – List of diamond exploration targets with a Keating correlation coefficient above 92% (absolute value). Targets highlighted in yellow were staked as of January 23, 2011.

Target	Easting	Northing	Amplitude	Correlation coefficient	Target	Easting	Northing	Amplitude	Correlation coefficient
1	698940	5738700	174.6	94.2	39	533400	5783220	26.7	92.3
2	705720	5739840	281.1	93.9	40	638040	5783400	117.9	94.2
3	679140	5741040	898	95	41	633240	5784060	30	93.4
4	703080	5760780	32.7	92.9	42	568200	5784120	132.4	92.7
5	526500	5761380	21.6	95.8	43	640980	5784660	135.9	94
6	622020	5763120	97.3	96.3	44	661800	5785080	97.7	92.1
7	611100	5766240	98.6	94.6	45	676260	5786220	228.5	96.2
8	647040	5767200	108.9	92	46	597420	5786820	59.4	92.2
9	623820	5767800	158.7	92.9	47	634680	5787180	22.9	96
10	526200	5768640	56.9	93	48	659940	5787420	30.6	93.1
11	526980	5768700	94.2	97.9	49	682680	5788320	72.9	93.3
12	580680	5769300	35.9	94.7	50	658380	5789340	306.3	94.5
13	666780	5770140	219.9	96.1	51	667860	5789580	208.9	96.2
14	503640	5770320	76.9	95.4	52	666600	5789820	196	93
15	665280	5770380	274.9	94.8	53	594060	5791080	214.4	93
16	504900	5770920	257.8	94.2	54	635820	5791740	16.1	92.3
17	663720	5772480	26.7	92.3	55	669540	5791860	141.9	95.9
18	598200	5772840	82.6	93.4	56	551520	5791980	391.6	92.8
19	543780	5772900	456.5	95.1	57	521340	5792880	72.7	92
20	607440	5773260	121.5	93	58	649500	5792940	224.7	92.5
21	580800	5775000	146.5	92.5	59	686040	5792940	114	93.8
22	630240	5775060	177.7	94.1	60	510600	5796300	50.9	92.3
23	519360	5775840	51.7	92.1	61	666540	5797680	52.3	94.2
24	701460	5776920	182.8	92	62	667560	5798100	89.7	93.2
25	564780	5777280	108.3	92.6	63	671040	5799780	73.1	93.4
26	663540	5777700	36.6	92.5	64	698880	5802720	147.7	92.2
27	657720	5777760	111.6	94.2	65	551460	5804100	56.9	93.1
28	602520	5777880	146.1	92.3	66	505260	5804700	115.5	92.3
29	511620	5778660	109.6	93.6	67	699060	5805000	286.8	94.5
30	509940	5779020	43.7	93.1	68	701220	5806980	133.6	92.7
31	569700	5779140	70.7	92	69	683220	5808120	163.2	92.5
32	527400	5779260	46.9	94.1	70	675840	5812020	40.1	95
33	511920	5779980	61.3	92.3	71	596400	5812080	148.7	92.3
34	579720	5780400	365.7	96.2	72	651660	5812320	37.2	94.2
35	577260	5780760	59.3	92.5	73	579780	5813400	151.4	-92.5
36	634320	5780940	52.2	93.7	74	590280	5816700	117.8	92.1
37	545340	5781960	192.6	92.6	75	588840	5817960	81.4	92.3
38	637500	5782260	297.1	95.7					

TABLE 2 – Parameters used to calculate Keating coefficients.

Magnetic inclination	75.3o
Magnetic declination	18.2oW
Relative intensity of total magnetic field (kH)	100 nT
Distance to top of cylinder	115 metres
Radius of cylinder	100 metres
Length of cylinder	infinite (-1)
Minimum correlation coefficient	0.90 (90%)
Size of window	9 (9 X 9 grid cells)
	480 m
Smoothing filter	2 iterations

TABLE 3 – List of uranium exploration targets. Targets highlighted in yellow were staked or partly staked as of January 23, 2011.

Target	Surface area	Easting	Northing	Max U/Th	Average U (ppm)	Max U (ppm) on target
1	10.73	564000	5769617	0.81	1.04	2.63
2	3.84	506825	5769251	1.09	1.93	4.81
3	7.48	607151	5772952	1.19	1.94	4.07
4	4.70	683196	5766905	0.88	1.92	4.36
5	2.98	536087	5768356	2.52	1.80	5.30
6	2.04	525817	5764537	0.71	2.07	4.43
7	3.36	547180	5768651	0.53	2.27	5.14
8	2.83	552794	5773059	0.70	1.34	3.51
9	2.05	580731	5770412	0.58	1.53	3.27
10	2.13	580973	5767244	0.93	2.00	3.70
11	1.71	569342	5765273	0.71	1.73	3.05
12	1.04	578139	5767248	0.42	1.87	2.84
13	1.13	605906	5766381	0.33	2.14	3.32
14	14.66	628089	5767796	0.44	2.12	4.50
15	3.05	642242	5768023	0.46	2.20	3.64
16	5.37	635222	5774274	0.53	2.12	3.60
17	16.72	633885	5778129	0.95	1.60	3.55
18	10.24	672221	5765565	0.51	1.69	3.27
19	3.04	701767	5782901	0.77	1.91	3.78
20	1.20	593133	5767117	0.34	1.71	3.08
21	0.45	572941	5763812	0.49	1.84	2.76
22	3.03	624139	5769237	0.50	1.78	2.87
23	1.57	648083	5773969	0.28	1.91	3.11
24	1.64	638616	5773990	0.40	2.07	3.13
25	2.90	654080	5772088	0.31	2.11	3.73
26	1.57	667228	5781065	1.01	1.79	2.65
27	2.79	669458	5787729	0.57	1.59	2.95
28	1.58	675499	5794987	0.56	1.76	2.55
29	0.51	571069	5796887	0.42	2.14	3.29
30	0.55	574190	5798689	0.56	2.34	3.08
31	1.59	577027	5799650	0.42	1.89	2.80
32	1.50	603930	5796494	0.51	2.50	4.56
33	0.54	592127	5790713	0.36	2.41	3.29
34	0.86	583396	5792742	0.52	1.99	3.27
35	0.32	590888	5791989	0.52	2.48	3.28
36	0.28	587171	5792442	0.47	2.68	4.67
37	0.98	670519	5785881	0.74	1.94	3.62
38	1.13	639146	5798730	0.46	1.76	2.70
39	0.92	543078	5801847	0.48	1.78	2.69
40	0.48	556787	5806067	0.34	1.85	3.14
41	0.28	513308	5764395	0.51	2.38	3.20
42	0.62	510294	5760906	0.65	2.15	3.26
43	0.91	628051	5772412	0.44	2.29	3.73
44	0.37	627891	5770773	0.38	2.35	2.91
45	1.69	676019	5738715	0.30	2.29	4.64

Ressources naturelles
et Faune
Québec