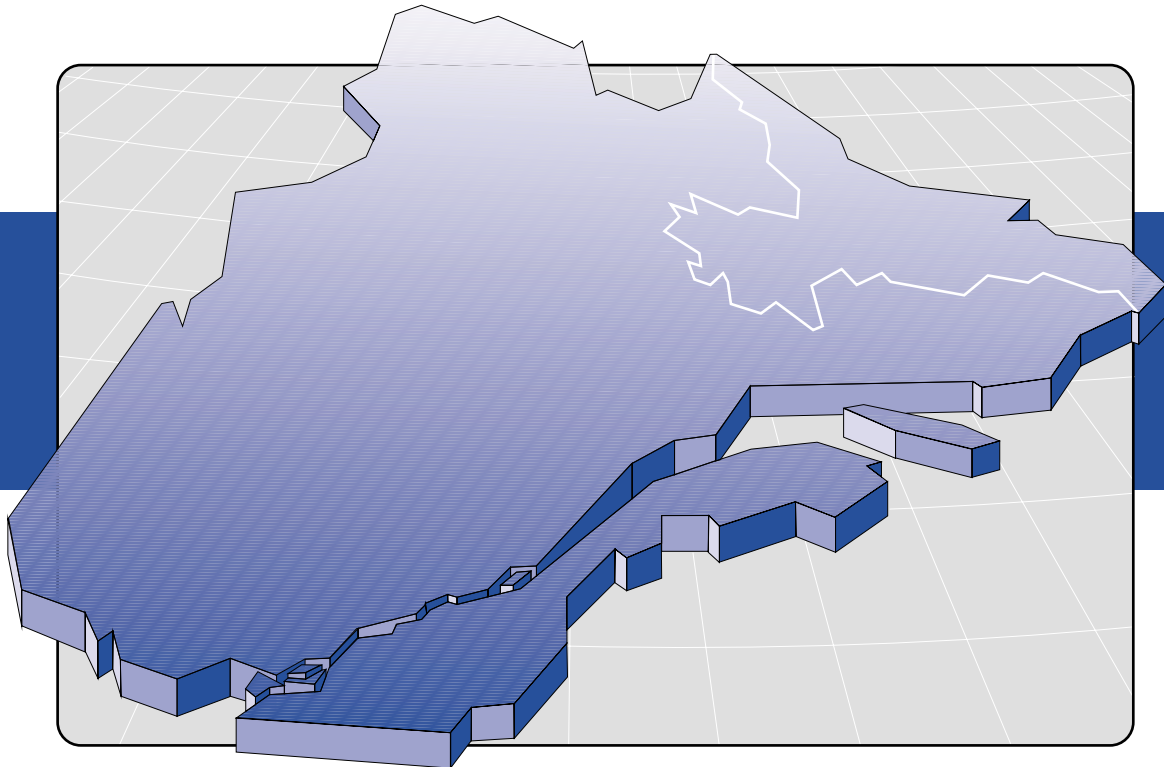




Crustal lineaments and kimberlite discovery potential in western Nouveau-Québec

Jean-Yves Labbé

PRO 2001-02



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INTRODUCTION

A new mineral potential map production system has been developed by Géologie Québec in order to assess the mineral potential of the province. It works in parallel with SIGÉOM (Système d'Information Géominière) and makes it possible, with the help of spatial analysis software, to combine data from various sources and produce mineral potential maps. These potential maps are produced at a scale of 1:250,000 and are based on theoretical ore deposit models.

In conjunction with the Far North mapping project, aimed at completing the geological coverage at a scale of 1:250,000 for western Nouveau-Québec (west of the Labrador Trough), it was decided to use the system to assess the kimberlite discovery potential of this vast region. The area is underlain by Archean rocks of the northeastern Superior Province; they represent an Archean cratonic setting favourable for the discovery of diamonds.

A theoretical model for kimberlite and lamproite occurrences was developed (Labbé and Lacoste, in preparation) based on our current understanding of kimberlite and lamproite pipes. It is not meant to assess the diamond potential as such, but rather to build a model assessing the kimberlite (and lamproite) discovery potential, as the latter represent the principal diamond-bearing lithologies.

The kimberlite model is based on three parameters that were considered individually, then combined to create the final assessment map for the discovery potential. These three parameters are:

- Major crustal lineaments
- Local structural control
- Signs of kimberlitic volcanism

The first parameter takes into account important deeply-rooted structures that can act as conduits and exert control on the position of kimberlite fields. These structures extend over a few hundred kilometres. The second parameter is based on local faults (tens of kilometres) that may control the position of pipes within a kimberlite field. Finally, the third parameter is based on the geophysical, geochemical, topographic and geological expression of near-surface kimberlite pipes.

This document includes a map of crustal lineaments interpreted from aeromagnetic and gravity maps, used in the first part of the model. These lineaments constitute favourable structures for the discovery of kimberlites.

Results obtained from the kimberlite discovery potential assessment in the Lac Aigneau area (NTS 24E) are also reported.

CRUSTAL LINEAMENTS

Two types of crustal lineaments are interpreted : structural corridors and regional breaks. The structural corridors correspond to zones crossed by numerous faults. These zones may be sites of late sedimentary basins or of alkaline magmatism. Regional breaks are linear structures or lineaments interpreted from gravity and aeromagnetic maps.

Figure 1 shows the distribution of interpreted crustal lineaments and the principal alkaline intrusions in the study area. The four structural corridors that cut through the area (figure 1) are from Moorhead et al. (1999).

The Saindon-Cambrien corridor (SCC) is interpreted from the alignment of a series of seven Proterozoic sedimentary basins, unconformably overlying the Archean basement, with the Lac Castignon carbonatite complex (8 on figure 1). This corridor has no particular geophysical signature on the aeromagnetic map, but the corridor shows up on satellite images as a series of ENE-trending lineaments (Portella, 1980). The Wemindji-Caniapiscau corridor (WCC), which marks the southern boundary of the study area, is also defined by the alignment of Proterozoic sedimentary basins (Moorhead *et al.*, 1999). A few syenitic intrusions, including the Niaux alkaline suite (9), are also present. The Richmond corridor (RC) corresponds to a graben in which Proterozoic sedimentary formations were deposited (Chandler, 1988). It may represent an aulacogen (Chandler and Schwartz, 1980). Finally, the Allemand-Tasiat corridor (ATC; Moorhead *et al.*, 1999) is interpreted from the alignment of alkaline intrusions (Allemand (1), Couture (3) and Tasiat (6)). It does not correspond to a specific geophysical lineament. These four corridors represent potential permeable zones that may have played an important role during a period of kimberlitic magmatism. They are taken into consideration in the assessment model for the kimberlite discovery potential.

The major regional breaks shown in figure 1 also constitute an important part of the assessment model. This type of deep regional structure provides a passageway for ascending kimberlitic magmas, and controls the position

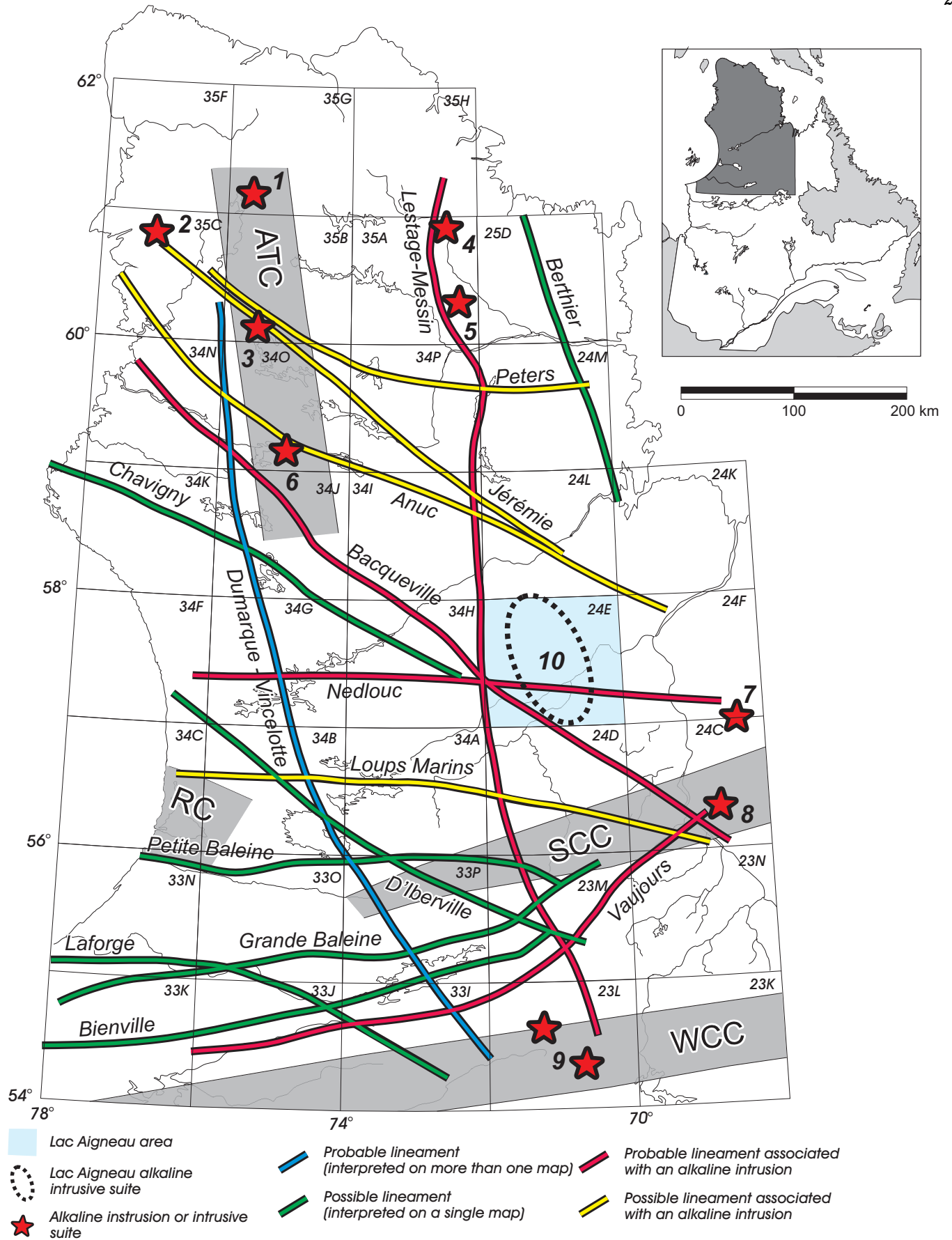


FIGURE 1 - Interpreted crustal lineaments and location of principal alkaline intrusions. ATC = Allemand-Tasiat Corridor, RC = Richmond Corridor, SCC = Saindon-Cambrien Corridor, WCC = Wemindji-Caniapiscau Corridor. Alkaline intrusions are numbered as in Table 1.

of kimberlite fields (White *et al.*, 1995; Card *et al.*, 1997). These lineaments were mainly interpreted from 1:1,000,000 scale aeromagnetic and gravity maps. They are not visible on the LANDSAT mosaic, which highlights less extensive more superficial structures, taken into consideration in the second parameter of the model as indicative of local conduits. Interpreted regional breaks are structures that extend over a few hundred kilometres in length. On aeromagnetic maps, they mainly correspond to breaks in the magnetic trend. Zones of strong magnetic contrast (i.e. contacts between magnetic “lows” and “highs”) correspond to lithological contacts. These zones are generally restricted (a few tens of kilometres) and are not considered as crustal lineaments except in cases where they evolve laterally into breaks in the geophysical signature. On the gravity map, regional breaks correspond to high contrast zones.

Certain breaks are as obvious on the gravity map as they are on the aeromagnetic map, whereas others are only visible on one of the two maps. Since these are interpreted structures that were not necessarily observed in the field, we have attributed, in our assessment model, more weight to structures visible on both geophysical maps. These structures are classified as “probable”, whereas those interpreted from a single map are classified as “possible”.

Particular attention was paid to breaks associated with alkaline intrusions. The presence of alkaline intrusions, such as nepheline syenites, ultramafic lamprophyres and carbonatites, is an indication of magmatism derived from deeper crustal levels, which required the existence of conduits for ascending magmas. We may therefore assume that lineaments associated with alkaline intrusions represent crustal-scale structures favourable for the transport of kimberlitic magmas. These lineaments were given a higher rating in our assessment model than those not associated with known alkaline intrusions. Known alkaline intrusions are listed in table 1.

Four types of lineaments are thus defined (figure 1) : probable lineaments, possible lineaments, probable lineaments associated with alkaline intrusions, and possible lineaments associated with alkaline intrusions. Of course, probable lineaments associated with alkaline intrusions are the most interesting in the search for kimberlites.

GLOBAL POTENTIAL OF WESTERN NOUVEAU-QUÉBEC

A total of 16 lineaments, or breaks, were interpreted from geophysical data. Four of these lineaments (red on figure 1) particularly attracted our attention in that they have both a magnetic and gravimetric signature, and they are associated with alkaline intrusions. The Lestage-

Messin lineament extends over more than 700 kilometres in a north-south direction. Northward, it marks the boundary between the Lepelle domain to the west and the Douglas Harbour domain to the east (Madore *et al.*, 2000). This lineament is associated with the Briscot and Des Ombles syenites (4 and 5 on figure 1), near its northern end. Southward, syenites of the Niaux alkaline suite (9) occur in the extension of the Lestage-Messin lineament. The Bacqueville lineament is oriented NW-SE and extends over more than 600 kilometres. The Lac Castignon carbonatite complex (8) is located near the intersection of this lineament and the Vaujourns lineament, about 500 km long and classified as a “probable” lineament. In the Lac Gayot area (NTS 23M), the Vaujourns fault marks the boundary between rocks of the La Grande Subprovince and those of the Ashuanipi Subprovince (Gosselin and Simard, 2000). The fourth lineament in our first category (i.e. probable lineaments associated with alkaline intrusions) is the Nedlouc lineament, which transects the area along an east-west axis. The Nedlouc lineament extends for about 400 kilometres, to the Lac Lemoyne carbonatite complex (7). It crosses the Lac Aigneau area, characterized by an impressive suite of ultramafic lamprophyre and carbonatite dykes (Berclaz *et al.*, 2001). This lineament corresponds to a high contrast zone on the gravity map, and marks the boundary between a high-density domain in the north and a lower density domain in the south. It may correspond to a major regional structure from a geotectonic standpoint.

The Dumarque-Vincelotte lineament (blue) is another important structure that extends for about 600 kilometres in a north-south direction, and is visible on both aeromagnetic and gravity maps. As opposed to the preceding lineaments, it is not associated with a known alkaline intrusion. However, it is worth mentioning that most of the terrains bordering this structure have not yet been mapped at a scale of 1:250,000, and that it is quite likely that alkaline intrusions could be discovered in its vicinity.

Four other lineaments associated with alkaline intrusions were interpreted (yellow). The Peters, Anuc and Loups Marins lineaments are characterized by important breaks in the magnetic trend on the aeromagnetic map, but they are not apparent on the gravity map. The Jérémie lineament, on the other hand, is visible on the gravity map, but not on the aeromagnetic map. These lineaments are classified in the “possible” category.

Finally, seven other possible lineaments (green) not associated with known alkaline intrusions are interpreted. The Petite Baleine, Grande Baleine and Bienville lineaments are interpreted from the aeromagnetic map, whereas the Berthier, Chavigny, d’Iberville and Laforge lineaments are interpreted from the gravity map.

Terrains bordering these large-scale lineaments represent favourable areas for the discovery of kimberlites, particularly at the intersection of two or more lineaments. The area at the boundary of map sheets 24E and 34H (Lac Natuak area) is particularly interesting as it corresponds to the

intersection of three of the four principal structures interpreted (Lestage-Messin, Bacqueville and Nedlouc), and it is directly adjacent to the Lac Aigneau alkaline intrusive suite. We consider this area as a first-order target. The Lac Castignon area (NTS 24C) represents another interesting target; it corresponds to the junction of the Bacqueville and Vaujours lineaments, in the vicinity of the Lac Castignon carbonatite complex (8), and it falls within the Saindon-Cambrien corridor.

ASSESSMENT OF THE KIMBERLITE DISCOVERY POTENTIAL IN THE LAC AIGNEAU AREA (24E)

The area selected to produce the first kimberlite discovery potential map is the Lac Aigneau area. The main reason behind this decision lies in the discovery, during the 1999 summer mapping program, of numerous carbonatite and ultramafic lamprophyre dykes, some of which are compositionally very similar to kimberlites (Berclaz *et al.*, 2001). It is also an interesting study area since it lies in the vicinity of the triple junction of the Lestage-Messin, Bacqueville and Nedlouc structures.

In addition to the major crustal lineaments, the assessment model brings into play two other parameters (Labbé and Lacoste, in preparation). The second parameter of the model takes into account local brittle faults (a few tens of kilometres) that represent a superficial porosity and may control the position of individual kimberlite pipes. These faults are interpreted from the aeromagnetic map and the LANDSAT image at a scale of 1:250,000. Brittle faults indicated on the geological map as well as Proterozoic diabase dykes are also integrated into this parameter. In this case, faults associated with alkaline intrusions are given a higher rating than those who are not. The third parameter deals with signs of kimberlitic volcanism. Studied aspects include: discrete magnetic and electromagnetic anomalies, geochemical anomalies in the secondary environment (lake sediments, tills, stream sediments), geomorphology (small rounded deep lakes), indicator minerals in till, and finally, the presence of kimberlite itself. As opposed to the first two parameters that outline linear zones, this parameter generates discrete targets.

Figure 2 shows the results of the kimberlite model applied to the evaluation of the Lac Aigneau area. This map will soon be available in SIGÉOM, at a scale of 1:250,000. In this model, a buffer zone 20 kilometres wide is attributed to major crustal lineaments, which translates into wide bands observed in the south part of the map. Local faults are given a 1-km buffer zone; these clearly stand out on the assessment map.

TABLE 1 - Alkaline intrusions in western Nouveau-Québec. The location of each site is shown in Figure 1.

Site	Name	Lithologies	References
1	Lac Allemand pipes	Mafic and ultramafic carbonatite diatremes	Moorhead, 1989; Moorhead <i>et al.</i> , 1999
2	Lac Leclair Complex	Mafic and ultramafic carbonatite diatremes	Baragar <i>et al.</i> , 1992; Moorhead <i>et al.</i> , 1999
3	Lac Couture Carbonatite	Carbonatite dyke 3 m wide by 500 m long	Percival <i>et al.</i> , 1996; Skulski <i>et al.</i> , 1997
4	Des Ombles Syenite	Nepheline syenite intrusion about 5 km in diameter	Madore <i>et al.</i> , 2000
5	Briscot Syenite	Nepheline syenite intrusion about 5 km in diameter	Madore <i>et al.</i> , 2000
6	Lac Tasiat Syenite	Nepheline syenite intrusion about 2 km by 3 km in size	Percival <i>et al.</i> , 1995
7	Lac Lemoyne Complex	Syenite and carbonatite intrusions	Birkett and Clark, 1991
8	Lac Castignon Complex	Carbonatite and lamprophyre intrusions and volcaniclastic rocks	Chevé, 1993
9	Niaux alkaline Suite	Syenite and nepheline syenite intrusions several km in size	Thériault and Chevé, 1999
10	Lac Aigneau Suite	Numerous ultramafic lamprophyre and carbonatite dykes	Berclaz <i>et al.</i> , 2001; Moorhead <i>et al.</i> , 2000

Five prospective areas are identified (figure 2). Zone 1 represents a vast area of about 1,000 km² that corresponds to the zone where the Lestage-Messin, Bacqueville and Nedlouc lineaments converge. Zone 2 corresponds to the intersection of local structures within the buffer zone of the Bacqueville structure. In the assessment model, a lake sediment sample is considered to be anomalous and potentially indicative of kimberlitic volcanism when its Cr content exceeds 37 ppm, its Ce content exceeds 175 ppm and its Ba content exceeds 140 ppm (according to a study by Beaumier in Moorhead *et al.*, 2000). A lake sediment anomaly of this nature is noted 3-4 kilometres SE of this intersection zone. Zone 3 is highlighted by a circular magnetic anomaly less than one kilometre in diameter straddling an important local fault along the margin of the Nedlouc structure buffer zone. Zone 4 corresponds to a circular magnetic anomaly (< 1 km) overlapping the intersection of two local structures. Finally, Zone 5 marks the intersection of three important local faults. This area is however located a fair distance (about 40 kilometres) away from major regional lineaments.

The assessment of the kimberlite discovery potential of this area would be greatly improved by the presence of high-resolution aeromagnetic data or data on diamond indicator minerals in till. Isolated magnetic anomalies were interpreted from a regional aeromagnetic survey with flight lines spaced every 800 metres (Lamothe *et al.*, 1993). We believe that the prospective areas we outlined warrant further attention. They represent good targets for exploration programs involving high-resolution aeromagnetic surveys as well as studies of diamond indicator minerals in till.

CONCLUSION

Diamond exploration in this part of Nouveau-Québec is still in its infancy, despite the fact that this vast region is underlain by an Archean craton, which represents a very favourable setting for kimberlites. We believe that the two maps presented herein will prove useful in establishing an exploration strategy for diamonds in northern Québec.

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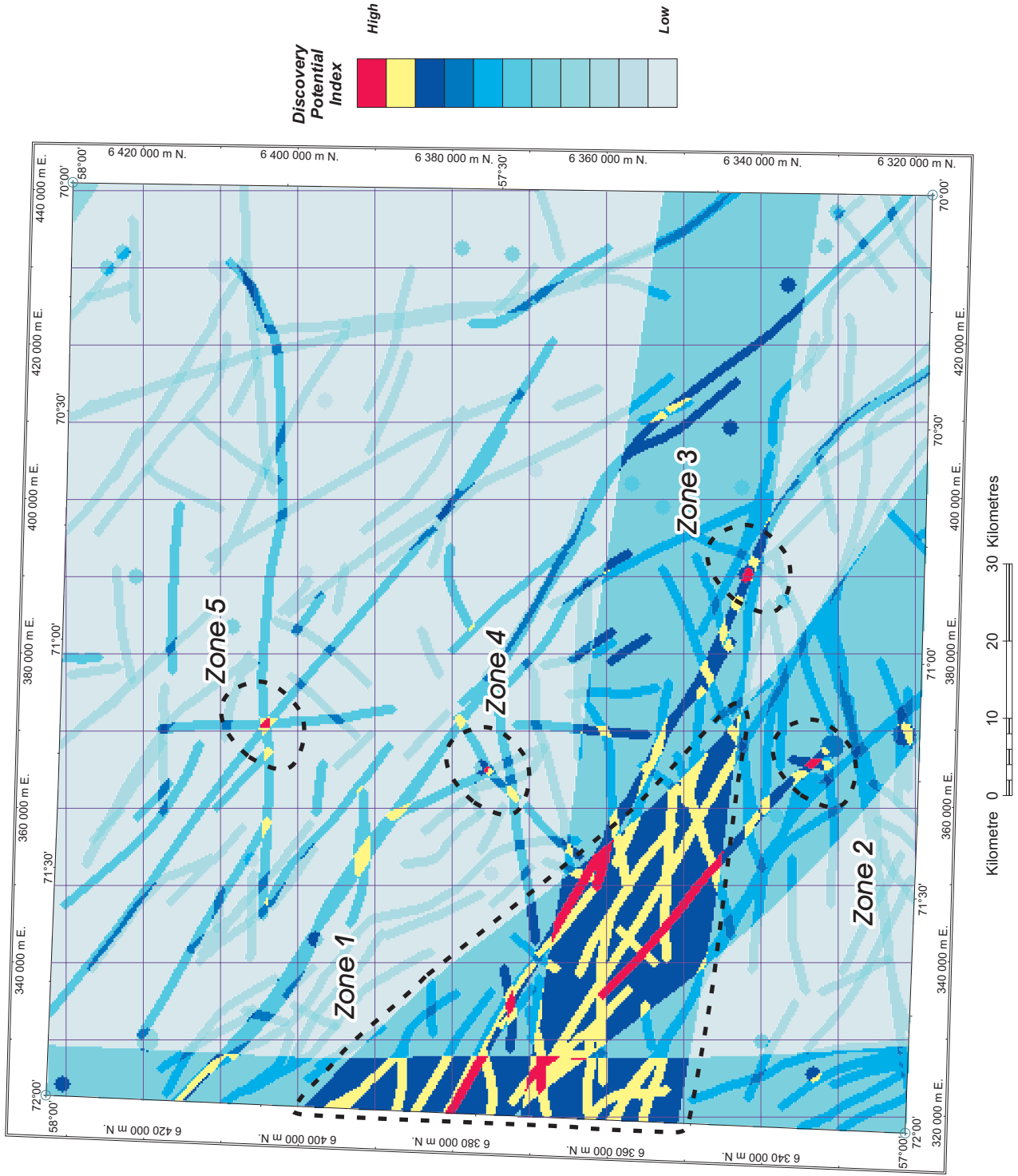


FIGURE 2 - Kimberlite and lamproite discovery potential for the Lac Aigueau area (24E) and location of the five favorable zones identified.

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DOCUMENT PUBLISHED BY « GÉOLOGIE QUÉBEC »



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Translation into English

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Document accepted for publication : 2001/02/15

March 2001