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# REMOTE SENSING ON MOBRUN MINE, ABITIBI, QUEBEC CANADA: CORRELATION WITH FIELD DATA FOR THE RECOGNITION OF SYN- AND/OR POST-VOLCANIC STRUCTURES CONTROLLING BASE METAL MINERALIZATION.

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The purpose of this paper is to correlate LANDSAT-TM data and interpretation to structural field data in order to recognize syn- to post-volcanic structures that could be at the origin of the Mobrun mineralizations.

Mobrun is a 25 million tons polymetallic mine (Zn, Cu, Ag, Au). The mine lies within the volcanic rocks of the Blake River Group in the Abitibi Greenstone Belt, which is part of the Superior Province (Canadian Shield). The Blake River Group is bounded by three major structures: the Larder Lake-Cadillac fault, the Porcupine-Destor fault and the Lac Parfouru fault. The mine is located only few kilometers S-W of the Lac Parfouru fault. At the present time, the Mobrun mineralizations can be considered as a group of six orebodies spatially correlated with two tectonic zones: Mobrun tectonic zone (N110° - N290°) and North Briar zone (same trend). Host rocks belong to several facies of rhyolite.

Remote sensing has been done regionally (1:50 000) and locally (1:15 000) using LANDSAT-TM data image analysis system. At regional scale, structural domains have been outlined. At local scale, lineaments were classified by means of their geographical extent and their surface expression. They were grouped into families of same directions or trends.

Successive shear zones (N110° - N290°) containing mineralizations can be represented on the surface as second-order local lineaments; these shear zones are late to post-volcanic structures. Spatial relationship between orebodies in both tectonic zones shows an alignment that could be a syn-volcanic structure. The presence of some second-order lineaments (N340°) nearby would confirm this hypothesis.

Therefore, base metal mineralizations could be correlated to syn- and/or post-volcanic structures. Lineaments interpretation and classification can be a valuable tool to define areas of potential base metal concentrations, as effective as it is for gold mineralization.

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## 1. INTRODUCTION:

The purpose of this paper is to correlate LANDSAT-TM data interpretation to geological field data in order to recognize syn- to post-volcanic structures that could be at the origin of Mobrun mineralizations.

The Mobrun polymetallic orebody (Zn, Cu, Au, Ag) is located 34 km. North-East of Rouyn-Noranda, Quebec, Canada (see figure 1). More than 28 millions tons of sulphides make Mobrun one of the most important mine in the Rouyn-Noranda mining camp. Two distinct orebodies define the mine: the MOBRUN lens (main lens plus 850, 870 and 930 orebodies) and the 1100 lens.

### 1.1 REGIONAL GEOLOGY:

Mobrun mine lies within the volcanic rocks of the Blake River Group (BRG) in the Abitibi Greenstone Belt (AGB), which is part of the Superior structural provine (Canadian Shield). The BRG is one of the most important volcanic complex in the AGB, since it contains some other important massive sulphides deposits such as Horne (54 millions tons) and Quemont (15 millions tons). It is bounded by three structures : the Larder Lake-Cadillac fault (South), the Porcupine-Destor fault (North) and the Lac Parfouru fault (East), the latter cutting the BRG in half-lozanges (Hubert and al., 1984).

Two phases of deformation are featured in this area: (1) D1 results from the development of fold axes and foliation NW-SE (Hubert and al., 1984) and (2) D2 results from inverse faulting, fold axes and sub-vertical E-W foliation (Hubert and al., 1984). Volcanic rocks from the BRG are characterized by tholeiitic and bimodal (andesite-rhyolite) calc-alcaline sequences. The bimodal sequences are closely related with the massive sulphides formations.

Massive sulphides orebodies from the BRG were all interpreted as exhalative volcanogenic mineralizations with stratigraphic controls where some were located in syn-volcanic structures (Knuckey and al., 1982). Recently, Gibson and Watkinson (1990) suggested that syn-volcanic structures could control the localization of volcanic domes and, consequently, the concentrations of sulphides.

### 1.2 GEOLOGY OF THE PROPERTY:

Mobrun is located near the NE margin of the BRG, South of Lac Parfouru fault, which cuts the BRG rocks from the Kewagama Group rocks.

Geology of the property (see figure 2) shows some facies of rhyolites and andesites, some pyroclastics and, finally, some sediments. The schistosity and the strike of the formations are oriented NW-SE, dipping from sub-vertical to either the North or the South. The regional schistosity results from the first phase of deformation D1. The property is crossed by five shear zones N110°-N290°, delimiting monoclinal volcanic sequences with the polarity to the North (Riopel and al., 1991a). From the five shear zones, three are representing ductile tectonic zones named Mobrun, North Briar and Copper Hill. Mobrun and North Briar tectonic zones contains the massive sulphides orebodies and the Copper Hill one contains several chalcopyrite veins (Riopel and al., 1991a). The 850, 870 and 930 orebodies are crossed by N-S dextral shear zones, which have great influence on stratigraphy (Riopel and al., 1991B). Mobrun main lens is included in mylonitic rocks developped by the Mobrun tectonic zone (Riopel and al., 1991b). Host rocks are sericite schists (felsic rhyolite and pyroclastite). The massive sulphides are tabulary and conform to the foliation and the lithological contacts. Economic minerals (chalcopyrite, sphalerite and galena) show late textural relations within the deformation evolution (Riopel and al.,1991b).

## 2. IMAGE ANALYSIS METHODOLOGY:

### 2.1 DATA:

The reflectivity data come from LANDSAT-TM scanner. A lot of attention has been allowed to the time of image acquisition. The surface expression of geological features in the Abitibi area is very sensitive to the different surface covers, depending on the season. Because there is snow in winter, thawing water in spring and deciduous vegetation in summer, fall images are likely to be the most effective for geology under such surface morphology.

### 2.2 IMAGE ANALYSIS:

Some phases of image analysis have been done on the data. First, a band combination was chosen in order to have the most effective image for surficial expression of geological features. Bands 4, 5, and 7 (in red-green-blue order) have proven to be the best bands for such a work, not only for Mobrun, but for the whole Abitibi area, where surficial deposits and vegetation are hiding the geological informations.

Then, interactive contrast stretching has been done either on each band individually and on the band combination in order to have the maximum amount of information from each band. Then, resampling by cubic convolution has been done for the LANDSAT-TM data and provided a 10 m.pixel. The reason for this is to be able to generate images at 1:15,000 that can be usable for lineament study.

Next, a number of different shaded images have been generated from the data. The software used for shadow generation is very "RADAR-oriented" since one can change interactively (and in real-time) the direction of illumination, the inclinaison and the contrast. Slope scale factor and cutoff can be ajusted in order to have an image on which the interpretation is highly correlated with one done on SAR images of the same scale. The different directions of illumination allows to define the best direction for enhancing lineaments of a particular trend. The interaction between the false-colour image and the shaded images interpretation is important as explained in the next section.

## 3.0 INTERPRETATION METHODOLOGY:

### 3.1 LINEAMENT CONCEPT:

The lineament notion exists since 1903, well before the advent of satellite and image analysis. Through the century, as especially through the '70s (when lineament studies were in vogue), there have been a lot of discussions concerning what was a lineament. The settlement for a lineament definition is important, since it is strongly influencing the interpretation. This study is done along the following definition: a lineament is a simple or complex linear feature, detected on surface, which different portions, aligned according a straight line or a curve, stand out distinctively from their surrounding, and reflect possibly a phenomenon generated below the surface (O'Leary and al., 1976).

### 3.2 LINEAMENT CLASSIFICATION:

The classification of lineaments has been presented by the authors in another study (Carboni and al., 1989). This classification is based on the fact that the lineaments do not have the same surface expression and therefore, they have to be mapped differently. The purpose of this classification is to characterize and to group the lineaments susceptible to represent one or many specific geological features as to facilitate their interpretation.

Thus, lineaments are classified according to their geographical extent, their surface expression and their preferential directions.

In any image, there are features of different lenghts. Some lineaments are longer, representing important structures or lithology contacts while other are smaller, like the subsidiary structures to major faults. For the need of this study, lineament that have been observed and interpreted from 1:50,000 scale image are called regional lineaments. The ones that come from 1:15,000 scale image are called local lineaments.

The same notion apply to surface expression of lineaments. Some are expressing clearly while other stand out in a more subtle fashion. Lineament classification retained here is related to the image analysis phases of section 2.2. Lineaments coming from images that have undergone band combination and contrast stretching are called first-order lineaments. They usually represent major structures of strong surface expression or geological features located near the surface. Lineaments coming from the various shaded images are considered as second-order lineaments, because complex processing of data is necessary to be able to interpret them. Usually, they represent subtle geological features on surface or more important features located deeper in the sub-surface.

In geology, regional and local strains rarely generate one lonely structure but a trend, composed by a certain number of structures. Accordingly, the lineaments are grouped into families of the same trend. This means that lineaments of a particular direction coming from a particular fracturation event would be grouped into one single family.

In conclusion of this section, lineaments will be claasified as first-order regional, second-order regional, first-order local, second-order local lineaments with numerotation of trends for better visualization.

## 4.0 INTERPRETATION

### 4.1 REGIONAL LINEAMENTS:

Figure 3 shows the interpreted first and second-order regional lineaments from 1:50,000 scale images. Within the area of interest, lineament 10 represents a lithology composed of sediments and lineament 11 is the contact between andesite and rhyolite.

Lineaments 12 and 13 are considered to be part of a regional conjugate patern with the 20 family lineaments, which features lineaments 20 to 24. Lineament 21 is considered as a reidel of lineament 20. All these lineaments, of first and second-order represent the late fracturation and they have little or no relation with the base metals concentrations. However, if gold was the explored mineral, these lineaments would be of great interest.

## 4.2 LOCAL LINEAMENTS - LATE FRACTURATION:

Figure 3 shows the interpreted first-order local lineaments with the second-order lineaments but only of the same trend (meaning that other second-order trends will be presented later) These lineaments are of two main directions, N320° and N070°. They are the local counterpart of the regional lineaments: they represent a very well developped local conjugate fracturation pattern which is late fracturation relatively to the deformation that caused mineralization. The NW structures are dextral while the NE are senestral, according to the regional compression pattern found in the whole Abitibi area (compression coming from the North and the South).

## 4.3 SECOND-ORDER LOCAL LINEAMENTS - LATE TO POST-VOLCANIC FRACTURATION:

Figure 4 shows the second-order local lineaments interpreted from two shaded images, as to enhance lineaments of particular trends. Field evidences conducted the most interesting structures to look for and processing have been done to maximize the enhancement of known features related with the mineralizations.

One particular shaded image lead to the interpretation of the 30-family lineaments. They have the strongest expression on all shaded images generated. In fact, these N-S lineaments represent the late fracturation (shear zones) that are displacing either the stratigraphy and the different orebodies. Lineaments 36 and 38 are known shear zones from field cartography. The rest of these N-S lineaments are suggeting N-S structures of the same trend. They are of importance if one wants to follow adequatly the mineralization in the neighborhood of the orebodies.

Another particular shaded image enhanced the 40-family lineaments, of direction N110°.

They are suggested to be late to post-volcanic structures, since field observations showed that there might have been mobilization within structures during the deformation event D1 (Riopel and al., 1991b). These structures are thought to be reactivated by a post-volcanic fracturation event. Lineament 43 is correlated with a suggested tectonic zone defined from field observations (Riopel and al., 1991b). Lineaments 44 and 45 correlate with the two main orebodies, repectively the Mobrun and the 1100 lens. Finally, lineament 48 seems to be the surface expression of Copper Hill tectonic zone. The other lineaments of this family could be the eastern extention of the tectonic zones. Riopel and al.(1991a), pointed out that orebodies were located along two systems of lens of N110° and N320° directions.

One final shaded image gave three important directions of lineaments (figure 5). The first trend, the 50-family lineaments (N320°) is thought to be syn-volcanic and then reactivated by late fracturation. The reason for this is because they seem to control the localization of orebodies (lineament 50 for the main orebody, lineament 51 for the 1100-lens). They seem to be related to the 60-family lineaments (N110°) which preferential direction is comparable to the 40-family lineaments. Here, these suggested structures are controlled with late to post-volcanic field structures, controlling the mineralization and modifying it substantially: the N320° oriented orebodies are changing in places to N110° (or N290°) orientations. Lineaments 61 and 62 are showing this fact very cleary. Finally, the 70-family lineaments (N340°) differs from the N-S late fracturatyion pattern. Because of the fact that they are actually linking orebodies along their extention, they are suggested as syn-volcanic controlling structures, through microfractures and percolation. It should be mentionned here that no field evidence has been observed to substain this last suggestion.

A geostatistical model has been applied on the late fracturation lineament families. The purpose of this study is to estimate the regional compression direction and to use a proxy variable simulating the fracturation intensity as a regional metallotect. As a first step, the area has been divided into cells of 500m·* 500m. A proxy variable have been defined, that is the number of lineaments N110° and N340° passing through each cell. The variograms have been calculated all over the plane and an experimental model has been fitted for each family. The calculated variograms for both lineament families show distinct anisotropies. For the N110° family, a N045° direction is estimated to coincide with the regional compression direction as the variogram shows a non-stationnary behaviour.

For that direction, the variance is depending on a local stationnary component and a quadratic trend associated with the regional compression direction, contributing to the non-stationnary component of the observed variance. By doing the same exercice for the N330° direction, we obtain the N060° direction that estimates the regional compression direction at the Mobrun mine site, that is around N030°.

Finally, the proxy variables (N110° & N330°) have been kriged all over the area and a combined estimate from the two separate kriged families has been provided and represents the whole intensity fracturation process related to late fracturation. The contours of the combined estimate is represented on figure 5.

## 5. CONCLUSION

Remote sensing using LANDSAT-TM data has proven to be a valuable tool not only to correlate the interpretation (lineaments) to structural field data but also to suggest other geological features of different nature. In particular, classification of lineaments has proven to be an effective method to separate several different trends of structures.

In fact, the interpretation methodology is almost the same as the way geologists work on the field. With regards to structures, the geologist sees more distinctively the results of the latest fracturation event. Then, in order to define older patterns, a very attentive image observation and interpretation is needed to define late and even syn-volcanic structures.

In the Abitibi area, more and more massive sulphides are considered to be structurally controlled by syn-volcanic structures. Remote sensing has been a very useful tool to define late fracturation by the interpretation of first-order lineaments. Now, it can be as effective for base metal exploration, through the interpretation of second-order lineaments, based on a solid theoretic and/or empirical mineralization model.

## 6. REFERENCES

Carboni, S., Moreau, A., Britt, C. 1989. Remote sensing and data integration for targeting stratabound gold mineralization in glaciated terrain: a case-study from Atikokan area, Ontario, Canada. in. Proceedings of the 7th Thematic Conference on Remote Sensing for Exploration Geology, Calgary, Alberta, Canada, October 2-6 1989, pp. 1239-1252

Gibson, H.L., Watkinson, D.H., 1990. Volcanogenic sulphide deposits of the Noranda cauldron and sheild volcano, Quebec. in. The Northwestern Quebec Polymetallic Belt, M. Rive and al. (eds.) Canadian Insitute of Mining and Metallurgy, Special Volume 43, pp.119-132.

Hubert, C., Trudel, P. & Gélinas, L.,1984. Archean wrench fault tectonics and structural evolution of the Blake River Group, Abitibi Belt, Quebec. Can. Journ. Eart. Sci. no.21, pp.1024-1032.

Knuckey, M.J., Comba, C.D.A & Riverin, G., 1982. Structure, metal zoning and alteration at the Millenback deposit, Noranda, Quebec. in. Precambrian Sulphide Deposits, H.S. Robinson Memorial Volume, R.W Hutchison and al.(eds.) Geological Association of Canada Special Paper 25, pp.255-295.

O'Leary, and al., 1978. Lineament and linear, a terminological appraisal. in. Proc. of 3rd Conf. on Basement Tectonics, Delaware,USA, Podwyscki, M.H. & Earle, J.L. (eds.) pp. 571-577.

Riopel, J., Hubert, C., Cattalini, S. & Barrett, T.J., 1991a. Geologie, structure et géochimie du gisement Mobrun, Noranda, Québec. MER Québec, rapport MB (under press).

Riopel, J., Hubert, C., Cattalini, S., Brown, A.C., Barrett, T.J., Hoy, L., 1991b. Structure, gîtologie et géochimie du gisement Mobrun, Noranda, Québec. MER Québec, rapport ET (under press).

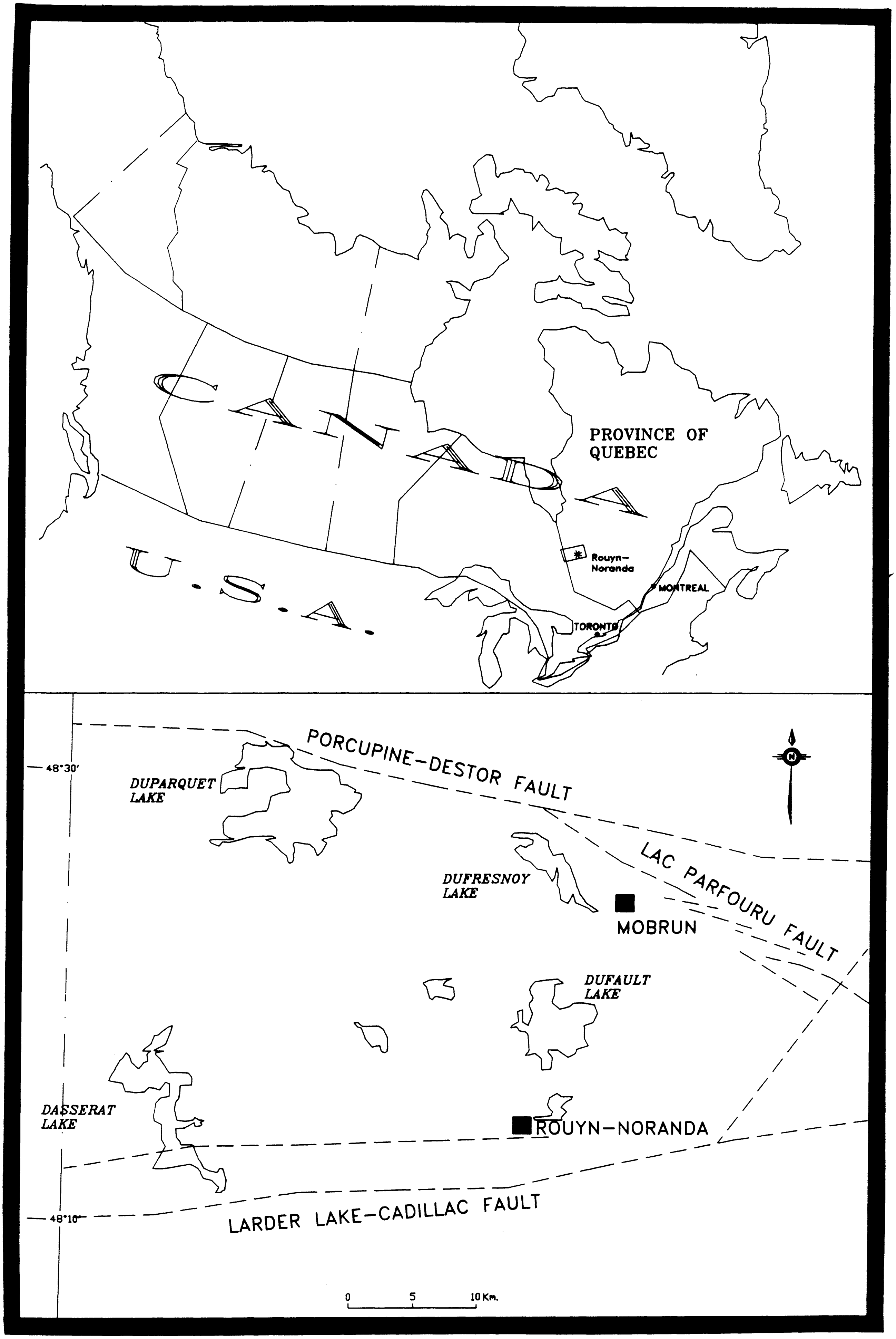

FIGURE 1: (TOP) LOCALIZATION OF MOBRUN MINE IN CANADA (BOTTOM) GEOGRAPHICAL AND GEOLOGICAL LOCALIZATION ON MOBRUN MINE IN THE ABITIBI AREA.

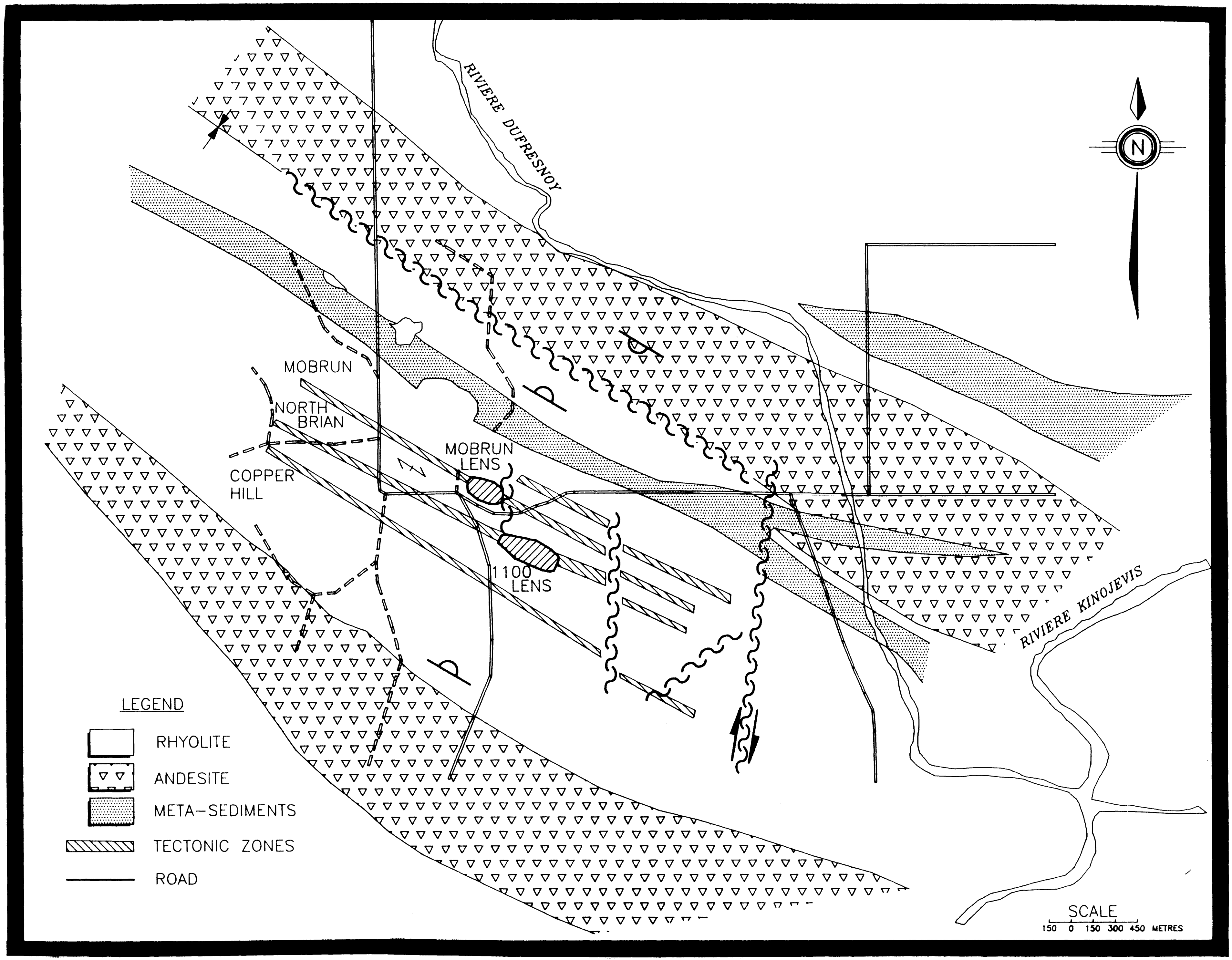

FIGURE 2: REGIONAL GEOLOGY OF MOBRUN MINE PROPERTY
(MODIFIED FROM RIOPEL AND AL. 1991a)

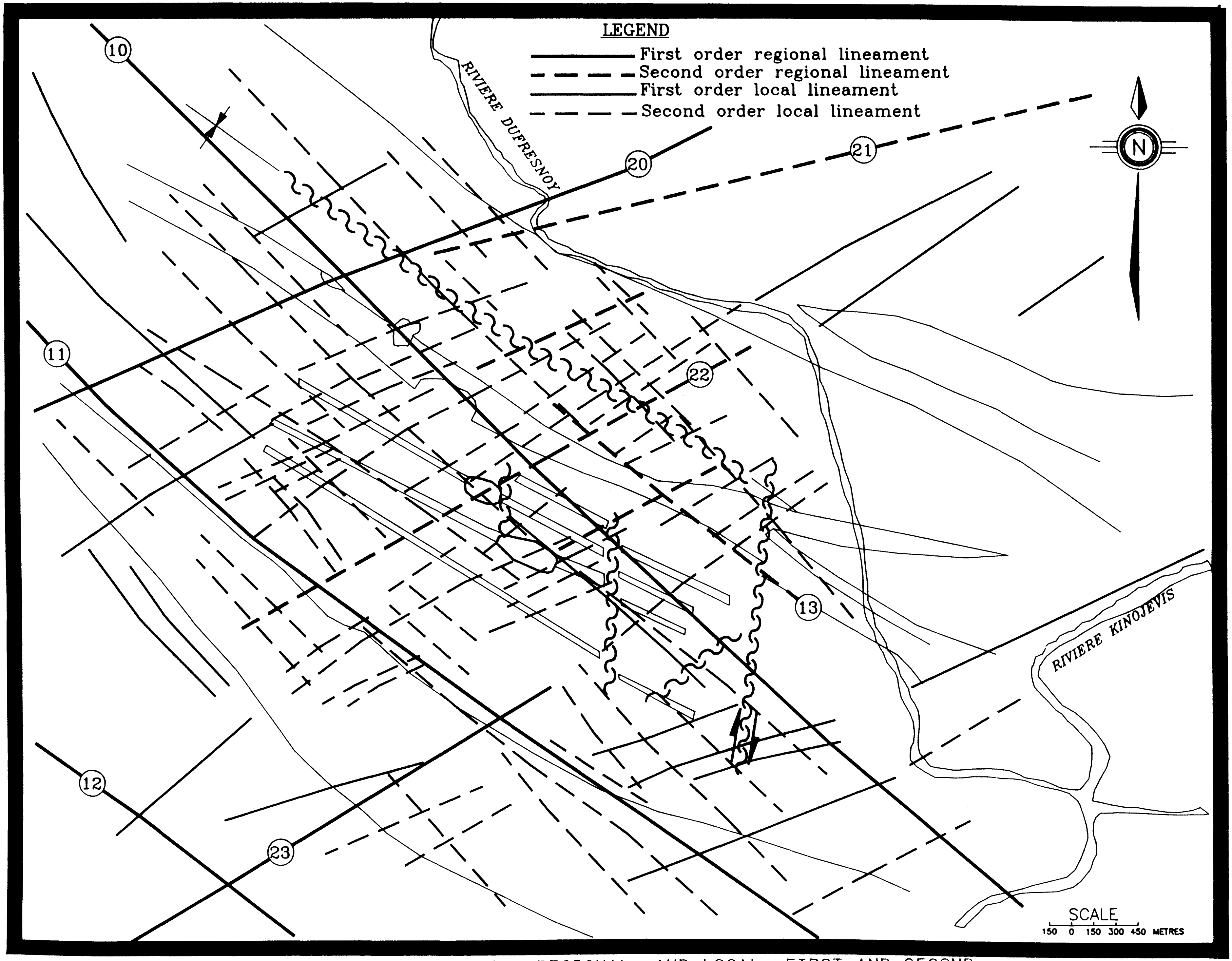

FIGURE 3: POST-VOLCANIC REGIONAL AND LOCAL, FIRST AND SECOND-ORDER LINEAMENTS.

FIGURE 4: SECOND-ORDER LOCAL LINEAMENTS INTERPRETED FROM SHADED IMAGES.

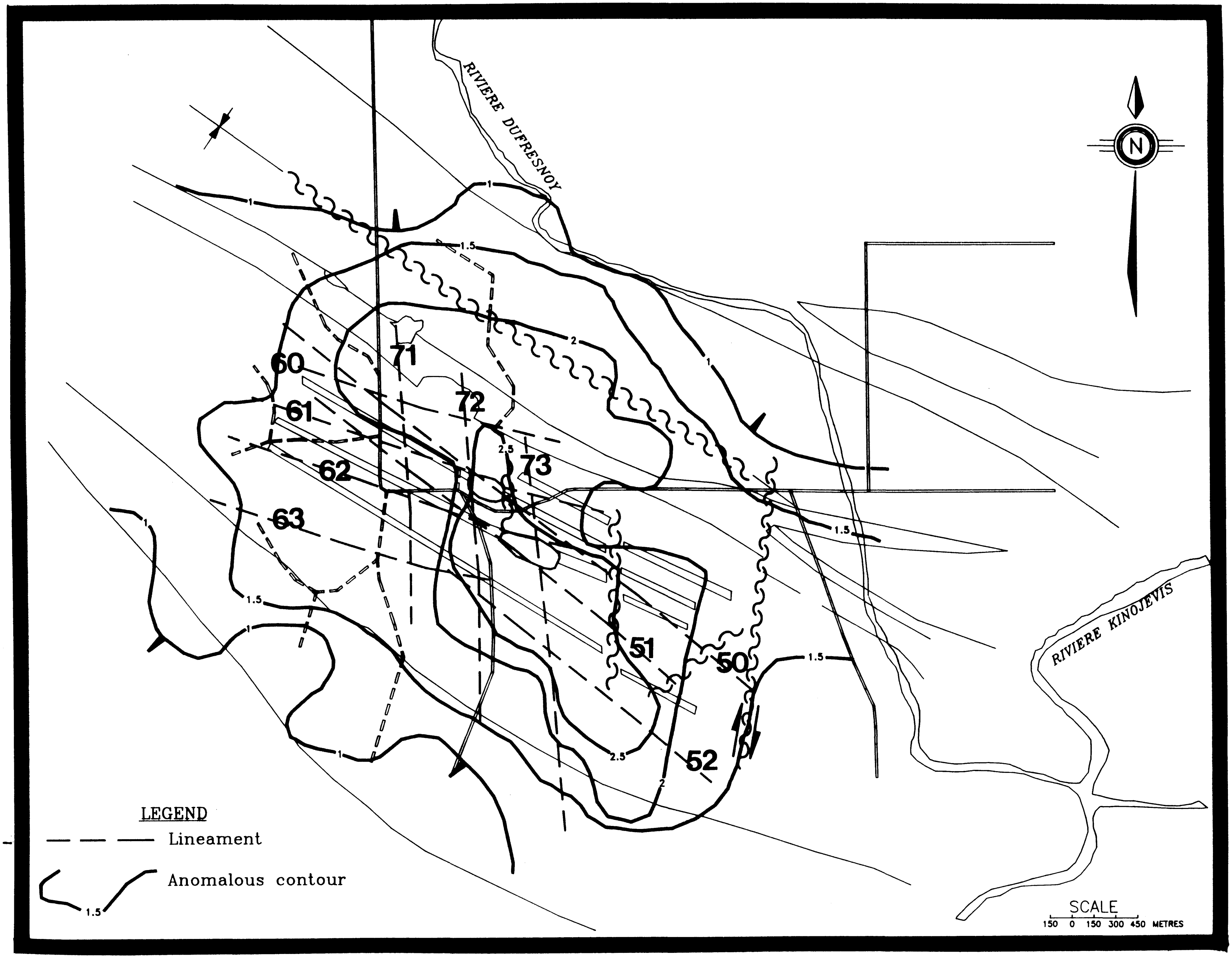

FIGURE 5: SECOND-ORDER LOCAL LINEAMENTS INTERPRETED FROM A DIFFERENT SHADED IMAGES THAN FIGURE 4.