EXPLORATION TARGETS SOUTH OF LG4, BAIE-JAMES, QUÉBEC: INTERPRETATION OF A NEW GEOPHYSICAL SURVEY

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Introduction

The *Ministère des Ressources naturelles et de la Faune du Québec* announces the publication of new geophysical data (D'Amours, 2010). Pursuing its objective to outline strategic areas for mineral exploration work, Géologie Québec carried out in 2009 a new magnetic and gamma-ray spectrometry survey in the Baie-James region (Figure 1). This survey covers 12 maps sheets at 1/50,000 scale (33A09 to 16 and 33B09, 10, 15, 16), for a total surface area of 11,250 km^2. This new publication comes with a report describing all the technical aspects of the survey, a set of 120 geophysical maps at 1/50,000 scale and all related digital data. It is now available under document number DP 2010-03 at the following address: *http://www.mrnfp.gouv.qc.ca/english/products-services/mines.jsp*, via "**E-Sigeom (Examine)**".

Géologie Québec began in 2007 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 in the triangle delineated by three advanced mining projects: Renard (diamond), Éléonore (gold), and Coulon (zinc, copper; Figure 1). This document describes two quantitative interpretation techniques for this survey and proposes a series of targets for mineral exploration.

Regional geological setting and mineral potential

Despite the efforts of a few mineral exploration companies in certain areas of the Baie-James region in the early 1990s, geoscience knowledge within 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 map sheets at 1/50,000 scale and one at 1/250,000 scale (see references included in Simard and Gosselin, 1998; Goutier *et al.*, 2002; Moukhsil *et al.*, 2003). Recent MRNF mapping efforts are now focused in the area near Opinaca Reservoir, in the vicinity of the Éléonore project (Figure 1; Bandyayera and Fliszár, 2007; Bandyayera and Lacoste, 2009; Bandyayera *et al.*, in preparation).

The area covered by the new geophysical survey (D'Amours, 2010) lies within the Opinaca Subprovince (Card and Ciesielski, 1986). It is primarily underlain by migmatitic paragneisses and diatexites of the Laguiche Complex and by late felsic to intermediate intrusive suites. The western part of the area was covered by a regional mapping survey at a scale of 1/250,000 by Simard and Gosselin (1998). The central part, between longitudes 73°00' and 74°00' (Figure 1), has never been covered by a geological survey, whereas the eastern past was the object of regional mapping in the 1970s (Hocq, 1975, 1976 and 1985). Finally, note that not a single mining claim is currently registered in the central part of the area, which thus remains entirely open to exploration.

Apart from the diamond deposits on the Renard project (33A16), one tungsten showing (33A16) and one thorium showing (±uranium; 33B10) are the only mineral occurrences reported in the study area. This lack of known showings may be explained, at least in part, by the lack of detailed mapping or even regional mapping in certain parts of the area. Two important deposits, namely the Roberto deposit on the Éléonore project and the MacLeod Lake porphyry Cu-Mo-Au deposit (33A03), discovered in 1982, are located nearby.

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 2). Magnetic

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anomalies for which the absolute value (positive or negative) of the correlation coefficient with the model is greater than 0.90 (Table 1) are illustrated on the map showing the first vertical derivative, as circles with a radius that is proportional to the correlation coefficient (figures 3 and 4). Negative correlation coefficients represent reversely magnetized anomalies, a common feature observed in kimberlite pipes in the Northwest Territories (Keating and Sailhac, 2004). The cylinder parameters are selected based on the grid cell size (60 m), so that the size of the modeled response will be similar to that of the analysis 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 the results of the modelling are illustrated, and no geological interpretation has been carried out. For example, anomalies that correspond to Proterozoic gabbro dykes are also illustrated. The parameters used in the calculations are listed in Table 2. The distance to the top of the cylinder was set at 115 m. The nominal flight altitude is 80 m. However, the average altitude is 115 m over the entire survey, and one may assume there is a certain thickness of overburden, particularly in flat areas where the plane was able to maintain its nominal altitude. This theoretical model was 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 are defined over the Renard 1, 2, 3, 4, and 65 kimberlite pipes (Figure 5). One possible explanation is that the model is based on a body with a diameter of 200 m, whereas Renard kimberlites are smaller, with diameters ranging from 75 to 150 m. Note also that the geometry of the Renard 65 composite body is quite different from that of a vertical cylinder. Anomalies generated using the Keating coefficient method nevertheless remain a useful tool in combination with other types of data (apparent resistivity, geochemistry, indicator minerals).

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

Uranium exploration targets defined using gamma-ray spectrometry data

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 first 30 centimetres of ground (IAEA–TEC-DOC-1363, 2003). Thus, it is 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), also integrating other types of airborne geophysical data such as magnetic and electromagnetic maps.

Exploration targets delineated in this report (figures 6 and 7; Table 3) consist of zones where the eqU/eqTh ratio ranks in the 100th percentile, and where concentrations in equivalent uranium are highest, *i.e.* above 1.9 ppm; the average for this survey being 0.43 ppm with a standard deviation of 0.3. 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 is emitted from a source with a 100-m radius below the sensor, and more than 20% of 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). We believe there are three apparently favourable areas that contain zones warranting further investigations: one area in the west (targets 1 to 7, Figure 6), one in the central part and one in the east (targets 8 to 19 and 20 to 22, Figure 7). Most targets in the western and eastern areas are located on lands covered by active mining titles, but the central area is completely open to exploration. Although poorly known, the latter is underlain by migmatitic paragneisses and diatexites, in a geological setting fairly similar to that documented further west (NTS 33B14) by Dios Exploration on the “Upinor” project (http://diosexplo.com/projects.php). Note that work by Dios revealed the presence of 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%.

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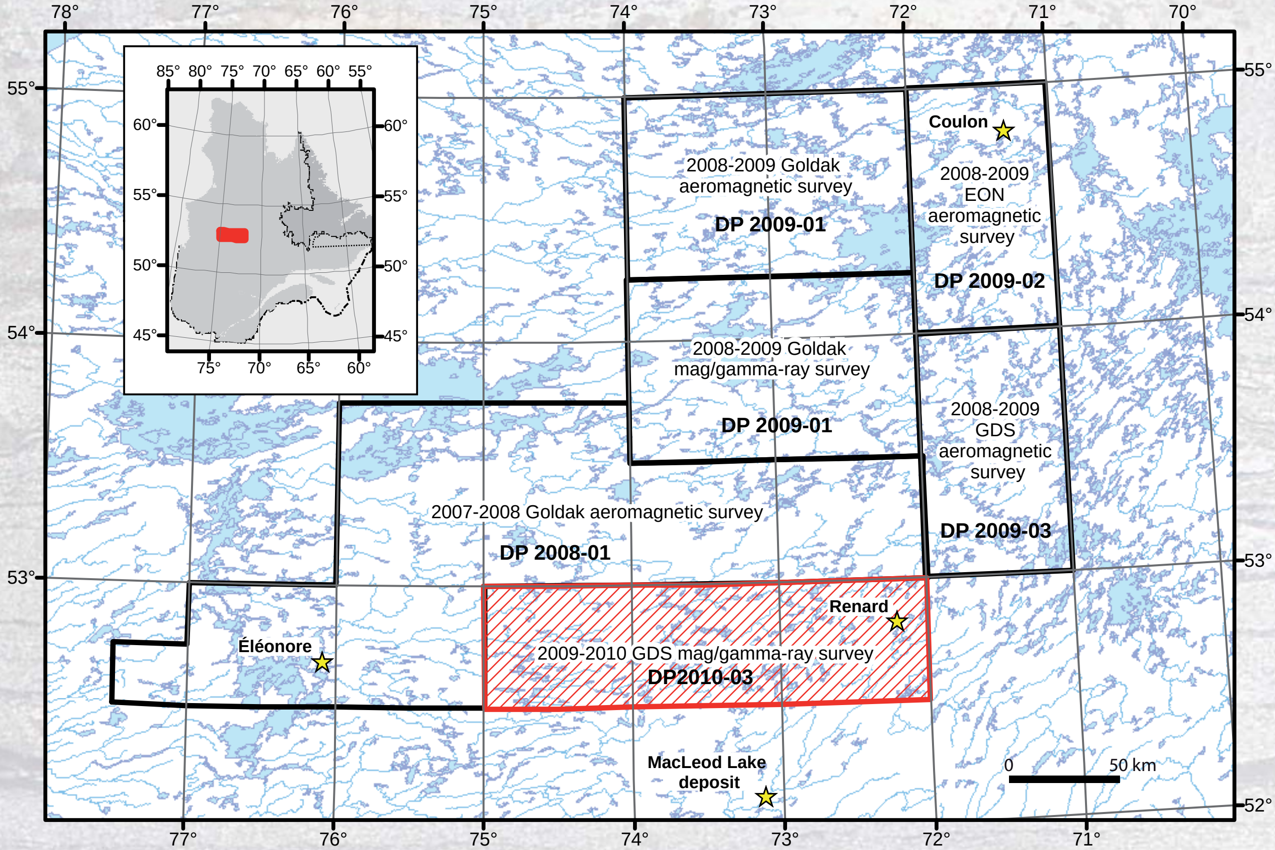

Figure 1 - Location of the new survey and previous high-resolution geophysical surveys carried out since 2007 in the Baie-James region.

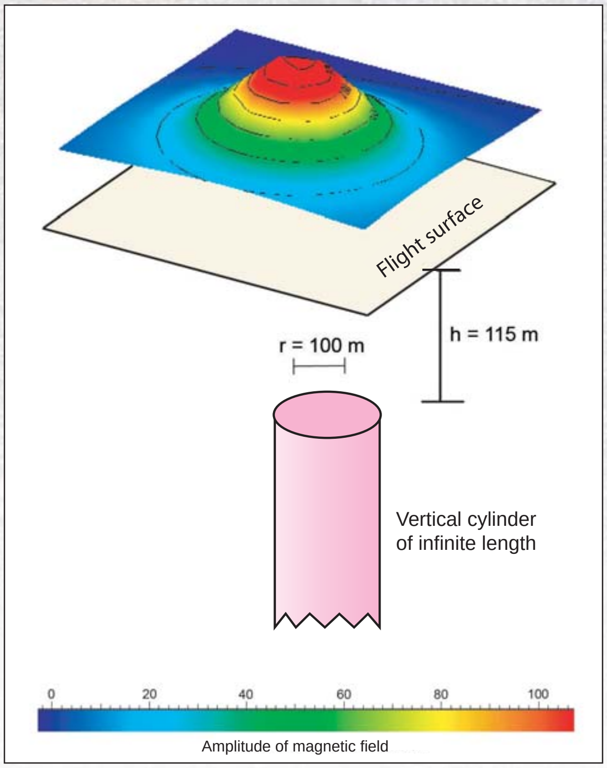

Figure 2 - Theoretical model used to calculate the Keating correlation coefficient (Keating, 1995).

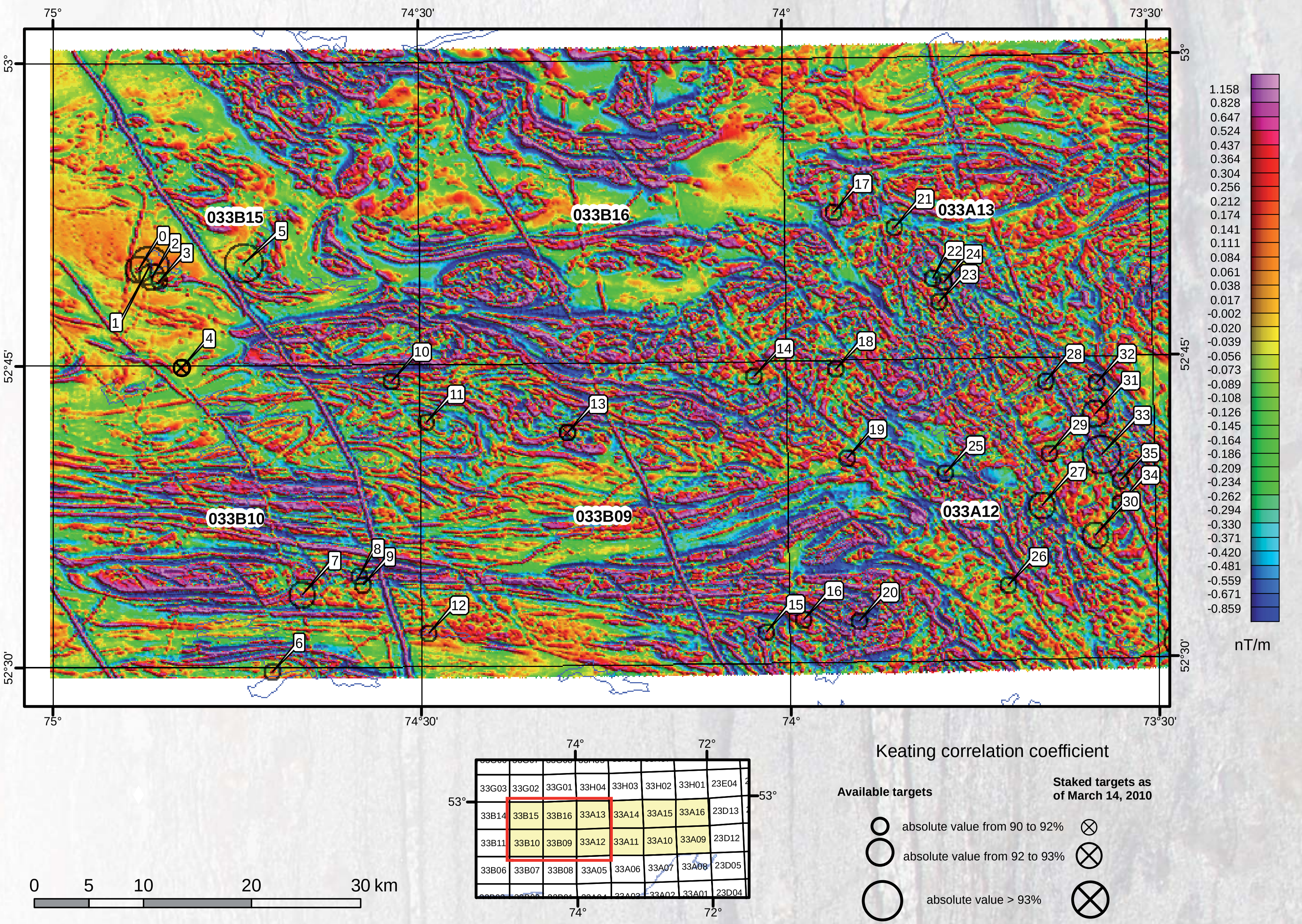

Figure 3 - Map showing the first vertical derivative of the magnetic field and diamond exploration targets established using the Keating coefficient in the western part of the survey.

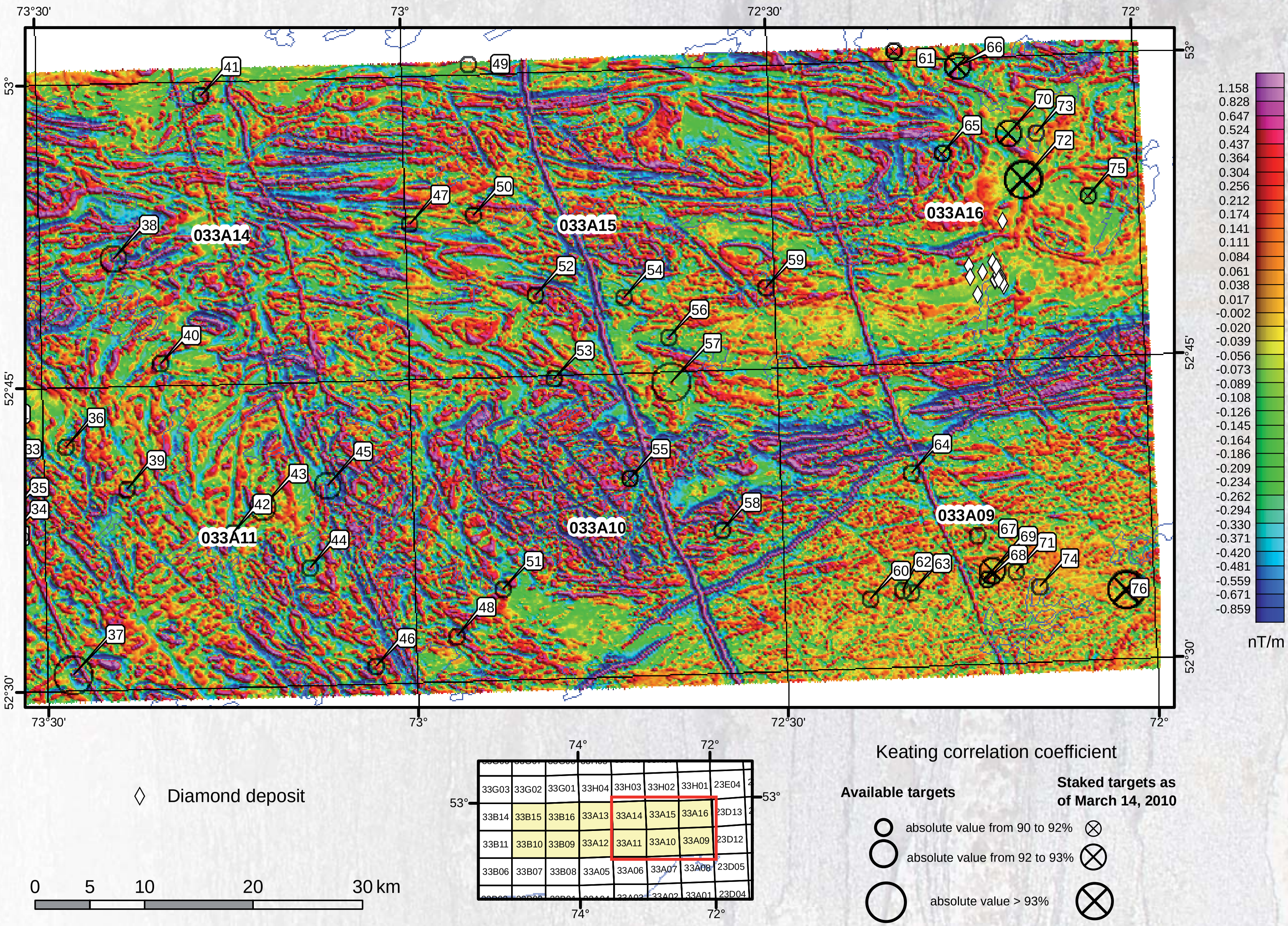

Figure 4 - Map showing the first vertical derivative of the magnetic field and diamond exploration targets established using the Keating coefficient in the western (eastern?) part of the survey.

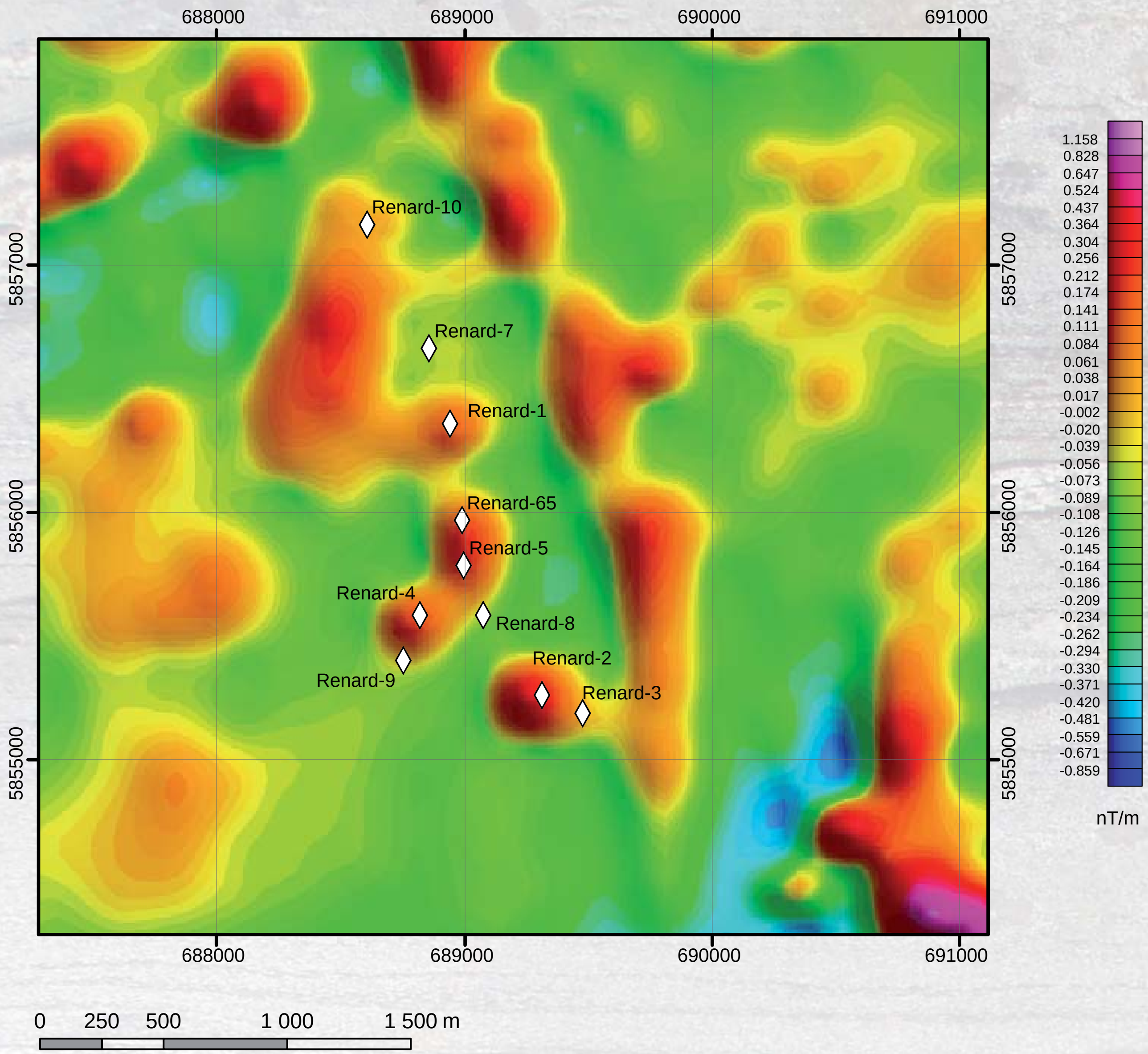

Figure 5 - First derivative of the residual magnetic field in the Lac Renard area.

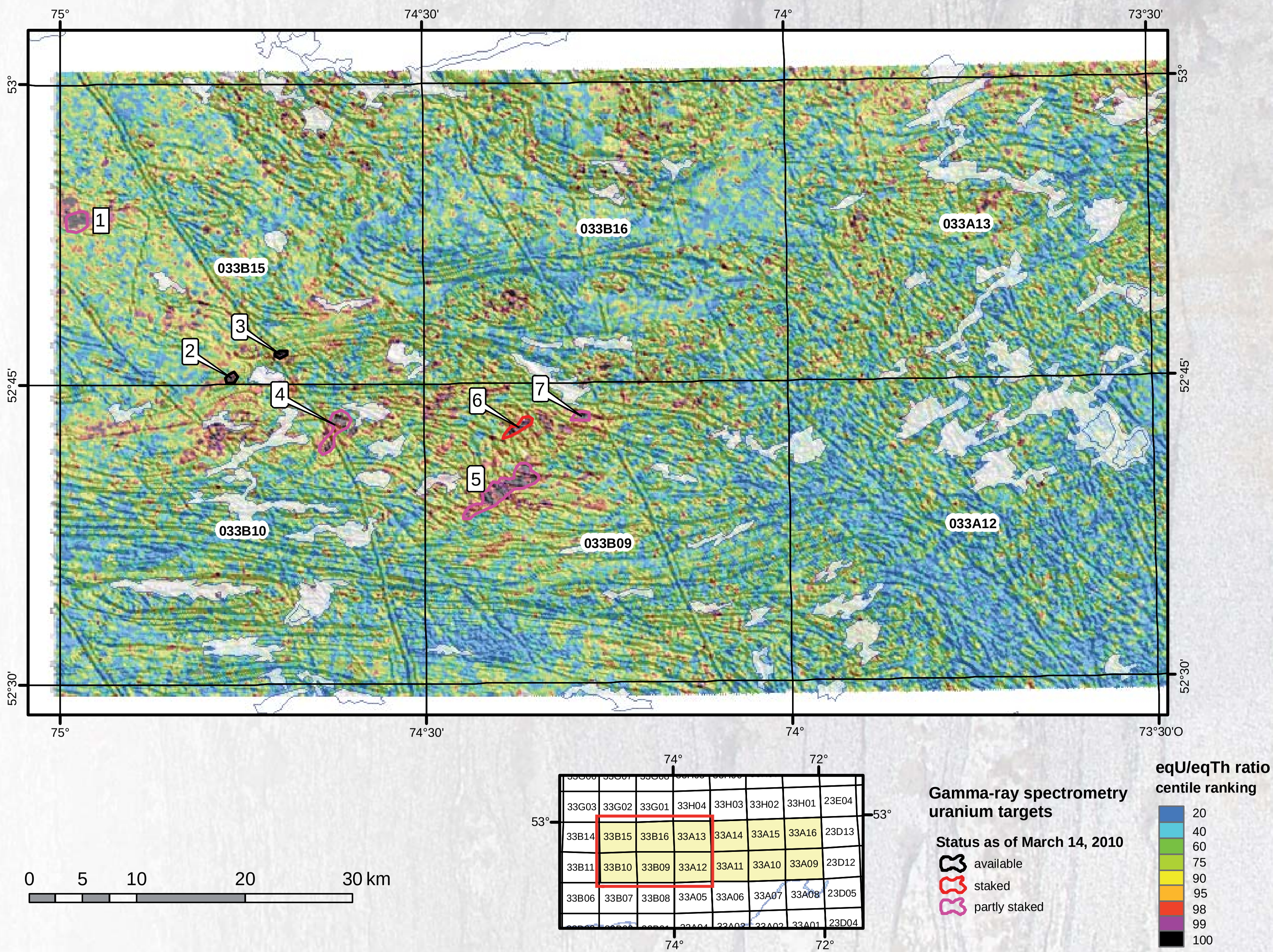

Figure 6 - Uranium/Thorium ratios overlain on the shaded relief image of the first vertical derivative of the magnetic field and uranium exploration targets in the western part of the survey.

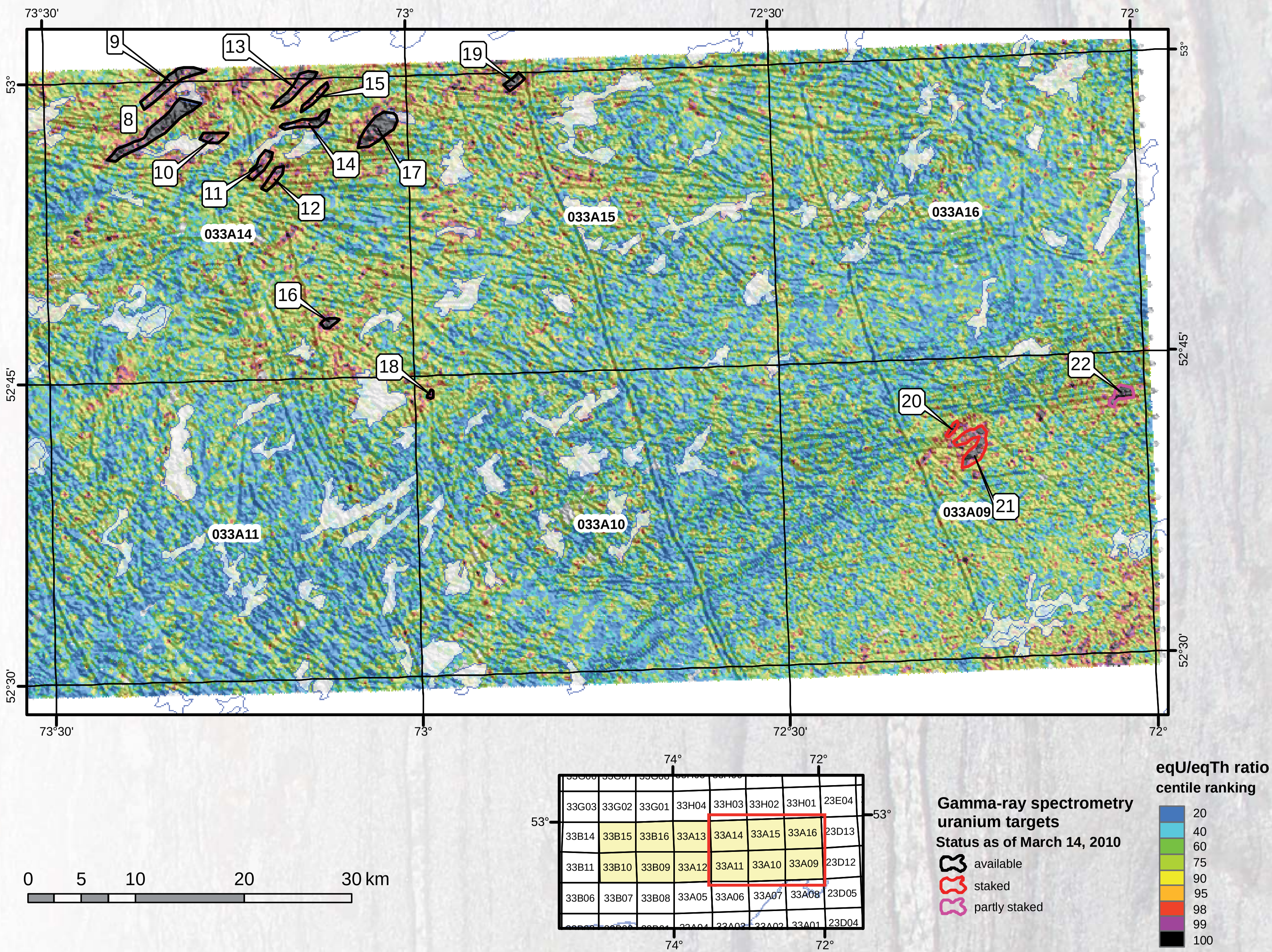

Figure 7 - Uranium/Thorium ratios overlain on the shaded relief image of the first vertical derivative of the magnetic field and uranium exploration targets in the eastern part of the survey.

TABLE 1 – List of diamond exploration targets with a Keating correlation coefficient above 90% (absolute value). Targets highlighted in yellow were staked as of March 14, 2010.

Target	Easting	Northing	Amplitude	Correlation coefficient
0	507840	5853300	83.1	93
1	508920	5853660	92.8	93.9
2	509160	5852640	103.5	92.8
3	509880	5852220	87.7	90.1
4	511920	5844300	55.8	90.6
5	517560	5853840	60.6	94.6
6	520260	5816280	68.1	91.3
7	522960	5823360	186.6	92.7
8	528180	5825040	199.7	90.2
9	528600	5824260	48.3	-91
10	531240	5843040	185.2	90.2
11	534420	5839200	107.6	91.4
12	534660	5819760	57	90.2
13	547440	5838300	140.4	91.1
14	564600	5843400	155.3	90.2
15	565680	5819880	145.3	90.7
16	569160	5821080	323.2	90.3
17	571860	5858580	92.1	91.5
18	572160	5844120	99.2	90.4
19	573180	5835960	381.4	90.1
20	574320	5820960	448.9	90.7
21	577500	5857200	176.7	91.8
22	581100	5852460	86.1	-90.8
23	581640	5850300	130.8	90.1
24	582060	5852160	155.5	90.7
25	582240	5834520	155.2	90.8
26	588060	5824260	82.2	91.4
27	591120	5831580	156.1	92.7
28	591420	5842980	324.9	91.9
29	591840	5836380	83.6	91.5
30	595980	5828820	149	92.4
31	596040	5839980	116.1	92.9
32	596160	5842920	275.4	91.2
33	596580	5836260	387.7	94.2
34	598320	5831760	177.2	91.3
35	598320	5833800	332.7	91.4
36	603480	5840160	80.6	90.3
37	604200	5819220	434.4	93.2
38	607800	5857380	541	92,4
39	609060	5836260	134.2	-90.1
40	612240	5847780	108.1	90.4
41	615900	5872380	317.6	90.8
42	618780	5832240	67.4	-90.2
43	621540	5834580	105.4	92.8
44	625860	5829000	216.1	90.2
45	627480	5836560	134.3	92.8
46	631980	5819940	78.3	90
47	635040	5860620	86.4	90.9
48	639360	5822760	99	-91.2
49	640380	5875200	30.2	-91.7
50	640920	5861400	62.3	90.2
51	643680	5827020	72.3	90.7
52	646620	5854080	102.1	90.5
53	648360	5846340	142.2	91.7
54	654720	5853780	100.1	90.2
55	655320	5837280	279.1	90.3
56	658860	5850120	157.4	90.5
57	659040	5846040	66.5	93.6
58	663720	5832420	72	91
59	667740	5854740	84.2	90
60	677400	5826120	52.2	90.8
61	679500	5876460	79.3	90.6
62	680340	5826960	65.8	90
63	681120	5826780	46.7	91.6
64	681120	5837760	37.2	91.2
65	683940	5867040	139.7	91.7
66	685320	5875140	191	92.8
67	687180	5832000	60.4	-91
68	688140	5828040	52.4	91.1
69	688500	5828760	36.8	92.8
70	690000	5868900	32.5	92.4
71	690780	5828700	36.1	90.8
72	691380	5864700	31.6	93
73	692520	5868900	38.3	91
74	692880	5827260	13.1	-91.4
75	697320	5863140	44.7	91
76	700920	5827020	31.2	93.2

TABLE 2 – Parameters used to calculate Keating coefficients.

Magnetic inclination	75.6°
Magnetic declination	18.5°W
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 March 14, 2010.

Target	Surface area	Easting	Northing	Max U/Th relative to background	Average U (ppm)	Max U (ppm) on target
1	3.18	501544	5859577	2.75	1.94	4.59
2	0.71	515879	5845076	2.30	1.94	2.88
3	0.59	520489	5847334	2.35	1.32	1.92
4	4.69	525498	5840263	3.16	1.18	4.18
5	10.72	541095	5834790	3.61	1.71	3.50
6	1.96	542487	5840572	2.33	1.60	4.43
7	1.17	548332	5841558	1.97	2.24	3.75
8	9.39	611154	5869322	5.07	1.99	5.60
9	5.45	612369	5873371	2.81	1.01	2.37
10	1.84	616405	5868451	1.71	2.11	3.62
11	2.50	620771	5865895	2.17	1.95	6.04
12	1.86	621967	5864647	1.73	1.95	3.36
13	3.86	624034	5873016	2.55	1.17	2.61
14	3.04	625146	5869846	2.39	1.57	3.54
15	1.57	625825	5872164	1.86	1.93	3.75
16	0.99	627126	5851296	2.30	1.93	2.91
17	6.53	631650	5869230	3.50	1.31	2.56
18	0.31	636489	5844627	1.53	2.25	3.11
19	1.50	644263	5873589	2.93	1.42	3.33
20	0.69	684821	5841425	2.23	2.12	3.17
21	5.62	686760	5839935	3.17	1.09	2.52
22	2.26	700500	5844683	2.68	1.20	3.55