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Peat Landforms Along The Albany River, Northern Ontario

A Progress Report for:

An Ecologic Study of Peat Landforms in Canada and Alaska

by

Paul H. Glaser

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University of Minnesota

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During the summer of 1985 field work was started in the Hudson Bay lowland region of northern Ontario. The Hudson Bay lowlands represent the largest expanse of peatland in North America and an important sink in the global carbon cycle. A key area in the lowlands is situated along the Albany River near the confluence he Chepay River. Here the striking vegetation-landforms are transitional between those found on the bed of Glacial Lake Agassiz in northern Minnesota and southern Manitoba and the more northern peatlands in the Hudson Bay lowland region (Glaser & Janssens in press). In peatland studies elsewhere the landform patterns have been used not only to classify different peatland types but also as an indicator of potential developmental trends (Glaser et al. 1981; Glaser 1983).

The study area is generally defined by the area covered by the TM scene E-40062-15532 taken on Sept. 16, 1982. The purpose of the field work was to acquire sufficent information to interpret the TM imagery and test various hypotheses on peatland development on the basis of the pattern transitions. The objectives of the field work were fourfold: 1) to level at least one large bog to determine the relationship of the surface pattern viewed on a TM image to surface elevation and subsurface topography, 2) to collect peat cores to the mineral substratum to determine accumulation rates of peat and to test various hypotheses on the development of the surface patterns, 3) to determine the relationship of the vegetation to the landform patterns, and 4) to determine the water chemistry as a indicator of hydrological conditions. The sampling plan was based on using the striking vegetation-landform patterns as an important indicator of both ground conditions and potential developmental trends.

Prior to field work a trip was made to the National Air Photo Library in Ottawa to review aerial coverage of the Hudson Bay lowlands and select photos for field work. Field work was conducted between July 27 and August 15 from a base camp along the Albany River. Access to the study sites was provided by a Hughes 500 jet helicopter, whereas all fuel and supplies were delivered by a beaver float plane. A base camp was established along the Albany River near the confluence of the Chemahagen River along the edge of a large raised bog. Thus we were able to conduct field work on days when it was impossible to fly because of bad weather or mechanical problems. The trip was led by Paul H. Glaser (principal investigator) and included Jan A. Janssens, John Almendinger, and Howard Mooers from the University of Minnesota and Roger Bissett from Rotor-Ways Ltd.

Surveying

A survey line was laid out with a transet on a large raised bog near the base camp (Fig 1). Surface elevations along the line were determined with an electronic level and peat depths were then determined by probing to the mineral substrate with a Davis peat sampler. Permanent benchmarks were established along the line for future reference. The methods used in this survey have previously been described by Almendinger et al (in press). The survey showed no close correlation between surface patterns on the bog and the topography of the mineral substrate. The bog surface is differentiated into water tracks that contained networks of pools and peat ridges oriented perpendicular to the slope. The size of the pools was related to the steepness of the surface gradient but showed no relationship to the topography of the mineral substrate, which was essentially flat. This survey supports the hypothesis of Glaser & Janssens (in press) that the development of pool patterns on bogs is a consequence of peat accumulation rather than topographic control by the mineral substrate. The survey line on this bog is directly comparable to a line established on a forested bog in the Red Lake peatland, which has a similar pattern of water tracks and ovoid bog islands.

Stratigraphy

A number of peat cores were collected down to the mineral substatum using Livingstone samplers specially modified for coring peat (Wright et al. 1983). The analysis of these cores is currently underway but a few observations are significant. First, cores taken from bog lakes in the southeastern portion of the study area are entirely composed of lake sediment confirming observations that the lake system in this area is part of large a glacial moraine that has been paludified and covered by ombrotrophic bog (Fig. 2). The lakes probably originated as kettle-hole depressions in glacial till rather than by degradation of peat. Second, cores taken from other bog lakes with degrading margins also contain lake sediment indicating that these lakes 1) are not formed by the melting of frost lenses within the peat and 2) have not recently formed by the corrosive oxidation of bog peat (Fig. 3-4). Third, cores from the nonforested bog near the base camp contain buried wood layers indicating that this bog was once forested as predicted by the model of bog development in Glaser and Janssens (in press). Fourth, permafrost was never encountered by probing or coring various peat landforms, and thus ground ice does not seem to play a role in the formation of the landform patterns in the Albany River area. The cores are now being sampled for dating by ^{14}C to determine accumulation rates. A pollen diagram will also be constructed from a lake core to determine the climate history of the area and help reconstruct the development of the peat landforms.

Vegetation

The vegetation in the study area was described by means of 64 releves that were collected within a 65 mile radius of the base camp. The range of the helicopter did not permit us to visit sites farther from camp but all the major types of patterns could be sampled within this area. The vegetation was exceptionally uniform in the study area and, the patterns were determined to consist of large relatively uniform stands of vegetation. The general uniformity and large size of the vegetation patterns greatly simplifies their interpretation from the small-scale TM imagery.

The releve data is now being analysed by detrended correspondence analysis to show the relationship of the vegetation to the major environmental gradients and the landform patterns. The vegetation patterns in the Albany River area appears to be much more unifrom than the vegetation of other patterned peatlands I have sampled in North America. This observation was unexpected because of the transitional nature of the vegetation-landforms in this area particularly the continuous gradients from forested to nonforested bogs (Fig. 5) from firm dry hummocks to deep pools of water. The bog flora and vegetation in the study area nevertheless had a lower diversity than that found farther north along the Attawapiskat River (Sjors 1963) or farther east in Labrador (Glaser & Foster 1984). The bog and fen vegetation, however, is also remarkably similar to patterns described in Minnesota (Glaser et al. 1981; Glaser 1983a).

Water Chemistry

Water samples were collected at each releve and also at other key sites. The samples were analysed for pH and specific conductivity at the end of each day and then filtered and acidified for future analysis of major cations. These analyses are now being performed by Donald I. Siegel at Syracuse

University. The pH and conductivity values fall within the ranges expected for the different vegetation assemblages of bog and fen. However, vegetation very similar to the extremely-rich fens of Minnesota (sensu Glaser 1983b; Glaser unpubl.) had a much lower pH in the Albany River region.

Origin of Solutes

In the largest peatlands of the world the source of alkalinity in the fen waters is unclear unless there is an obvious outcrop of mineral soil. Peatland ecologist have generally assumed that groundwater cannot discharge through deep layers of highly decomposed peat and therefore a peatland should become more nutrient poor as peat spreads over a landscape. The TM scene of the Albany River region shows only small isolated areas of mineral in the study area and a correspondingly small area of minerotrophic fens. Many fens, however, arise in areas where there is no apparent surface source for ions leached from mineral soil. Thus the source of alkalinity in these fens is problematic.

The water chemistry and landform patterns in the Albany River indicate two potential sites for groundwater discharge similar to those documented in Minnesota peatlands by Siegel et al (submitted). One potential site are lakes with degrading margins that are visible on TM imagery and aerial photographs (Fig. 3-4). These lakes are surrounded by ombrotrophic bog except at the lake margin and along small tracks draining downslope from the lake. No rifts were detected in the stratigraphy of these lakes, which are apparently foci for groundwater discharge from the underlying mineral soil. The poorly minerotrophic water in these lakes probably indicates significant mixing of the groundwater with precipitation and bog waters draining from the surrounding bog.

The other potential source of groundwater discharge are series of small water tracks that arise on the flanks of the southwestern moraine system (Fig. 2 & b). The vegetation in these channels is very similar to that found in the the spring-fen channels in Minnesota, which have been demonstrated to be in discharge areas for groundwater (Siegel et al. submitted). The moraine system itself, however, is covered almost entirely by ombrotrophic bog except for the large number of kettle-hole lakes and outcrops of moraine. Thus the discharge of groundwater from calcareous till under the peat is probably the source for the alkalinity in these tracks rather than surface runoff leaching of cations from mineral soil

The relative size of bogs to fens in the study area is probably directly related to the flux of cations in surface drainage because the growth of Sphagnum is arrested by waters with high pH and Ca^{2+} concentrations. A quantitative estimate of the relative area of these two landforms in each watershed is being made with a digital planimeter.

Vegetation-Landforms

In contrast to terrestrial areas the vegetation in patterned peatlands is composed of remarkably uniform stands of vegetation that are shaped in the form of striking landform patterns. In the peat covered landscape of the Hudson Bay lowlands these peat landforms are of sufficent size to be clearly visible on TM imagery. The very close relationship of the landform patterns to the vegetation and water chemistry indicates that the TM imagery can be used to precisely predict field conditions. In the Hudson Bay lowlands the very large size of the landform patterns and the nearly continuous peat cover makes the scale of the TM imagery essential for interpreting the development of these landforms relative to the surrounding landscape.

The only cloud-free TM scene for this area was taken at the end of the growing season on September 16, 1985. I hope to obtain a better quality image of this scene but an enlargement of the existing image was adequate for selecting sites and navigating in the field. Most of the vegetation landform patterns visible on the larger scale aerial photographs are also discernable on this TM scene despite its less than optimum quality.

Bog Patterns

This scene demonstrates that the majority of the study area consists of ombrotrophic bog. These areas are recognizable on the TM imagery by means of their 1) lighter tones indicating a high cover of <u>Sphagnum</u> and lichens 2) the oriented pattern of pools or trees indicating a raised surface topography, and 3) sharp streamlined margins where the bogs are bordered by water tracks.

The TM images show a clear transition from partially forested bogs in the southwestern portion of the study area to nonforested bogs with intricate pool patterns farther north or east (Fig. 5 & 7). Bogs with very large pools occur near James Bay indicating a potential climatic effect on pool development. However, the transition from forested to nonforested bogs with pools in the Albany River area provides support for the hypothesis that forest cover represents an early stage of bog development that is replaced in time by a nonforested surface with pools as peat accumulates and inhibits runoff and infiltration (Glaser & Janssens in press).

The other major bog pattern are narrow water tracks that arise within the middle of an apparently ombrotrophic (exclusively atmospheric-fed) raised bog (Fig. 8 & 9). These water tracks are ubiquitous features on all the bogs in the Albany River area confirming earlier assumptions (Glaser <u>et</u> <u>al</u>. 1981; Glaser 1983) that these water tracks are part of basic mechanism of bog development. On the ground the water tracks begin as apparently ombrotrophic pools in which the water chemistry is indistinguishable from that of the surrounding bog. Only the occurrence of <u>Menyanthes</u> <u>trifoliata</u>, a fen indicator species in Minnesota may indicate a slight minerotrophy. However, downslope the water tracks grade into minerotrophic patterned fens in a fashion similar to that found in Minnesota. The water tracks in the Albany River area also fragment the lower flanks of the bog into ovoid bog islands in a sequence very similar to that found in Minnesota. This pattern transition has been interpreted as part of a developmental by Glaser <u>et</u> <u>al</u> (1981). The continuity of this pattern type across such a large area strongly indicates a common developmental pattern for bogs in this region. The TM imagery, however, indicates an increasing frequency of these internal water tracks toward the north, which breaks the bog into smaller bog islands (Fig. 5,7, & 9). It is not clear at present whether this geographic trend is related to climate, isostatic rebound affecting groundwater flow patterns, or a developmental sequence.

Fens

The area of minerotrophic fens in the Albany River was unexpectedly small. The largest fens occur downslope from the moraine complexes and may be fed by groundwater discharge. The flanks of these moraine complexes contain a series of narrow water tracks with vegetation and water chemistry very similar to that found in the spring-fens of northern Minnesota. These fens consist of nonforested channels that are sharply delimited from the surrounding forest and by fields of tree islands oriented parallel to the prevailing slope. The pH readings in these channels were, however, significantly lower than those found in Minnesota.

The spring-fen channels feed into large swamp forests that have no surface patterning. On the TM imagery these areas show up as dark grey blocks because of their nearly continuous cover of Larix laricina and occur near the headwaters of various tributary streams that are eroding headward into the peatlands. The vegetation and water chemistry in these areas is very similar to the large areas of swamp forest in Minnesota but the absence of surface patterning is unclear.

An analysis of the TM image indicates that these swamp forests may be an initial stage of paludification in the lowlands and are replaced by large raised bogs as peat accumulation isolates the surface from alkaline drainage. The support for this hypothesis is twofold. First the area of featureless swamp forest increases near James Bay where the land surface has more recently emerged from the sea. In Quebec Dionne (1979) has shown that basal peat dates become progressively younger toward Hudson/James Bay, and that approximately 1000 years elapsed between land emergence from the Tyrell Sea and paludification. Because of the limited range of the helicopter it was not possible to collect cores on a similar transect in our study area. The field sampling of these swamp forests was also restricted by the continuous tree cover, which made it impossible to land. Second, large triangular bogs seem to be expanding over the swamp forest. These bogs have partially covered nearby tributary streams and contain radiating forest patterns that are presumed to be immature bogs according to the hypothesis of Glaser & Janssens (in press).

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Figure Captions

Figure 1. A large raised bog along the Albany River. The bog surface is marked by conspicuous systems of pools (1) that partially obscure the pattern of water tracks (2) and ovoid islands (3). The direction of water flow is indicated by arrows and can be determined by the shape of the pools, which are oriented perpendicular to the slope. This bog is located near the base camp along the Albany River. The aerial photograph measures 15 km across.

Figure 2. Bog and fen patterns along the Seseginagow River. The moraine complex (1) in the lower left corner of the photograph has been partially covered by ombrotrophic bog leaving isolated remnants of mineral soil (2) at the surface and kettle-hole lakes with lake sediment (3). Spring-fen channels (4) drain from the crest of the moraine into a large featureless swamp forest (5). At the downslope edge of the swamp forest a triangular bog (6) has expanded over the swamp forest and a tributary stream (7). The aerial photograph covers an area approximately 16 km across.

Figure 3. Raised bog and water tracks along the Seseginagow River. The large bogs (1) are dissected by narrow water tracks (2) that convert the lower bog flanks into ovoid islands (3). One of these water tracks has expanded into a large lake (4) that drains eastward to a tributary stream (5). The margins of the larger bog-complexes are trimmed by large water tracks (6) marked by networks of pools and peat ridges oriented perpendicular to the slope. The photograph measures 16 km across.

Figure 4. Large Bog complexes along the Albany River. The light-toned bogs (1) are dissected by darker-toned water tracks (2) fragmenting the bog-complex into ovoid bog islands (3). One of these water tracks has expanded into a large lake from which several water tracks drain

downslope in a centrifugal pattern. The water tracks ultimately drain into tributary streams (4) at the downslope margin of the peatland. The photograph covers an area 16 km across.

Figure 5. A transitional bog along the Kenogomi River near Albany Forks. The large bog plain is indicated by the light tones on the photograph. The crest is marked by radiating forest patterns (1) to the east and systems of pools (2) to the west. Water tracks (3) originating near the crest of the bog fragment the lower bog flanks into large ovoid islands (4). The photograph measures approximately 16 km across.

Figure 6. Raised bogs and spring-fen channels on a moraine complex along the Albany River. The spring-fen channels (1) originate near the crest of the moraine and drain downslope into a large featureless swamp forest (2). The large light-toned areas are ombrotrophic bogs (3), whereas the darker toned ridges are outcrops of mineral soil (4). The photograph measures approximately 16 km across.

Figure 7. Raised bogs with large pool systems near Belec Lakes. The large raised bogs (1) are marked by light tones and streamlined margins where they are trimmed by water tracks (2). The bogs are fragmented by internal water tracks (3) and large pools systems (5). The peatland is drained by tributary streams (6). The photograph measures approximately 16 km across.

Figure 8. Raised bogs and water tracks near Belec Lakes. Series of internal water tracks (1) arise near the same source on a large raised bog in the center of the photograph. The adjacent water tracks (2) have networks of large pools and peat ridges oriented perpendicular to the slope. The direction of water flow is form the lower to the upper portion of the photograph, which covers an area 16 km across.

Figure 9. Raised bogs and systems of bog islands north of the Albany River. The large area of bog in this photograph is indicated by the light tones. Darker- toned water tracks (1) arise near the bog crest (2) and flow toward tributary streams (3) at the downslope portion of the photograph. The water tracks apparently fragment the bogs into large ovoid islands (4) and fields of smaller islands (5). The photograph measures approximately 16 km across.

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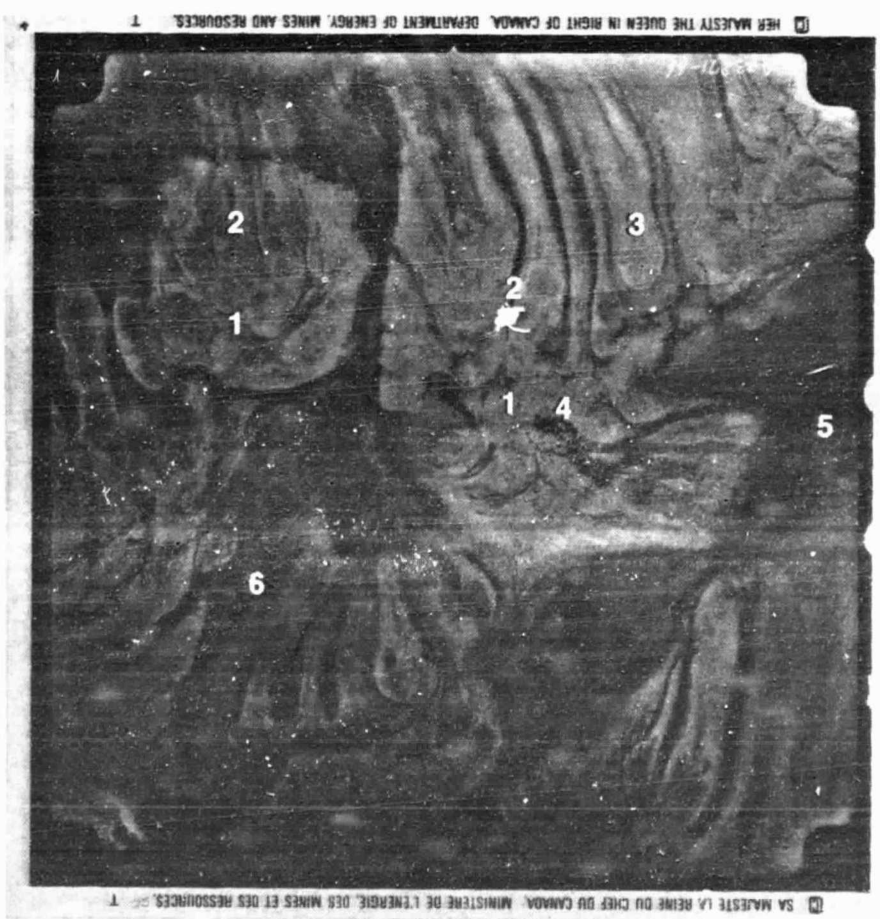
Fig. 3



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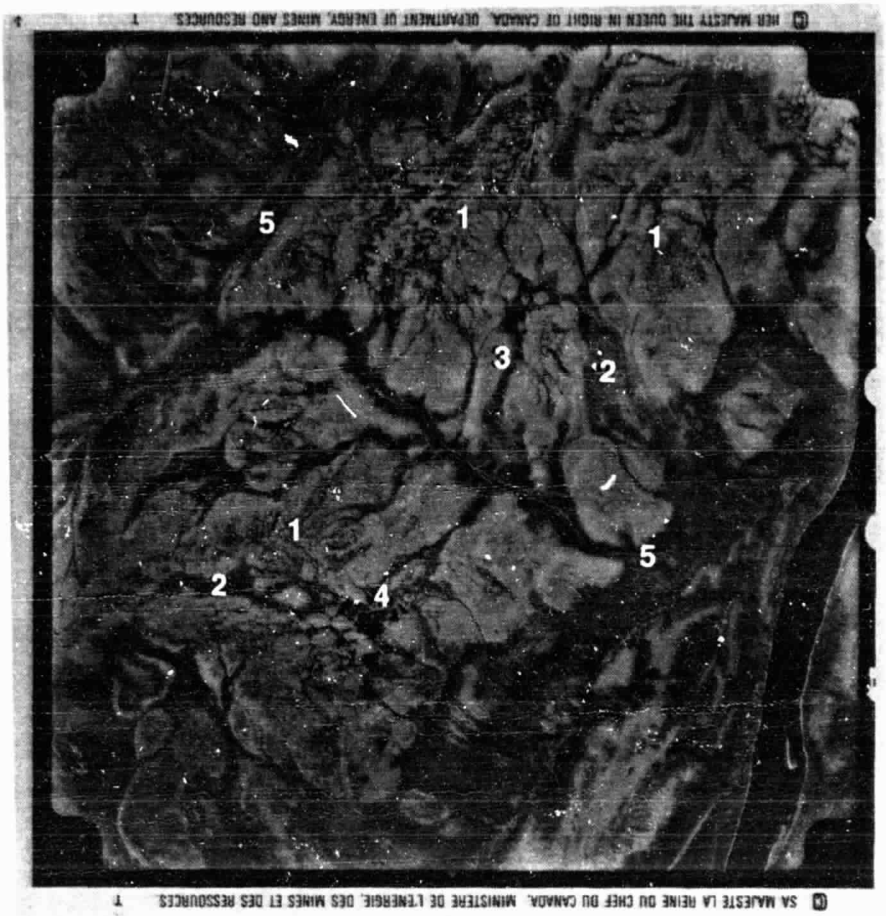

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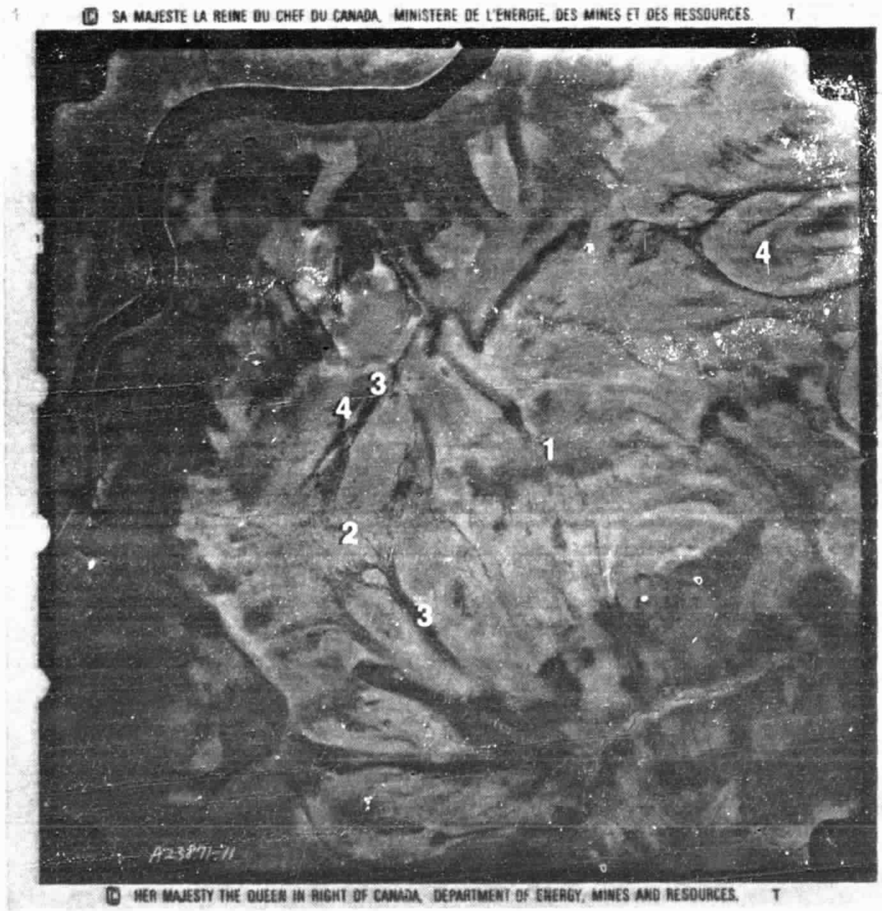

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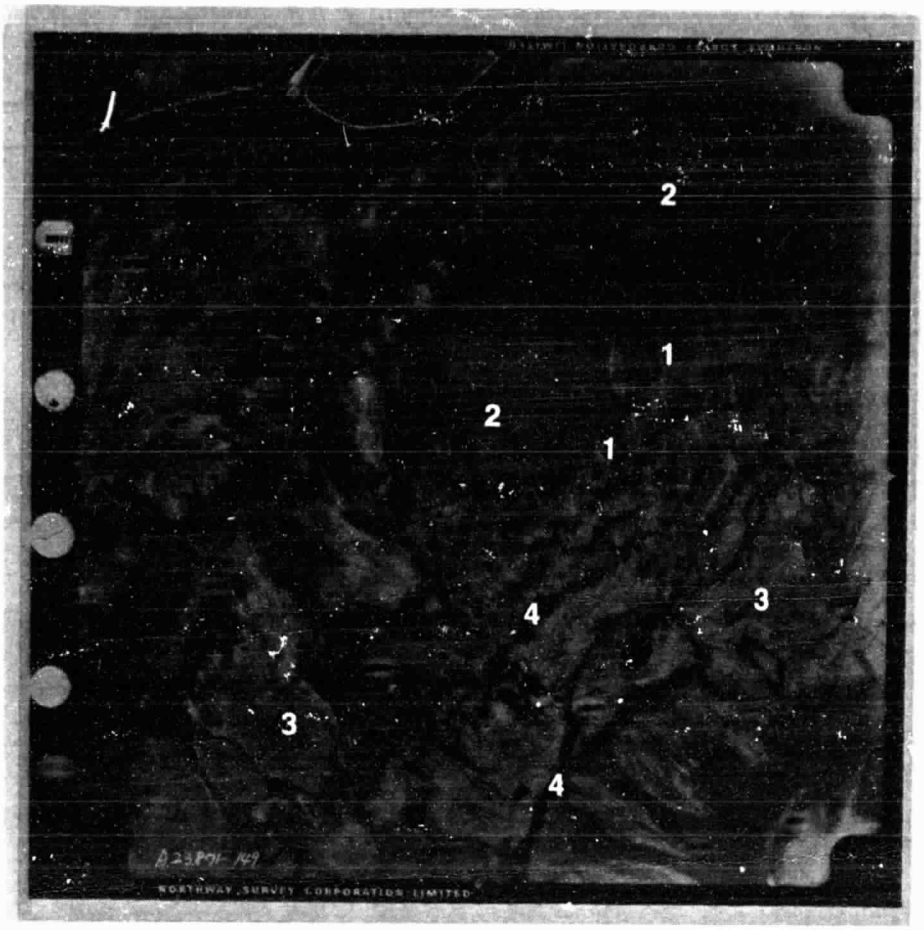

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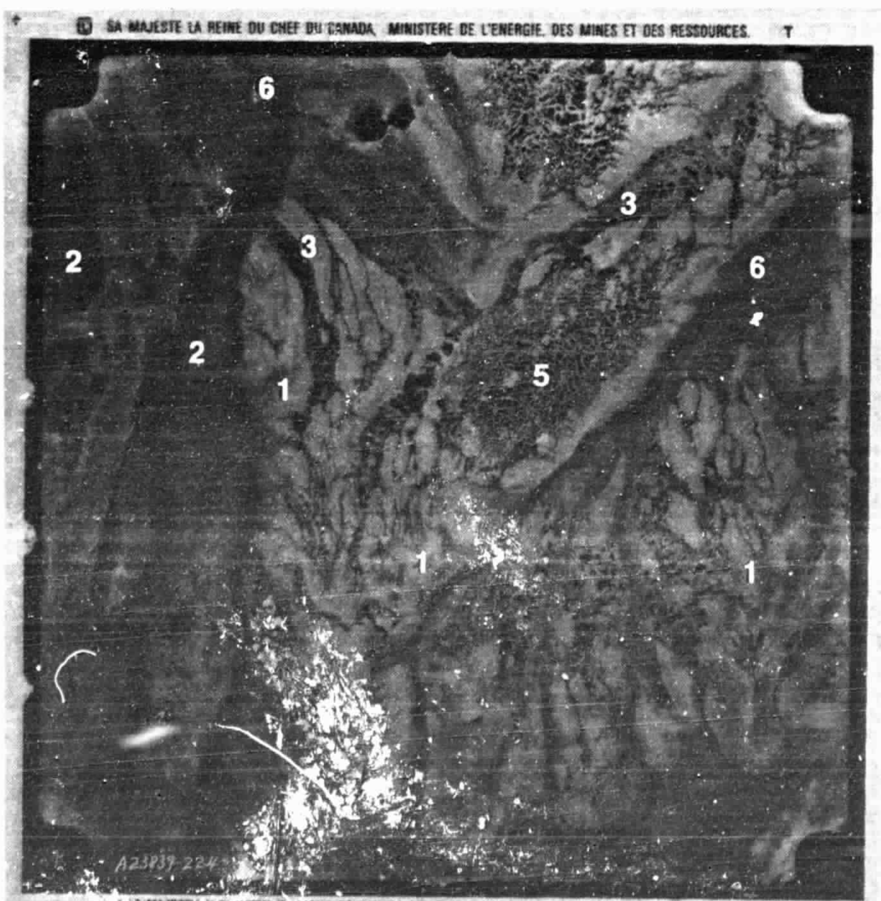

Fig. 8

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