MINERAL AGGREGATE SOURCE SEARCH

OFFICE AIRPHOTO STUDY

Coppermine Study-area

J D MOLLARD AND ASSOCIATES LIMITED

CONSULTING CIVIL ENGINEERS AND ENGINEERING GEOLOGISTS

Specializing in airphoto interpretation and ground-water studies

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Coppermine Study-area

Prepared for:

Government of Northwest Territories
Department of Public Works
Highways Division
Design and Construction Section
Yellowknife, N W T
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Attention: Mr. Peter Vician, Project Officer

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Prepared by:

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1984

MINERAL AGGREGATE SOURCE SEARCH

OFFICE AIRPHOTO STUDY

INTRODUCTION

The purpose of this office airphoto search was to obtain several scales of available airphotos, including the high altitude airphotos at 1:60,000 scale approximately, and identify potential sources of mineral aggregate in vicinity of Coppermine, NWT. The Government of the Northwest Territories (GNWT) Public Works Division (DPW) supplied 1:6000 and 1:20,000 low level airphotos, and the high level airphotos were purchased from the National Air Photo Library (NAPL) in Ottawa.

Because the quantity and quality of aggregate, the seasonal recoverable volume of construction material, the haul mode and distance and access, and environmental constraints,vary from one prospect to the next, it was felt that a regional search should be made first from the small-scale airphotos. This search should then be followed by examination of the large scale, low altitude airphotos covering a smaller area around the settlement of Coppermine, NWT.

BEDROCK GEOLOGY

Figure 1 shows the exposed and inferred drift-covered bedrock types in the area surrounding Coppermine. This figure has been xeroxed from GSC Map 1337A, which accompanies GSC Paper 71-39. In the area around Coppermine,isolated relatively flat-topped, steep-cliffed mesas consist of eroded gabbro sills while the surrounding bedrock types at lower elevations consist of stratified sandstone, siltstone and either shale or mudstone. Northwest of Coppermine, in vicinity of Richardson Bay, the rock types are mainly gabbro and limestone (see Figure 1).

OVERBURDEN GEOLOGY

Below elevation 150 m (500 feet) the main overburden deposit is stratified marine clays, silts and fine sands. Near the mouth of the Coppermine River a large sandy marine delta has been formed. It is scarred by roundish drained and undrained thaw basins and by abandoned ("fossil") distributary channel scars. Both the actively eroding fine-grained marine deposits, which appear in the photos as smooth darkish slopes with whitish gullies and whitish wind-eroded patches, and the channel-scarred raised sand delta are easily recognized and their extent can be mapped (see Figure 2).

PERMAFROST CONDITIONS

The study area lies in the zone of continuous permafrost, where the ground is frozen to great depths year round and the active layer (maximum seasonal thaw depth) varies from several centimetres to a metre or so thick in tundra-covered areas. The surficial soil deposits contain a high content of ground ice; and some of the large ice-contact granular deposits (kames, eskers, outwash) may still contain large blocks of residual glacier ice. One can expect the annually thawed surficial layer to be thicker on south-facing slopes and below the larger bodies of water, such as lakes and large rivers.

GRANULAR DEPOSITS -- GENERAL

Some 40 areas of sand or gravel of varying quantity and quality have been identified. They are expected to vary significantly in terms of the cost of stockpiled material at the settlement of Coppermine. Some of the granular material prospects are huge -- many tens of millions of tons of sand and/or gravel. Several are far from the settlement. It is expected that they are all frozen at shallow depth. Some are more difficult to get to or develop than others. Some of the deposits occur as exposed alluvial flats along the Coppermine River floodplain; they likely have a thicker recoverable layer (bulldozed into piles), but their gradation is suspect -- either overly sandy or too bouldery. Some local areas in the beach ridges mapped offer reasonably good possibilities, but the material would likely have to be stockpiled in summer and then hauled over ice by truck or tractor train in winter or by a towed barge in summer. The development of the beach ridges could have environmental implications, as stated later in this report.

Because of the many variables to consider and evaluate, it will be necessary to reconnoitre the different prospects by helicopter or motorboat and select the ones that appear to offer the best overall economics and whose development is environmentally acceptable as well.

The prospects are shown on strip mosaics 1 to 7, which can be viewed stereoscopically at a scale of 1:60,000. The closer prospects are shown on xeroxed copies of the large scale photos. See also key maps 3a and 3b showing the general location of prospects identified in the photos.

IDENTIFIED PROSPECTS SHOWN ON THE 1:60,000 MOSAICS

The best way to appreciate the different prospects identified in this study is to view them stereoscopically in airphotos before going to the field. Many details of areal extent, topography, access and places to inspect can thus be observed. As a result, I have outlined, classified, and annotated the prospects directly on the strip mosaics. Note that every other print has been used to assemble the strip mosaics.

The area shown by mosaicked photos covers a 25-mile radius on the land area from Coppermine. So the search area is rather large. As much inferred information as possible is given for each prospect described below (see strip mosaics from the small-scale airphotos and composite mosaic).

Prospect 1 (strip mosaic 1)

Large volume deposits (1a, 1b, 1c) consisting of valley outwash along the Nipartoktuak River valley. These deposits vary from gravelly sand to sandy gravel along with scattered patches of boulders. The granular material is expected to vary from less than 1 m to over 4 m in thickness. The material is frozen and is remote. It is considered to be a poor possibility for development because of poor access and long distance from Coppermine. Easily assessed by helicopter, landing to view areas of the deposits on the ground.

Prospect 2 (strip mosaic 1)

Exposed alluvial flat along the Coppermine River floodplain. Although remote, the material can be quickly assessed with very little exploration (hand shovel to estimate minimum thickness). Possible environmental concerns. Remote. Large volume is expected. Stockpile in summer and truck haul in winter. Gradation of surface material difficult to predict. Surface layer likely the coarsest.

Prospects 3, 4 and 5 (strip mosaic 1)

Altogether 12 individual deposits have been mapped in prospect areas 3, 4 and 5. Some deposits are terrace remnants and others are isolated remnants of raised marine deltas that have been cut by distributary channels. Shallow active layer. Perhaps a high sand content. Very large volume of granular material in total.

Prospect 6 (strip mosaic 2)

Prospects 6a and 6b are similar to Prospect 2. It is difficult to accurately predict the deposit gradation from the 1:60,000 airphotos. But this is something that is quickly and easily assessed on the ground. The thaw layer will be significantly thicker after the river water lowers and the bars are exposed. Will environmentalists concerned with fish reproduction allow alluvial materials to be harvested from the side-channel bars?

Prospects 7 and 8 (strip mosaics 2 and 3)

Large deposits of sand with, perhaps, some gravel sizes deposited in a marine delta as the land raised and the ocean level dropped. The deposits resemble terraced and channelled valley outwash but may be inwash deposits. Outcrops with no vegetation cover are few and only occur along river undercut slopes. Minor environmental constraints envisaged.

Prospect 9 (strip mosaic 2)

Large, deep deposit in flat-topped esker-delta. Small sinuous esker ridge continues to the east. The sands and gravels are expected to be clean and well bedded, often with steeply dipping interbeds of gravelly and sandy layers. Main problems are remoteness, thin thawed-layer thickness, and poor access.

Prospect 10 (strip mosaic 2)

The narrow, steep-sided esker ridges are marked 10a, 10b and 10c. These narrow eskers resemble railway embankments and project well above the surrounding landscape. There is a possibility that the ice cement joining particles may be weak enough in the crest of these ridges to allow them to be excavated to reasonable depths, like the Yaya esker on Richards Island. This possibility should be considered during field reconnaissance.

Prospect 11 (strip mosaic 2)

The narrow whitish bands at 11a and 11b are thought to be actively accumulating talus (gravity topple, fall and creep) material along south-facing cliffs surrounding gabbro sills. The blocks of talus rock may be too large and too scattered to be economically recoverable. I would suggest that you check these slopes during helicopter reconnaissance, possibly with someone like Jim Watson of Kenaston Contractors of Norman Wells. Someone like Jim can present a contractor's viewpoint, and I found this helpful to me on one trip to the Arctic Islands with Jim in which we assessed the costs of developing alternative aggregate sources I had identified previously in the aerial photographs.

Prospect 12 (strip mosaic 2)

Deposits 12a and 12b are very large and deep, and contain several tens of millions of tons of frozen sand and gravel. First I would examine slopes near the water level at prospect 12 to see if the deposits are thawed more deeply (for digging purposes in the field). I would check the active layer thickness (depth to the frost table). Worth field examination, even though remote. If not"dry frozen"and excavatable, one would have to assess the recoverable thickness each year and also the type of haul (winter truck haul, skidoo-pulled sleigh with dump box, Hercules aircraft, which is unlikely, etc.).

Prospect 13 (strip mosaic 2)

Prospect 13 is the largest deposit mapped. It is expected to contain over several 100 million tons of sand and gravel. I have marked X's at places to check this deposit on the ground. Although most of the surface is covered by tundra vegetation, one may still get a good appreciation of the likely gradation because the vegetation is sparse. Also, there are a few subsoil exposures to inspect directly. This prospect is downgraded because of its distance from Coppermine. Small bare exposures on steep slope will give one an idea of the gradation and the nature of layering of the deposit.

Prospect 14 (strip mosaic 2)

Deposits 14a, 14b and 14c are large valley train deposits (valley outwash) having a thin overburden but probably frozen at shallow depth. These deposits can be expected to contain scattered boulders as well. (I'm enclosing a glossary booklet in case some of the geological terms are unfamiliar.)

Prospect 15 (strip mosaic 2)

This prospect contains a larger quantity of sand and gravel than in prospect 14. Like 13 and 14, however, the area is a long distance from Coppermine. Thus one has to weigh the extra haulage costs against cost of processing (e.g. crushing) closer alternative prospects.

Prospect 16 (strip mosaic 3)

Terrace remnant along the Coppermine River. Check the exposed materials in undercut face. Expect the surficial layer to be sandy and to slough down over in situ finer-grained marine deposits. Origin and composition of the deposit is similar to prospect 8. But deposit 16 is a much smaller prospect.

Prospect 17 (strip mosaic 2)

Large area of exposed river bed at times when river flows are low in the Coppermine. This prospect should be easy to assess on the ground. No vegetation and no organic or fine-grained overburden. Also,the active layer is much thicker on the floodplain than it is on the tundra-covered upland prospects. However, removal of material may produce environmental constraints and concerns (fish reproduction?), although riverbed gravels were used for construction in places along the Dempster Highway in the Yukon. Note that X's are places to visit on the ground. Again, as with other prospects,one has to consider each one individually, visit it, assess it in the field, and then look at the economics and possible environmental restrictions.

Prospect 18 (strip mosaic 3)

One of the geologically more interesting prospects identified from study of the 1:60,000 scale airphotos. At first I thought that the granular material here was shallow (±1 to 2 m),in beach ridges on till or on a till-covered gabbro mesa. But a huge kettlehole, created by the melting of glacier ice, occurs in the centre of the deposit. Thus I visualize a huge deposit consisting of interlayered sands and gravels, possibly over 100 feet (33 m) thick. Again the deposit might be "dry frozen" and thus not too difficult to excavate. Field reconnaissance and a little dozer work in winter will reveal whether or not this prospect can be operated economically. The surface is below elevation 145 m and so may be veneered by finer marine sediments.

Prospect 19 (strip mosaic 3)

A huge esker ridge situated below the upper limit of marine submergence, which reached roughly 145 m elevation (see Figure 2). The crest and ends of esker segments ("beads") may contain "dry frozen" granular material. In general eskers tend to be highly variable in composition with, in places, interlayered uniform sands, clean well graded gravelly sand to graded sandy gravel, and with occasional silty and bouldery layers. This deposit is similar to the Yaya esker on Richards Island, west of Tuktoyaktuk. I mapped this High Arctic esker for gravel contractors and for oil companies 15 or more years ago, and it has been used for years.

Prospect 20 (strip mosaic 3)

Sandy delta and beach ridges at the mouth of the Asiak River. Located along the shore of Coronation Gulf. Accessible by boat in summer and by skidoo and truck during certain times of the winter. Considered a poor prospect because of anticipated lack of gravel sizes and long distance from Coppermine. Potential environmental problems.

Prospects 21, 22, 23, 24, 25 (strip mosaics 3 and 4)

These prospects are expected to be high in sand sizes and low in gravel sizes. But they are nearer to Coppermine than other prospects, and easier to check by chopper. The problem is dozing off the tundra and harvesting a thin layer of sandy material each summer. One would expect that these deposits contain more fines (silt and clay) toward the ocean -- i.e. from 21 to 24. Prospect 24a is an isolated remnant in a large distributary channel bed while prospect 25 is a reworked deposit along the coast, and will consist of wave-worked shore sands.

Prospects 26 and 27 (strip mosaic 4)

These are the relatively level to sloping mesas with steep cliffs. They are erosional remnants of gabbro sills, and their surfaces are littered with large blocks of frost-shattered gabbro rock. The cliff faces are also sprinkled with coarse blocky talus and finer debris that has been shed intermittently downslope over 5000 to 7000 years. Blasted and crushed rock obtained from these bedrock areas is worth considering because the areas are so close to where material is needed. The costs of processing the material should be evaluated and compared with hauling sand and gravel from more distance sources. There should be little environmental damage. The rock is hard, durable and monolithologic -- i.e. one rock type vs many rock types as in deposits 12,13,14 and 15. A suitable quarry site should not present permafrost problems,and a quarry could be operated for a greater period of time over the year.

Prospects 28(a) and 28(b) (strip mosaic 4)

These are existing open excavations. Likely they were opened to provide fill for constructing the runway at Coppermine,and for fill in the settlement. I expect that the thawed layer is somewhat variable, with the pit at 28a being largely sand, although it may contain a very small proportion of gravel sizes. Prospects 28a and 28b can be assessed by walking over them,and are accessible by vehicle.

Prospects 29 and 30 (strip mosaics 4 and 5)

I expect these beach ridges are environmentally sensitive. They may also contain fines and the odd boulder. Access is good by land, water and ice; and they are located near the settlement of Coppermine. However, I would rate them as poor prospects.

Prospect 31 (strip mosaic 5)

This deposit has been worked already, so is open to visual inspection and assessment. These deposits should be considerably coarser than either 29 or 30 because waves and longshore currents have reworked talus at the base of gabbro cliffs. The soil-covered bedrock underlying the low areas consists of dirty (i.e. clayey) limestones and dolomites. Fragments of these rocks, plus sandstone, may also have been worked by wave action. This is a good prospect to visit and evaluate in the field.

Prospects 32a to c and 33a to f (strip mosaic 5)

All these scattered deposits are similar in origin and in composition. But they vary locally in patchiness, thickness, gradation, and extent of existing ground cover (low vegetation). The better areas are not vegetated at all and appear light toned from the air.

I am inclined to rate the best areas within each of these deposits as good prospects because they can be dozed into piles in summer and hauled by tractor train (sleigh) or by truck over the ice in winter; or they can be towed by small barge in the summer, whichever is safest and most economic. Main concerns are 1) recoverable thickness and 2) environmental constraints. The local Eskimos appear to have shacks on some of these islands. Thus they may use the area for fishing, trapping and hunting at different seasons of the year. Easily assessed on the ground with access to them by motorboat -- or, better still, helicopter.

Prospect 34 (strip mosaic 6)

Wave and current modified beach deposit at the mouth of the Rae River. Worth casual inspection. Rated poor. If, however, the Rae River dumped gravel size particles onto the beach, it may have been reworked by wave action. But much of the lower watershed of the Rae River -- like the Richardson, Coppermine, Nipartoktuak and Asiak Rivers -- crosses very thick deposits of stratified clays, silts and fine sands that contain very little or no coarse sand and gravel.

Prospects 35,36,37a and b (strip mosaics 6 and 7)

These beach deposits are all located near the coast of Coronation Gulf and consist of generally thin beach gravels derived from carbonate (limestone and dolomite) bedrock. It is difficult to know how an experienced northern aggregate contractor might rate these deposits because several factors must be considered, of which haul is only one factor -- i.e. type of haul (water, land, ice), haul season and haul distance.

Prospects 38, 39, 40 (strip mosaic 7)

Beach ridges on or near the shore of Coronation Gulf. Remote.

PROSPECTS MAPPED ON LARGER-SCALE AIRPHOTOS (L)

Prospect L-1 (Figure 4)

Larger view of prospect 32a shown on small-scale airphotos. Check exposed beach gravel for gradation, depth of thaw in summer, and recoverable quantity (or yardage) in m^3 per m of thickness. Rated good because of nearness to Coppermine and haul by barge, truck or tractor train (sleigh).

Prospect L-2 (Figure 5)

Similar to L-1 except that it has already been worked. However, it also contains some wave-reworked talus. Rated good but limited in quantity. The same as prospect 31 shown on the small-scale photos.

Prospect L-3 (Figure 5)

Long, narrow beach deposit. Gradation expected to be finer than either L-1 or L-2. Much of material here originates from longshore (littoral) drift. Prospect 30 in the small-scale photographs.

Prospect L-4 (Figure 6)

One of a group of several gabbro sill erosional remnants at Coppermine. Shown as Prospect 26 in the high-altitude, small-scale airphotos. The upper slope shows varying sizes of blocks of detached gabbro rock, and in varying degrees of physical disintegration. See also the excavation at the base of slope, where a large quantity of material has been removed. The gabbro sills in this area overlie Precambrian sandstone, siltstone and shale or mudstone strata. These sedimentary rocks may or may not appear in the base of the quarry wall; it is difficult to tell this from the airphotos, even the large-scale low-level airphotos.

Prospect L-5 (Figure 7)

Check beach ridges at the Xs. Likely environmentally sensitive. Also, the materials may be poorly sorted as well. Corresponds to prospect 29 on small-scale photos.

Prospect L-6 (Figure 8)

Large, open excavations. Same as the prospects 28a and 28b on the small-scale photos. One can get some appreciation of the problems and costs faced from examining these excavations on the ground. I expect that much of the excavated material has been used for random fill in the settlement or used in the runway. One should compare the costs of blasting, excavation, primary crushing, secondary crushing, sizing and maybe even washing for concrete -- versus the use of a distant gravel source having an acceptable pit-run gradation.

Prospect L-7 (Figure 9)

Close-up of a small portion of prospect 24. Expect ice-rich, tundra-covered sands containing minor gravel. This deposit may be useful as random granular fill. It would entail stripping the vegetation, allowing for summer thaw and excavation of the thawed layer.

Prospect L-8 (Figure 10)

Terrace remnant in the abandoned distributary channel in a large delta. This deposit may be slightly coarser and cleaner than the materials in the adjoining upland areas. Shown as prospect 24a on the small scale photos.

Prospect L-9 (Figure 11)

Certainly worth detailed field assessment. The deposit gradation will be obvious. May be coarser at the surface. The surface changes every year as a result of stream erosion. May be too coarse (bouldery). What are the environmental implications of harvesting the surface layer at selected, if scattered, sites?

Prospect L-10 (Figure 12)

Face of exposed sand with minor gravel in an existing pit. Excellent access. Potential fill and source of fine aggregate when washed and sized.

Prospect L-11 (Figure 13)

A belt of "fossil" beach ridges on raised marine delta. Similar material to that in open pit off the runway shown in L-10.

Prospect L-12a,b,c (Figure 14)

Beach ridges at 12a; mostly sand. Check at Xs. In the case of prospects 12b and 12c, check the face of the cliff near its top to determine the depth of thaw and the gradation of this material.

Prospect L-13 (Figure 15)

Large source. Check at several of the X's. This deposit appears to be large and situated below the maximum marine (past ocean water) level of approximately 500 feet (145 m). Considered worth checking because of its proximity to Coppermine and potential large volume of material and possible "dry frozen" nature. Material would have to be truck hauled in winter.

Prospect L-14 (Figure 16)

Nichols Islands. Same as small-scale airphoto prospects 33b and 33c. I think these deposits should be looked at very closely in the field. Depending on the annual requirement for gravel required for streets and for concrete, these island deposits (31,32 and 33) could represent a good source of supply for many years.

Prospect L-15 (Figure 17)

Modern beach ridge along the coast (see prospect 25). Considered poor prospect because of sandy to silty (fine) nature of expected deposit.

Prospect L-16 (Figure 18)

Check at the Xs and the arrows. The best area is probably to be found in vicinity of the island at L-16. Suspect sands mainly -- and environmental concerns as well.

Prospect L-17 (Figure 19)

Nichols Islands. I would rate these small deposits quite high, especially local segments of them. But one can see Eskimo buildings, which may be temporary or permanent summer or winter fishing and trapping dwellings. This could lower the chances of harvesting what could otherwise be quite economic sources of gravel.

Prospect L-18 (Figure 20)

Small and scattered patches of coarse gravel and boulders surrounded by frost-shattered gabbro bedrock. May be difficult to harvest easily. Inferior to those deposits to the east on the peninsula point and on Nichols Islands.

SUMMARY OF THE MOST PROMISING MINERAL AGGREGATE PROSPECTS

I will list the prospects that I feel should be visited and assessed visually prior to detailed and costly field exploration.

Bedrock source

There are several hard rock sources in the immediate Coppermine settlement area. They are well known and can be visited by walking. Main questions are the economics of blasting, crushing, sizing, and washing for use of the material as concrete; and blasting, crushing and sizing for local earth fill and other uses. Annual volume requirements, availability of a crusher and cost of developing competitive sources are factors to consider. Marked 26 but there are many other rock outcrops in the area. Check for both gabbro and sandstone rock types.

Raised beach ridges

The materials available for waves and longshore currents to work and sort along the coast is a major factor affecting the composition (grain-size distribution) and thickness of these deposits. The best aggregate deposits are scattered, relatively small deposits at prospect areas marked 31,32 and 33 on the strip mosaics. These are easily visited and the best localities for economic development can be identified on the ground. The material can be hauled by truck over the ice in winter, by skidoo-pulled tractor trains over snow-covered ice, or by towed small barges moving along the coast in summer, whichever is safe and the most economical. There is a question of environmental constraints if these areas are inhabited for part or all of the year by Eskimos.

Narrow esker ridges

The three best prospects are 9, 10(a,b,c) and 19. Of these I prefer the short wave-eroded segments (raised beaches) at the X's on prospect 19. If development of this source looks feasible, a winter truck haul road could be quickly located from the airphotos. There are no obvious environmental constraints.

Huge flat-topped ice-contact deposits

Noteworthy examples are 9, 12, 13 and 18. Because prospect 18, which shows strandline markings around it, is the closest I would examine it very carefully first. I have placed Xs where the tundra cover is thin or absent. Because this deposit is below the upper marine submergence limit, there may be a marine sand veneer overlying thick stratified gravelly sands and sandy gravels.

Marine delta sands

I suspect the highest deltas, as at 8 and 16, may be outwash marine deltas and the lower deltas, as south of the runway at 28c, may be inwash marine deltas. I expect predominantly sand. The best place to examine these plateau-like channel-scarred frozen sandy places is along actively undercut river banks. I have marked several of these locations to check. Places to check appear on both the annotated small-scale (1:60,000) and large scale airphotos accompanying this report. My main concern about the distant prospects is lack of gravel sizes and long haul distance. Environmental concerns may be a problem close to the settlement. The cost of stripping off of tundra over the frozen sands at the runway area may be known.

RECOMMENDATIONS

1. After you receive this report and have had a chance to digest it, if you have any questions please phone me and we can discuss them. There may be some particular item that you feel needs clarification. (I have included a glossary of terms for your use.)

2. I wanted to examine a large area because not one but many factors have to be identified and assessed, such as haul mode and haul distance, the amount and cost of processing required to make a prospect suitable for

a given use, the annual volume requirements for different uses and individual use specifications, environmental constraints and concerns, work that can be done by native people versus outside contractors from southern Canada, etc. So one recommendation is to consider the various identified prospects from these standpoints when making your preliminary reconnaissance evaluations. We have already chatted about this over the phone.

3. I think one could visit nearly all of the major competitive-looking prospects in 1 to 2 days using a helicopter. I also think this might be the cheapest way to do your checking. As mentioned earlier, Jim Watson, former mayor of Norman Wells and a northern-based contractor (Kenaston Contractors) with experience, accompanied several of us on a field trip to northern Melville Island to assess prospects that I had mapped previously for road fill, riprap, and concrete aggregate. Watson had a good appreciation of costs and problems. Maybe you have this experience and don't require such a person.

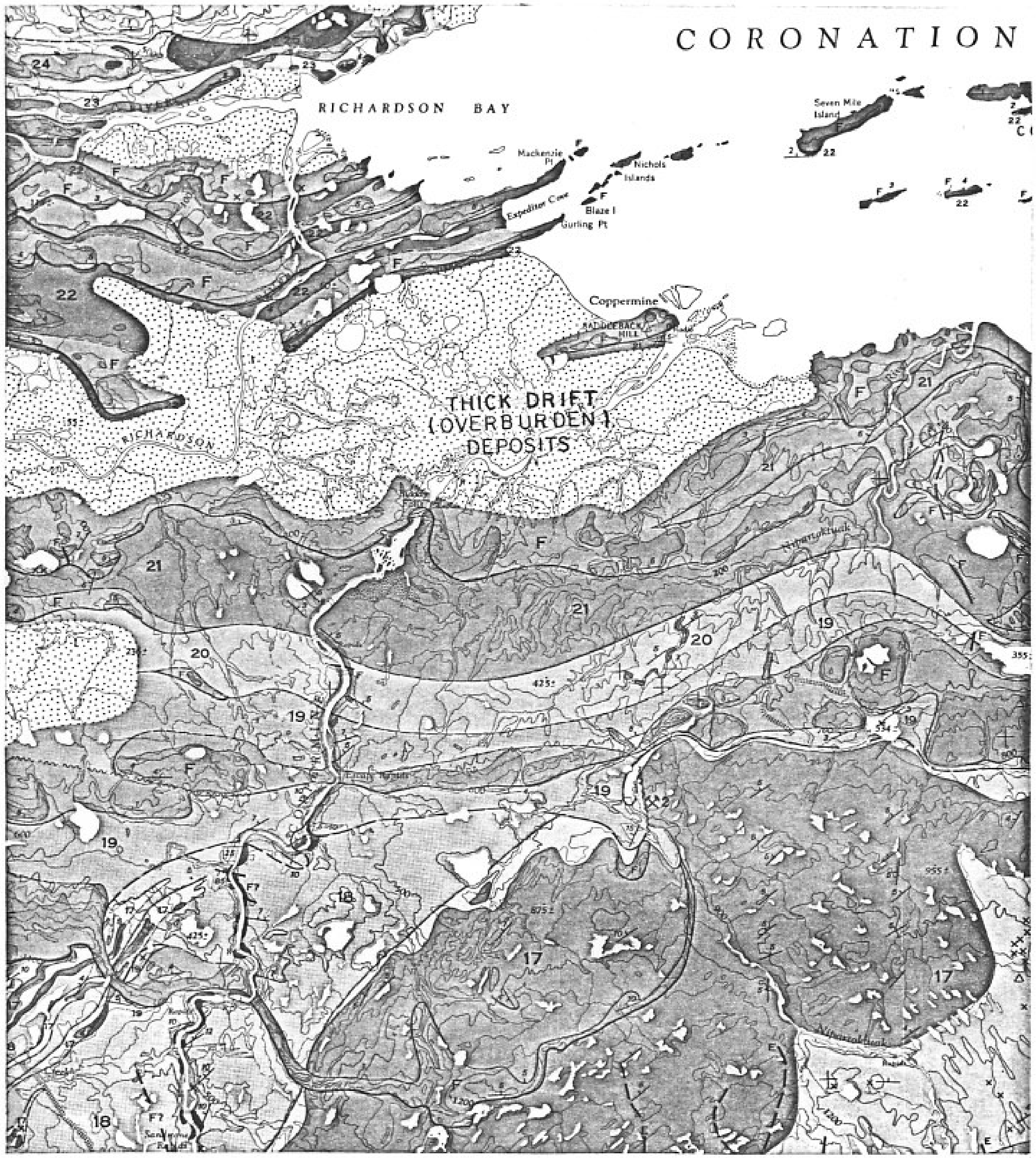
4. I would take along a hand spade and also a small auger. The hand spade can be used to clear away the sloughed debris over in situ granular material at the top of actively undercut riverbanks, along shorelines, and at exposures where the tundra vegetation is either sparse or absent. The auger may also be useful in determining the depth to the frost table on the upland, away from exposed faces -- i.e. at places where excavation of the material would take place.

5. As noted, feel free to phone me and ask questions. I hope you will keep us informed as you carry out any follow-up work in your field program.

6. I haven't estimated distances to the various sources because the haul roads will be longer than the direct "as the crow flies" or "gun barrel" route length. This may be done after your reconnaissance.

7. After your field trip I could make an estimate of the volume (m^3, yds^3, tons) of the quantities available per foot or per metre of depth.

8. The best place to inspect the terrace deposits along undercut riverbanks is just below the organic-rich topsoil. Some deposits may become finer with depth. Also, on sloughed or ravelled slopes the coarsest (gravel?) sizes will usually wind up at the base of slope and these may give a false impression of *in situ* material in the bank above.



Note: areas of outcrop are shown by deep colour; inferred extensions are shown by a lighter tint

LEGEND

PALEOZOIC

LOWER PALEOZOIC, *(Undivided)*

- 27 — *Dolomite*

CAMBRIAN ?

- 26 — *Quartz sandstone, conglomeratic sandstone and siltstone*

PROTEROZOIC

HADRYNIAN

RAE GROUP (19-25)

- 25 — *Dolomite*
- 24 — *Red and green shales, minor gypsum*
- 23 — *Sandstone*
- 22 — *Calcilutites, dololutites*
- 21 — *Shaly sandstone, siltstone, shale*
- 20 — *Red and green sandstone, siltstone, mudstone*
- 19 — *Sandstone, siltstone, shale*

HELIKIAN

NEOHELIKIAN

COPPERMINE RIVER GROUP (17-18)

- 18 — *HUSKY CREEK FORMATION: red sandstone and siltstone, intercalated basalt flows*
- 17 — *COPPER CREEK FORMATION: basalt flows, minor intercalated sandstone*

- F / — *CORONATION SILLS (and associated dykes): gabbro*

BEDROCK GEOLOGY MAP OF COPPERMINE AND SURROUNDING AREA (from GSC Map 1337A) note rock types are shown in legend

FIGURE 1

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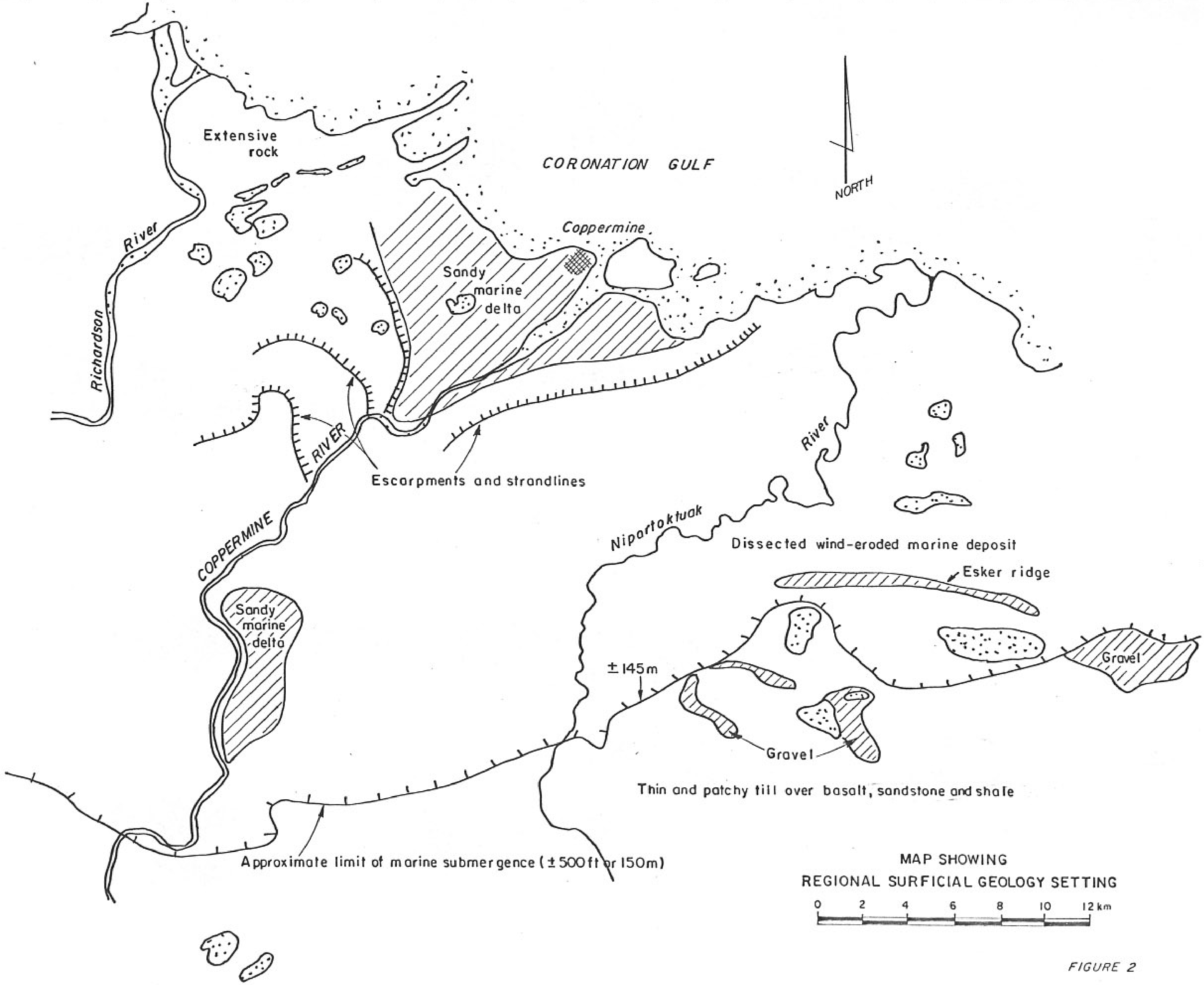

MAP SHOWING
REGIONAL SURFICIAL GEOLOGY SETTING

FIGURE 2

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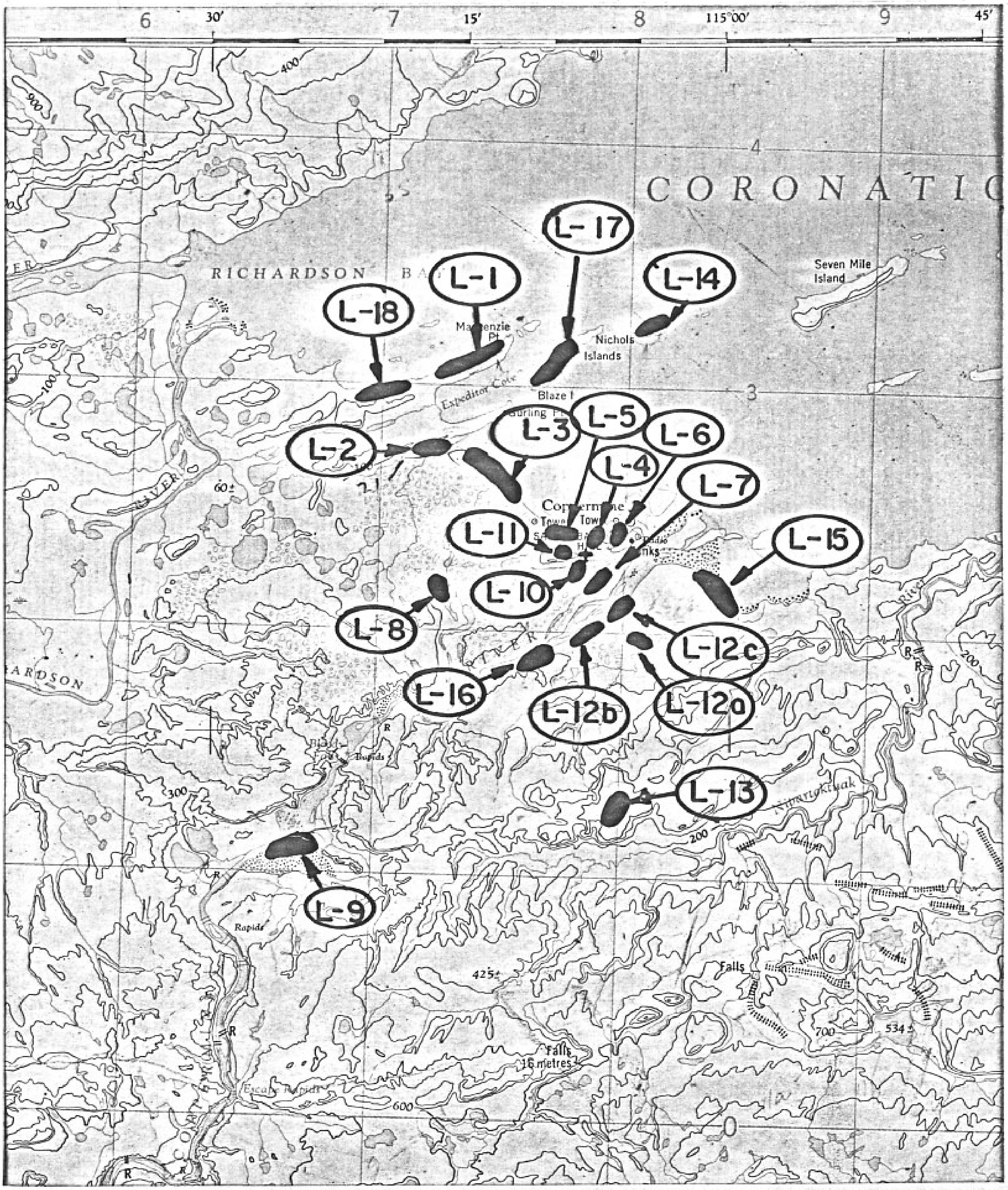
KEY MAP SHOWING
SAND AND GRAVEL PROSPECTS
1 to 40

FIGURE 3a



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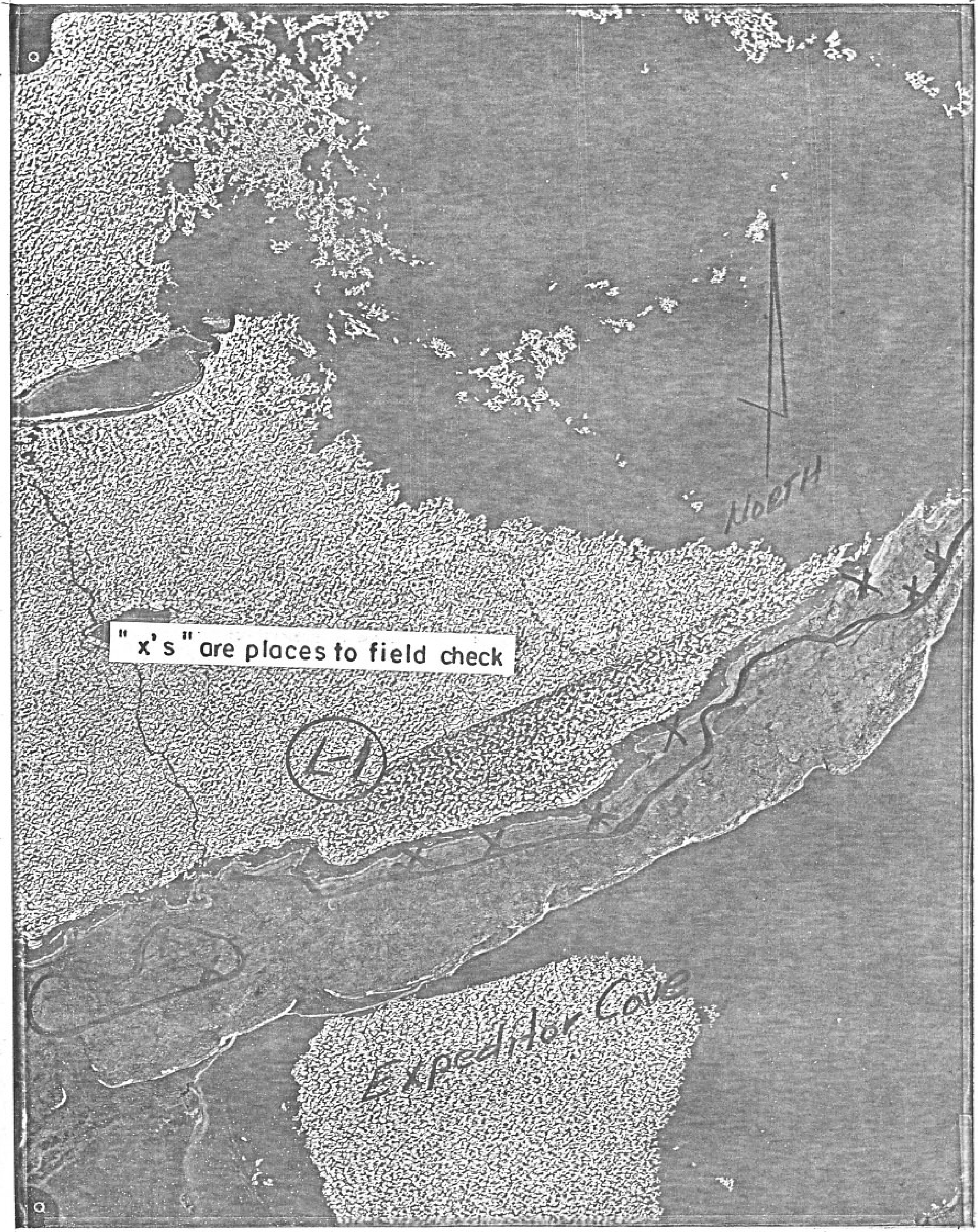
KEY MAP SHOWING
SAND AND GRAVEL PROSPECTS
L-1 to L-18

FIGURE 3b



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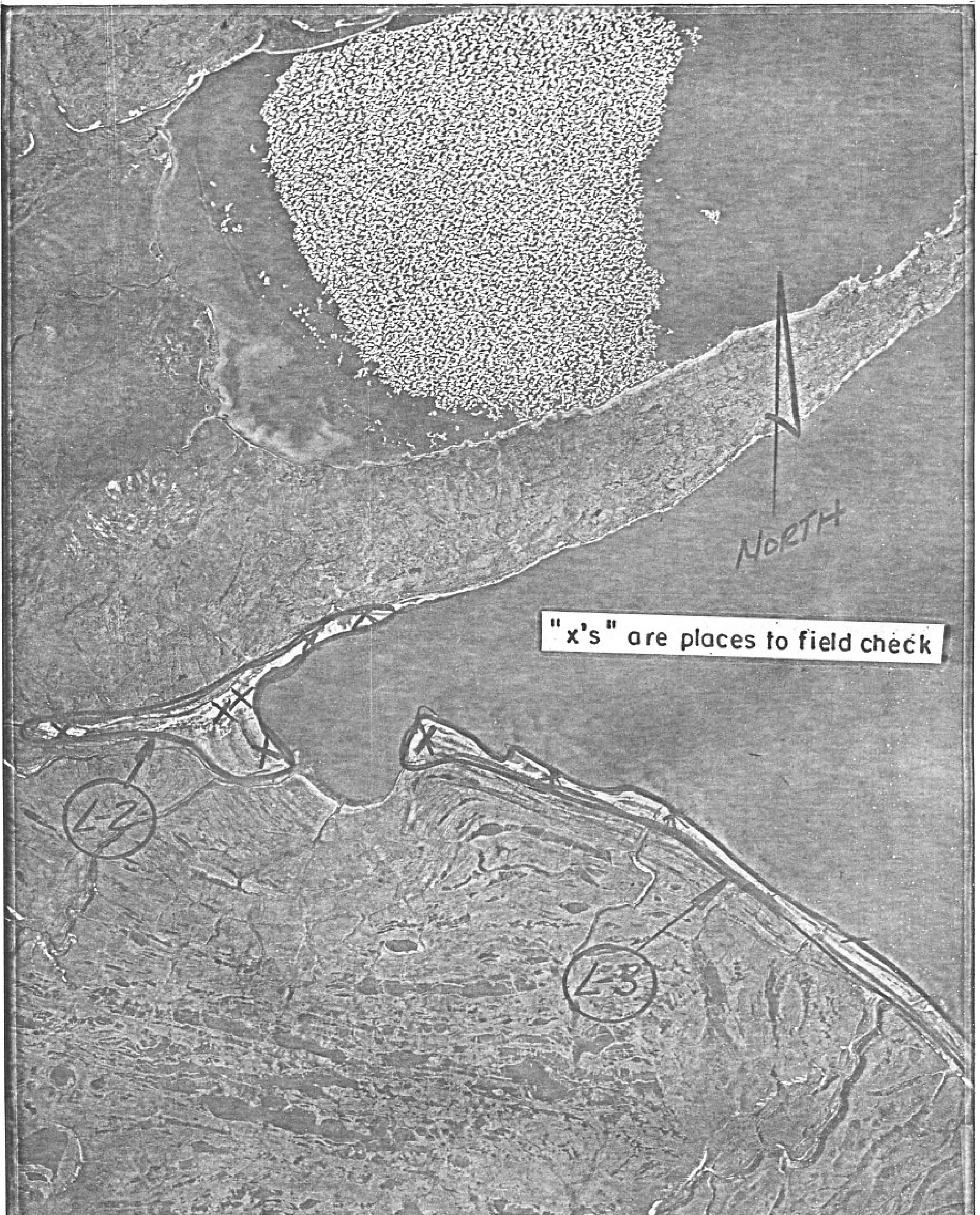
PROSPECT L-1

Figure 4



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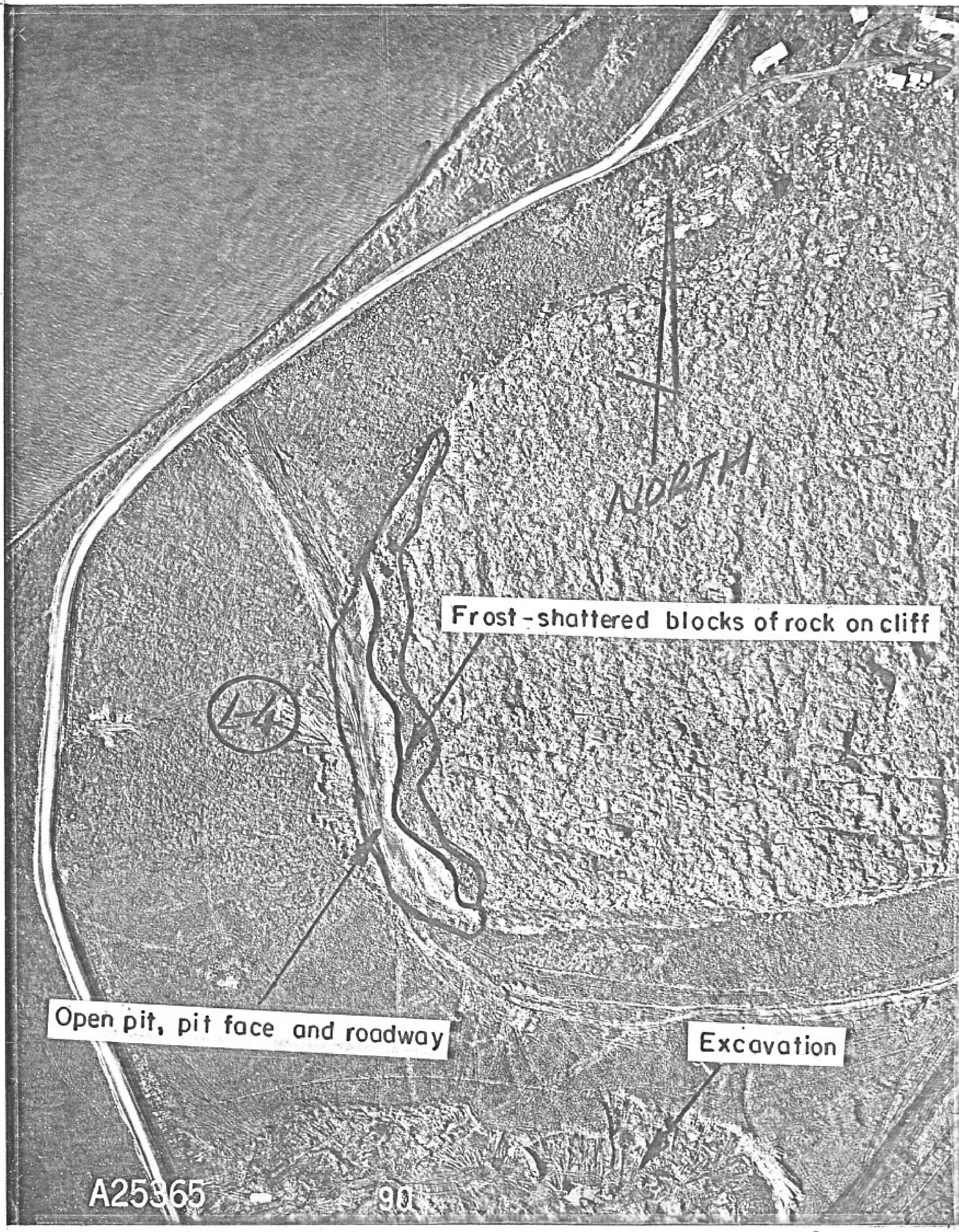
PROSPECT L-2 & 3

Figure 5



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PROSPECT L-4

Figure 6

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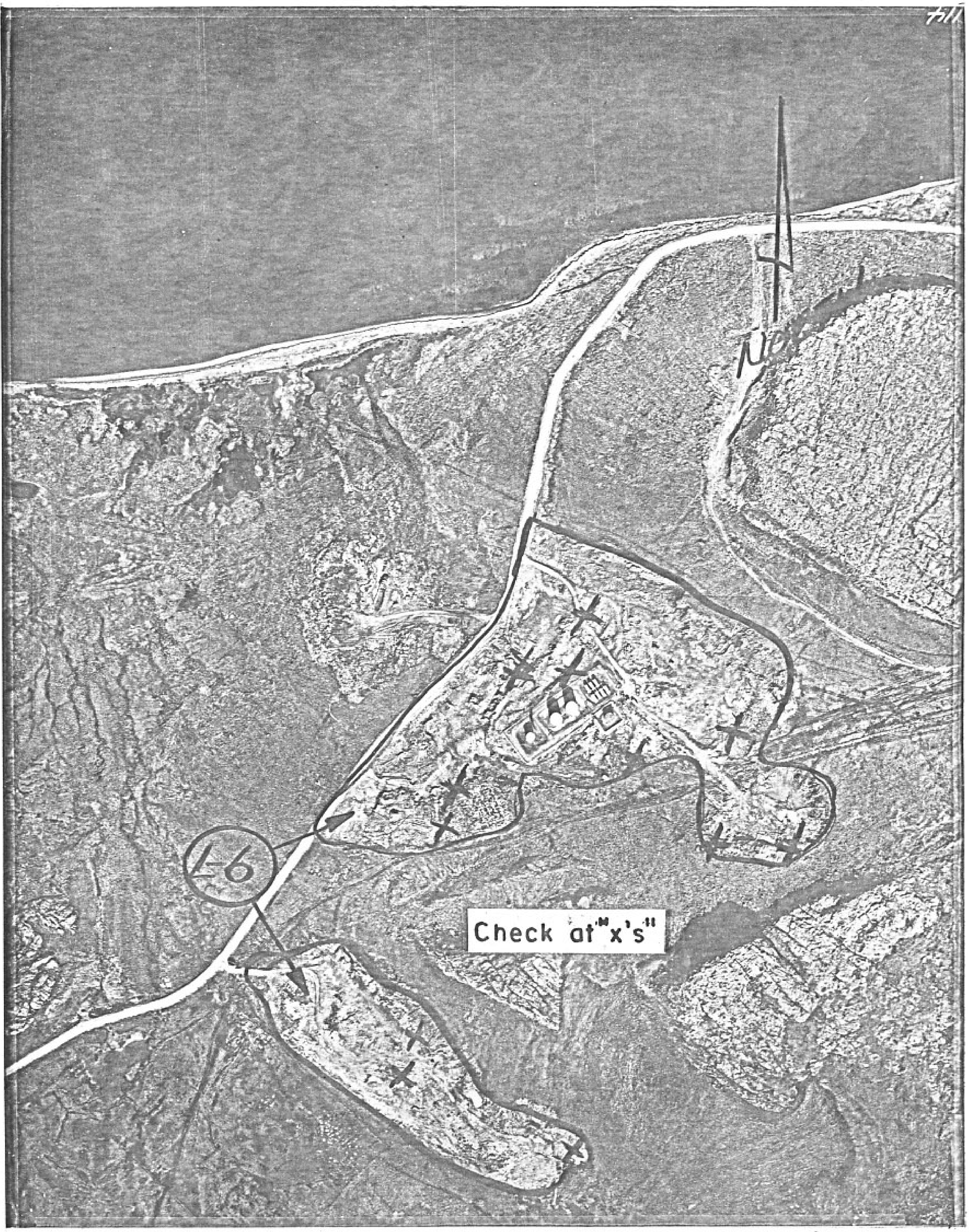
PROSPECT L-5

Figure 7



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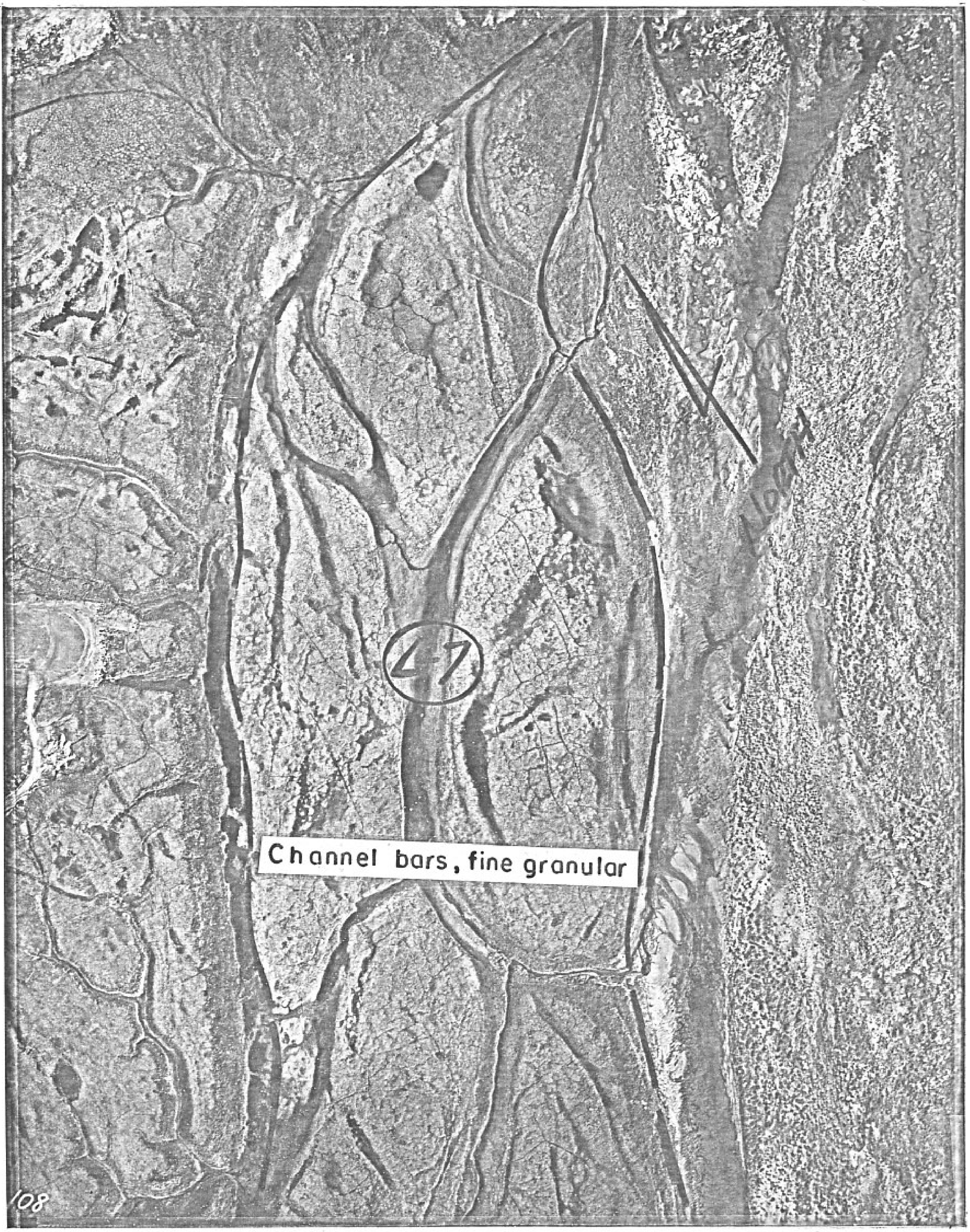
PROSPECT L-6

Figure 8



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PROSPECT L-7

Figure 9

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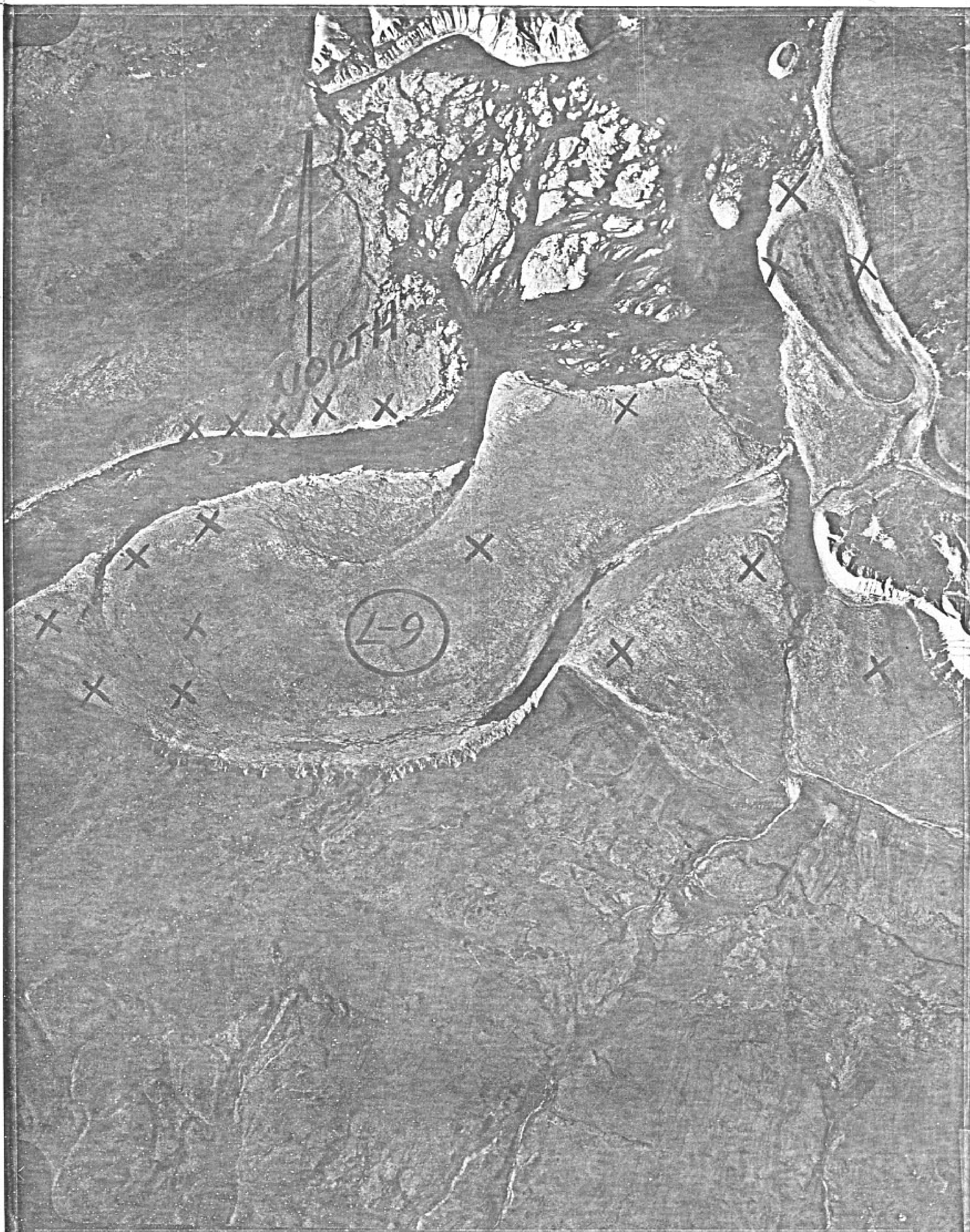
PROSPECT L-8

Figure 10



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PROSPECT L-9

Figure 11

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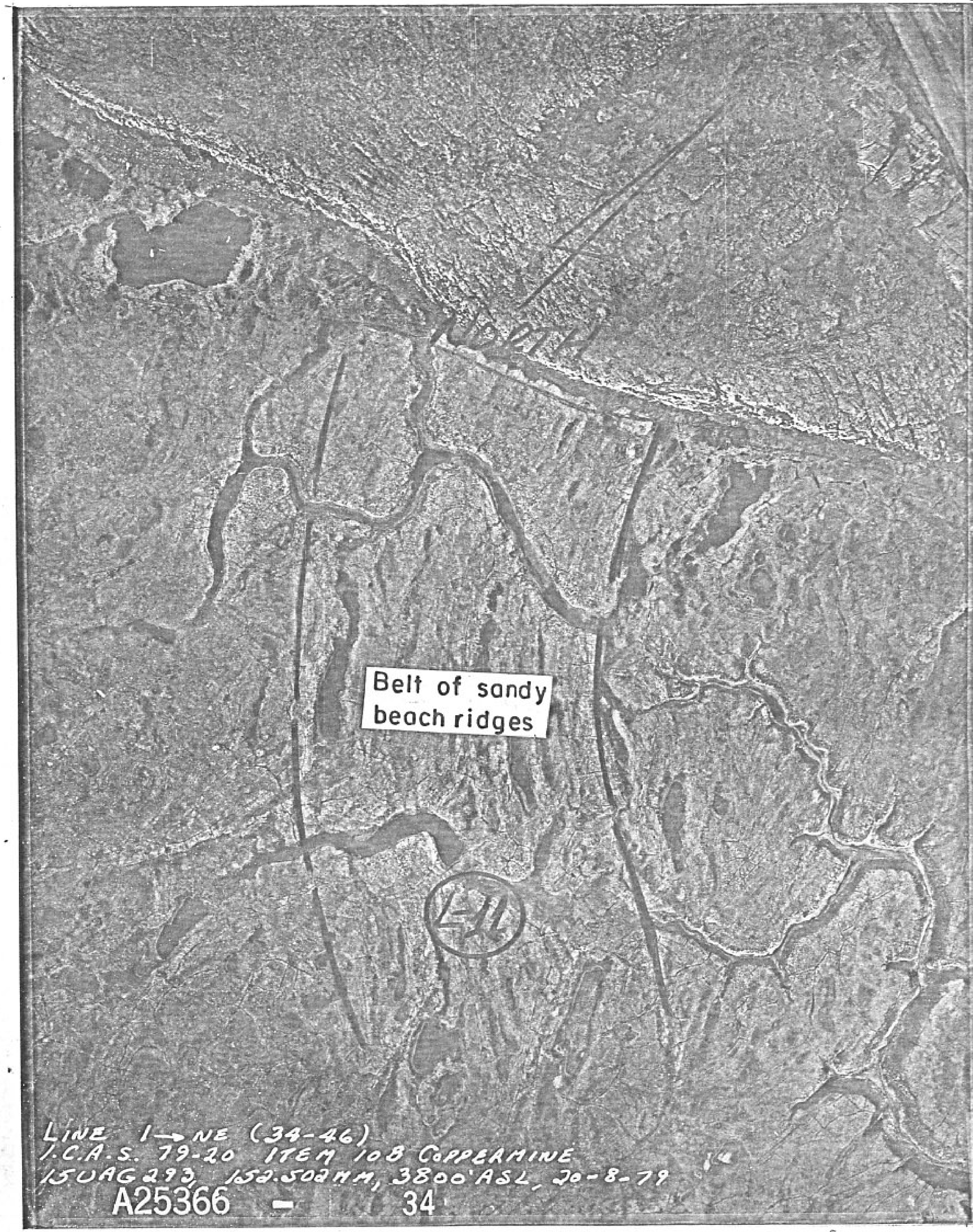
PROSPECT L - 10

Figure 12



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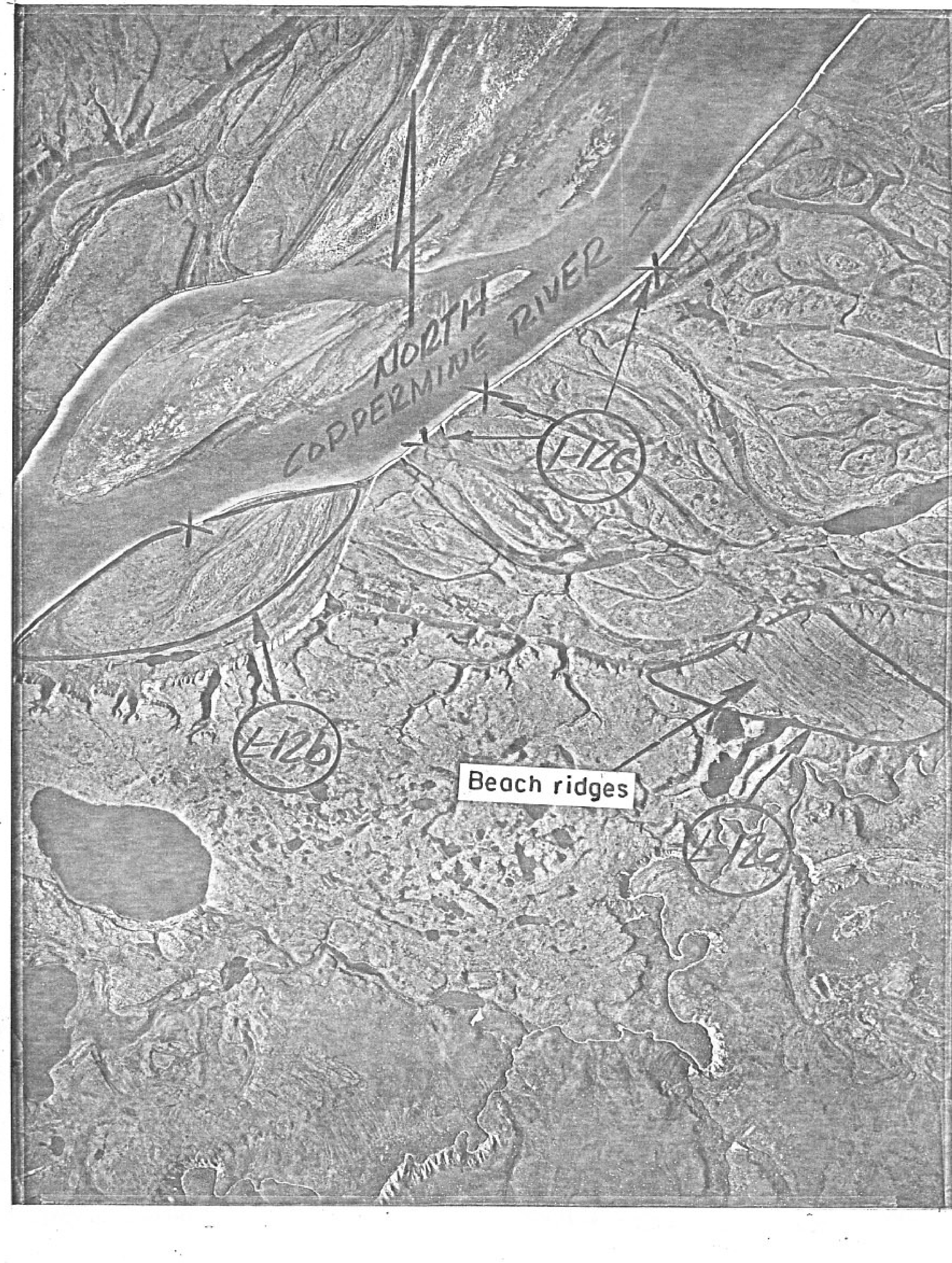
PROSPECT L-11

Figure 13



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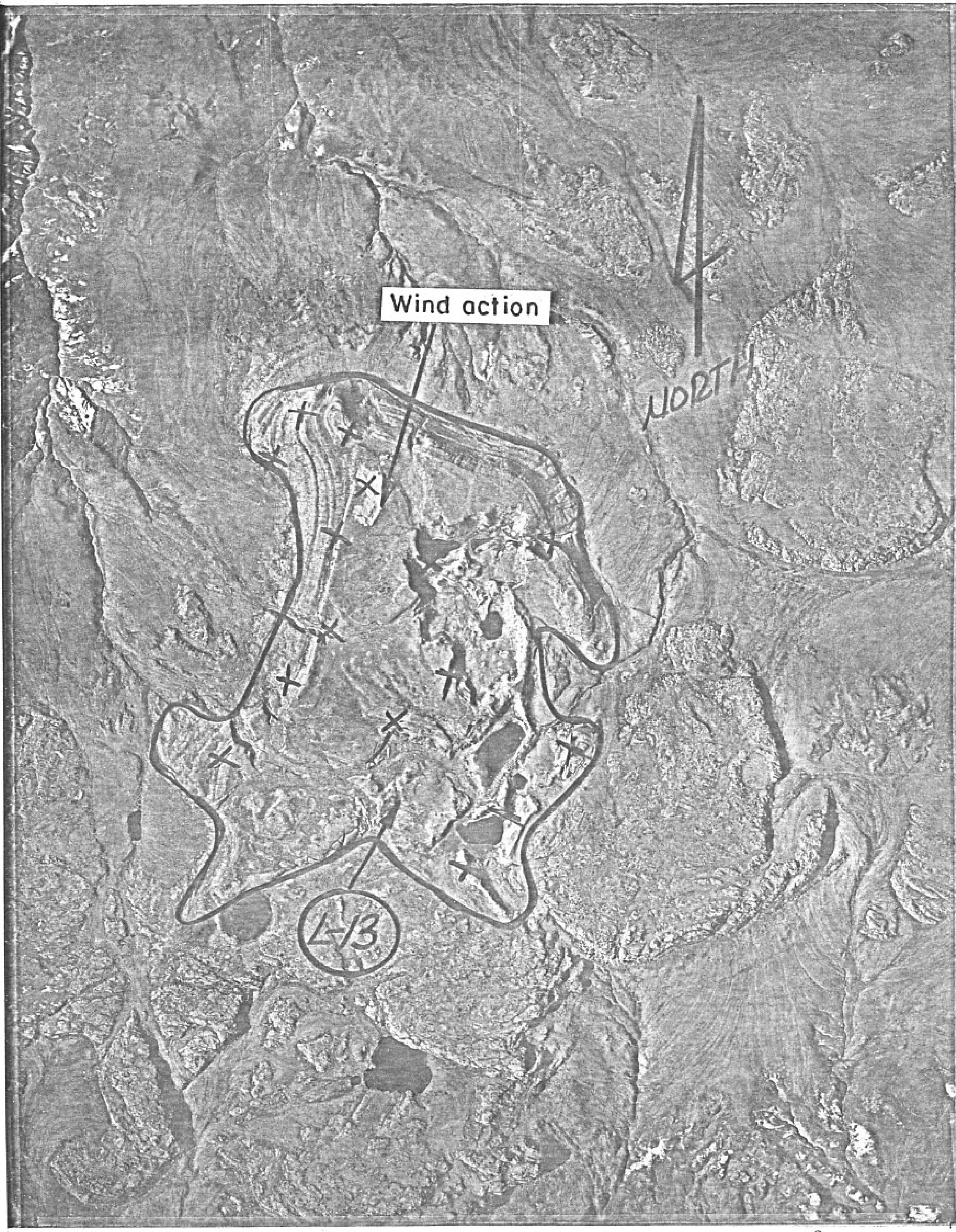
PROSPECT L-12 a, b & c

Figure 14



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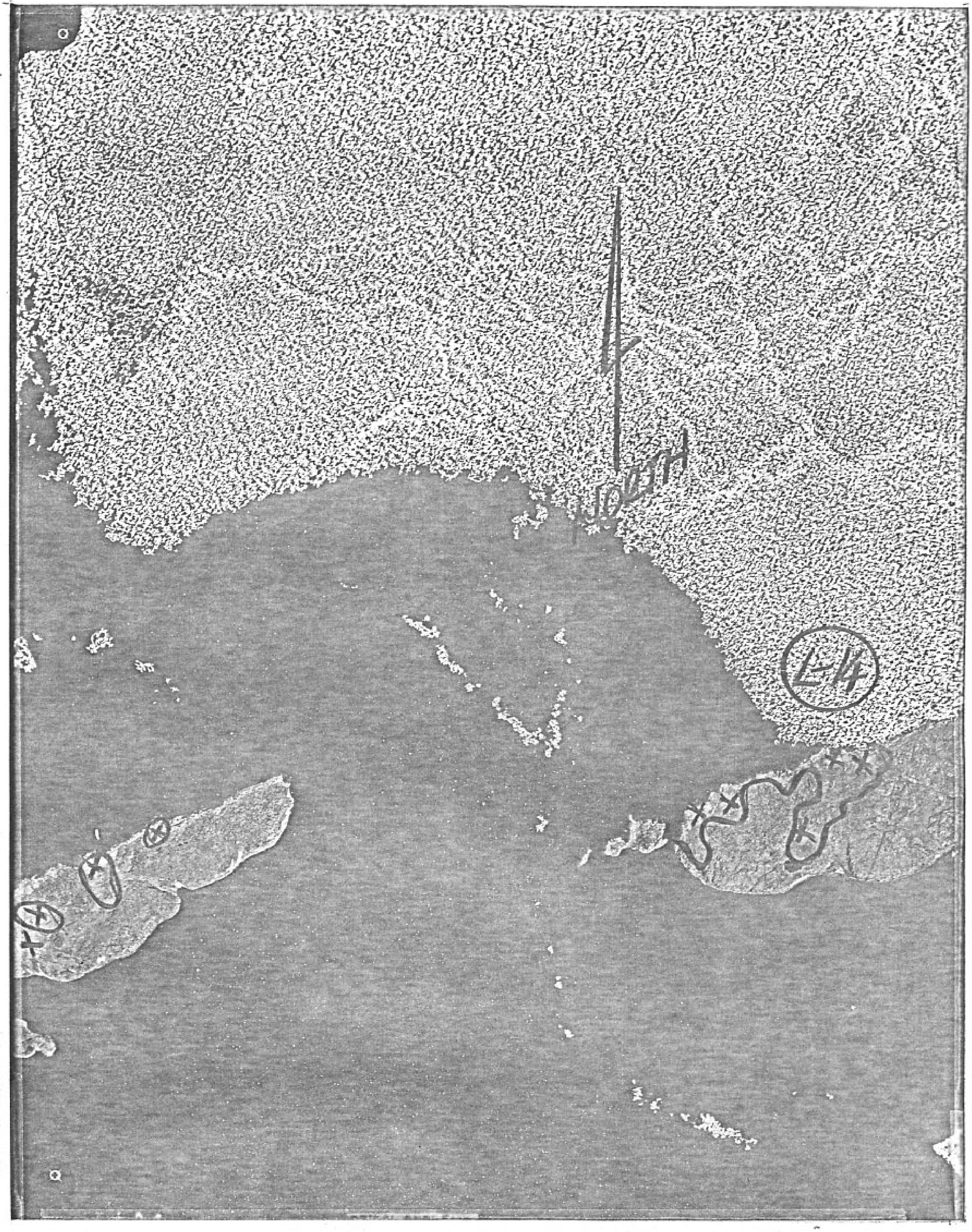
PROSPECT L-13

Figure 15



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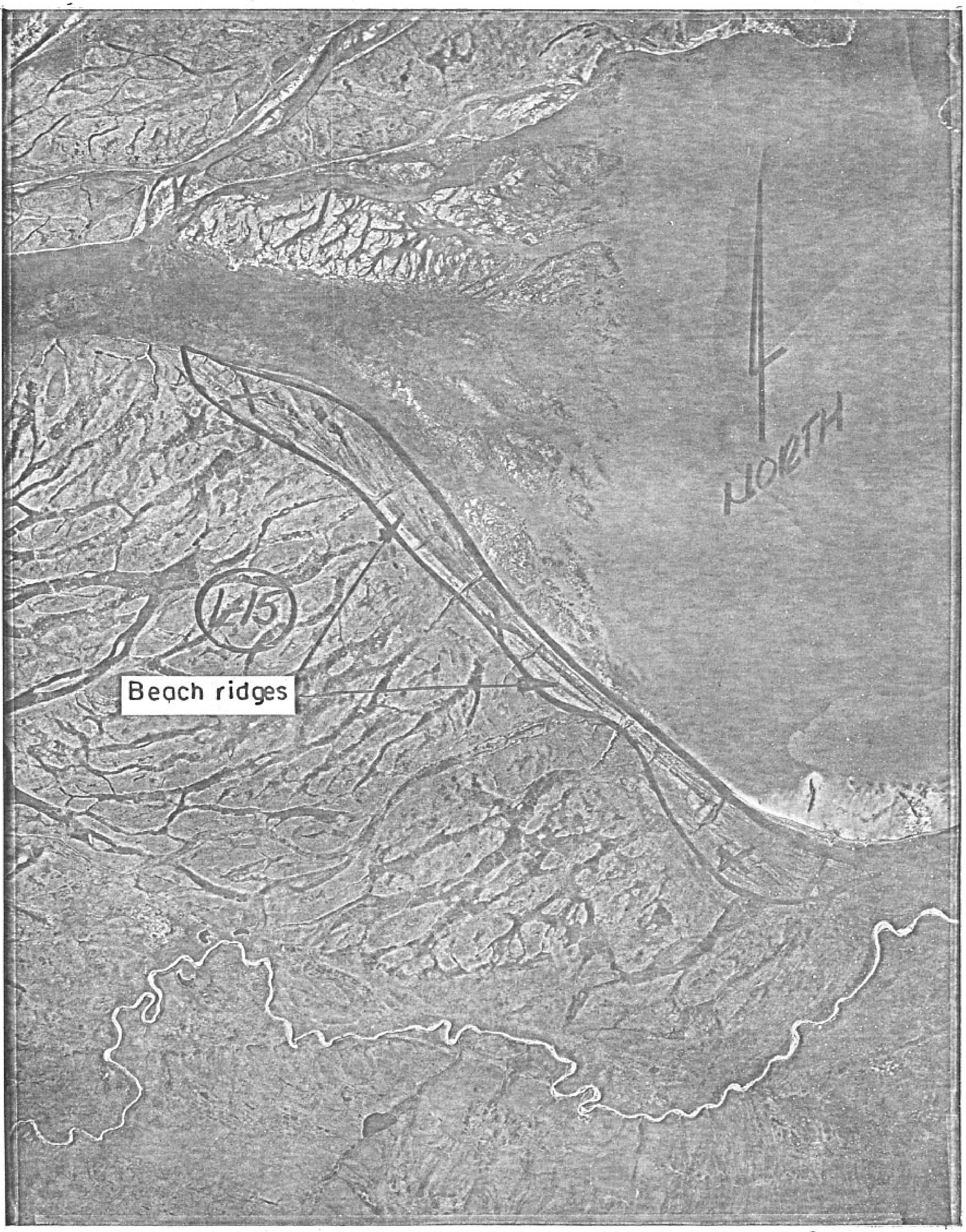
PROSPECT L- 14

Figure 16



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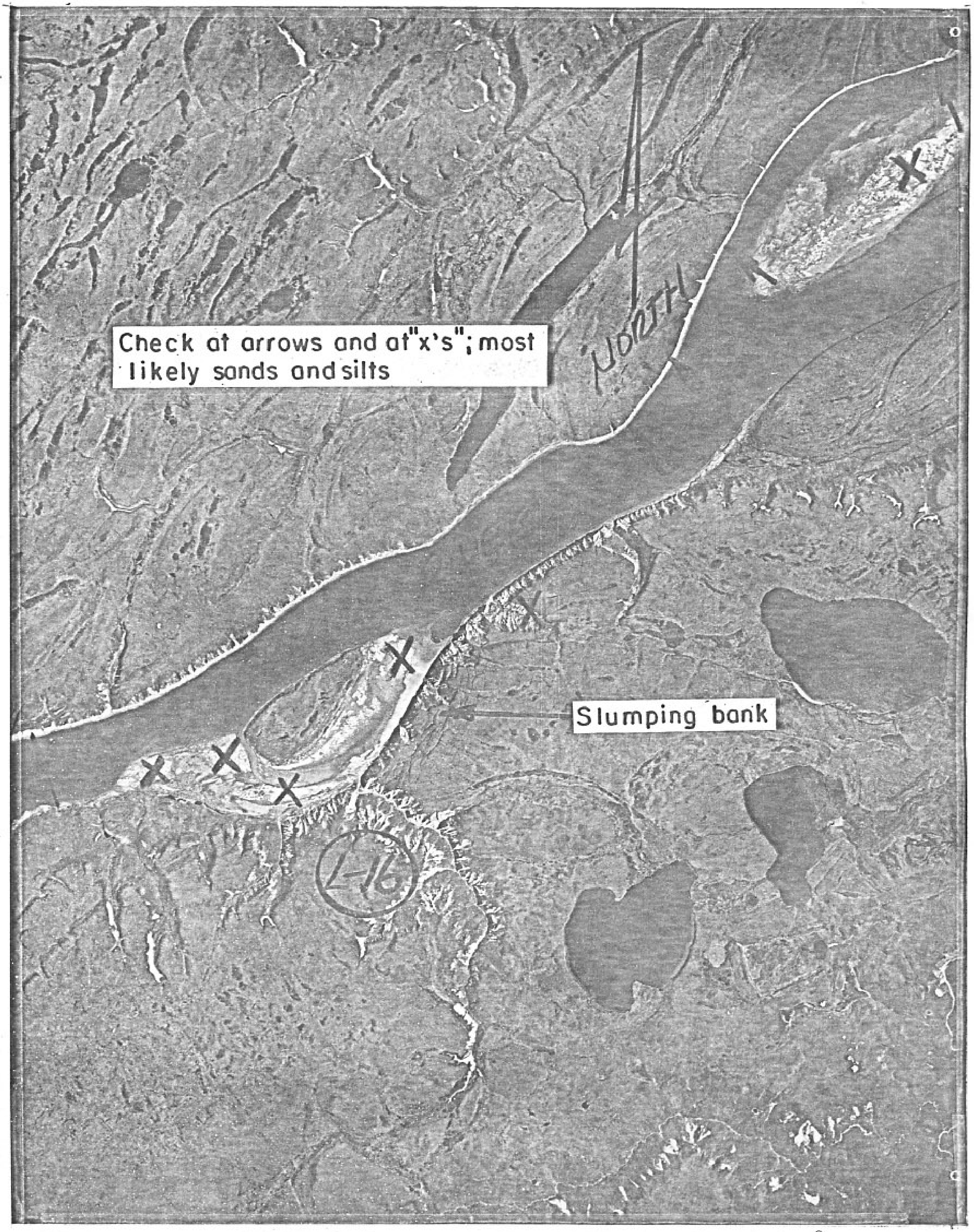
PROSPECT L - 15

Figure 17



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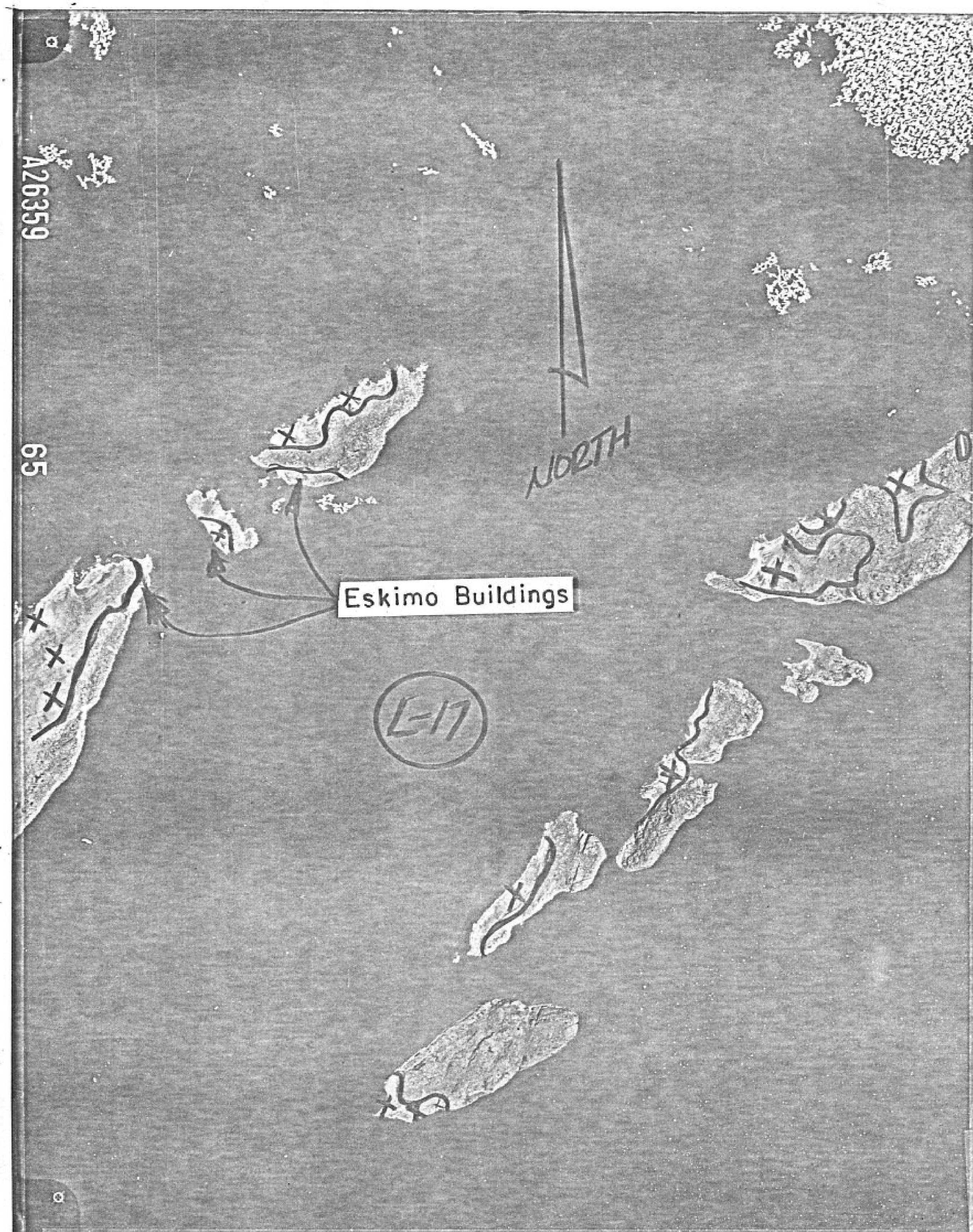
PROSPECT L-16

Figure 18



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PROSPECT L-17

Figure 19

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PROSPECT L - 18

Figure 20

PROSPECTS 1 to 40

PHOTOMOSAIC SHOWING MINERAL AGGREGATES PROSPECTS IDENTIFIED IN 1:60,000 SCALE AIRPHOTOS SEE REPORT FOR DESCRIPTIONS

0 1 2 3 4 5 6 km

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COMPOSITE MOSAIC MAP 1

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