Paper G 20

A STUDY OF THE TEMPORAL CHANGES RECORDED BY ERTS AND THEIR GEOLOGICAL SIGNIFICANCE

Harold D. Moore and Alan F. Gregory, *Gregory Geoscience Ltd., 1750 Courtwood Cr., Ottawa*

ABSTRACT

The temporal changes that are recorded by ERTS were evaluated for an area around Bathurst Inlet in the North West Territories. The seasons represented by the images included: early winter, spring, early summer, summer, and fall.

Numerous surface characteristics (vegetation, drainage patterns, surface texture, lineament systems and topographic relief, etc.) were used to relate the change in observable features with the different seasons.

It was found that the time of year when an observation is made has a strong control over the amount and type of information that can be derived by an experienced interpreter.

An example of this type of seasonal control over observables, is the fact that on the winter images one can see an extensive hummocky morainal deposit and much bedrock structure which cannot be seen, or not as easily so, on the summer image. In a similar fashion, one can see on the summer image a vegetation pattern which may be related to the distribution of lacustrine and marine clay deposits. Such a vegetation pattern is of course covered during the arctic winter. Many other such examples of temporal changes were recorded in the study.

It is therefore concluded that a detailed study of temporal changes is an important part of any ERTS interpretation for geology.

Introduction:

The data from ERTS-1 over the past year have recorded a full cycle of the seasons. In view of this, a company-supported project was started to study and evaluate, by means of visual analysis, the attendant spectral and temporal changes, and their significance to geological interpretation.

Terrestrial Canada, being located in the northern latitudes between 42°N and 83°N, has a wide variety of seasonal conditions which are faithfully recorded by ERTS. Canadian terrain is even more varied than the seasonal conditions, with geology ranging from Precambrian rocks over 2.5 billion years old to unconsolidated Pleistocene sediments deposited during the last ice age.

With such a great variety of seasonal and surficial conditions, it is obvious that the conclusions drawn from this study for one particular area in the Arctic tundra may have to be modified for use in a different area. However, this study should comprise a useful foundation for similar studies in other areas with different environments.

Area of Study:

The Bathurst Inlet area was chosen for this study because of its great variety of surficial and seasonal conditions. Other favourable factors were good continuous ERTS coverage and up to date mapping of the bedrock and surficial geology.

The Bathurst Inlet area is located on the Arctic coast of Canada and is cut by the Arctic Circle. As described by Fraser (1964) and Tremblay (1968), the topography is rugged, rising from sea level to over 650 m. with relief as great as 500 m. in some places.

The Pleistocene features in this area are quite varied in size and distribution ranging from eskers up to 120 km. long and 58 m. high to hummocky morainal deposits, which may cover thousands of square km. (Bird, 1961). Although the area is north of the tree line, one can still find a wide range of plant life. (Bird, ibid).

A generalized geological map of the area taken from work done by (Fraser, 1964, Tremblay, 1968) is present in (figure 1). All the rocks of the area are of Precambrian age, with a thick group of Proterozoic sedimentary rocks lying uncomformably above Archean basement rocks. The uncomformity between the Proterozoic and Archean has had a

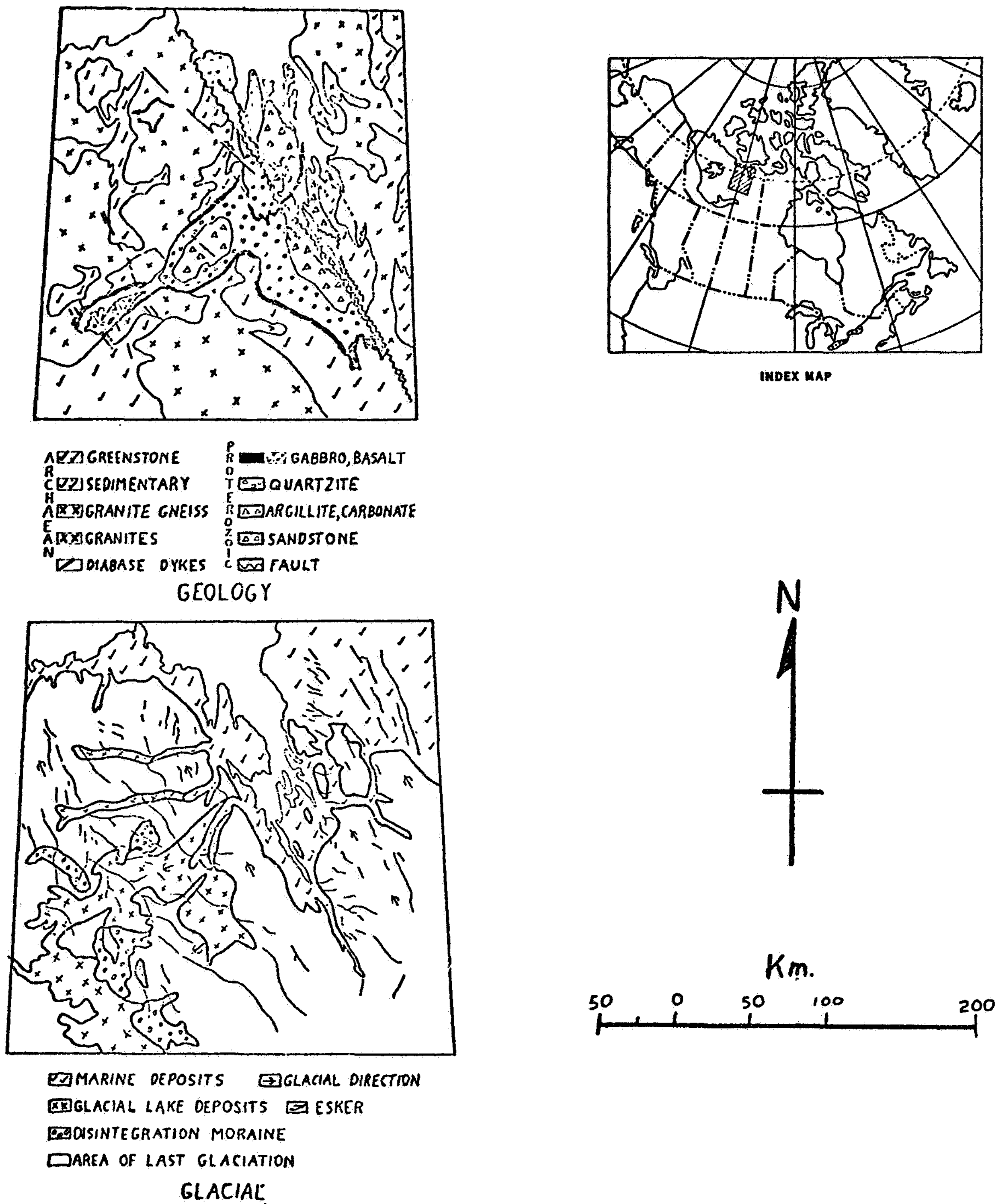

Figure 1. Bedrock and Surficial Geology Maps Bathurst Inlet, N.W.T. (after Bird & Bird 1961, Douglas 1968, Fraser 1964, Prest et al 1967, Tremblay 1968)

October 9, 1972

May 30, 1973

June 18, 1973

Figure 2. ERTS 1 imagery for three different seasons. Bathurst Inlet, N.W.T.

very strong control over the implacement of an extensive group of gabbroic sills which almost completely rim the Proterozoic basin. Numerous diabase dykes, with a common strike of N 25^{o} W, are found in the western part of the area. Several fault sets cut the area, the most prominent of which is the Bathurst fault zone with vertical relief of up to 330 m (Fraser 1964).

Method of Interpretation

Before starting the interpretation, data for all the seasons should be studied to find suitable imagery. Because ERTS images of any given area are obtained every eighteen days, there is a good possibility that high quality images can be found for each of the seasons.

Three sets of images suitable for study were available for this area at the time this investigation was started (summer 1973). Since that time, however, two more sets of images have become available, thus completing the full annual cycle. The two latest sets of images have not yet been analyzed.

The great volume of data which is used in a geological interpretation was found to be a problem when one tried to do a temporal analysis for the three sets of images without an organized plan of attack. Therefore all the observables which can be used in a geological interpretation were divided into groups to be analyzed one at a time (structure, geomorphology, vegetation, lithology, drainage patterns, etc.)

The interpretative procedures were thus based on the sequential analysis of the different types of observables. This allowed the interpreter to concentrate on one type of observable at a time, and therefore pick out changes of a more subtle nature. The information which was gained from the interpretation was then validated by comparison with existing maps. Ultimately a composite interpretation will be prepared by integrating the individual interpretations.

In summary the establishment of a systematic procedure for interpretation provides two major benefits:

1. A step-by-step approach is repeatable, and therefore all the seasonal imagery can be analyzed in the same way.

2. Sequential focusing on selected sets of data in the image allows the interpreter to obtain a maximum amount of information from subtle details in the least amount of time.

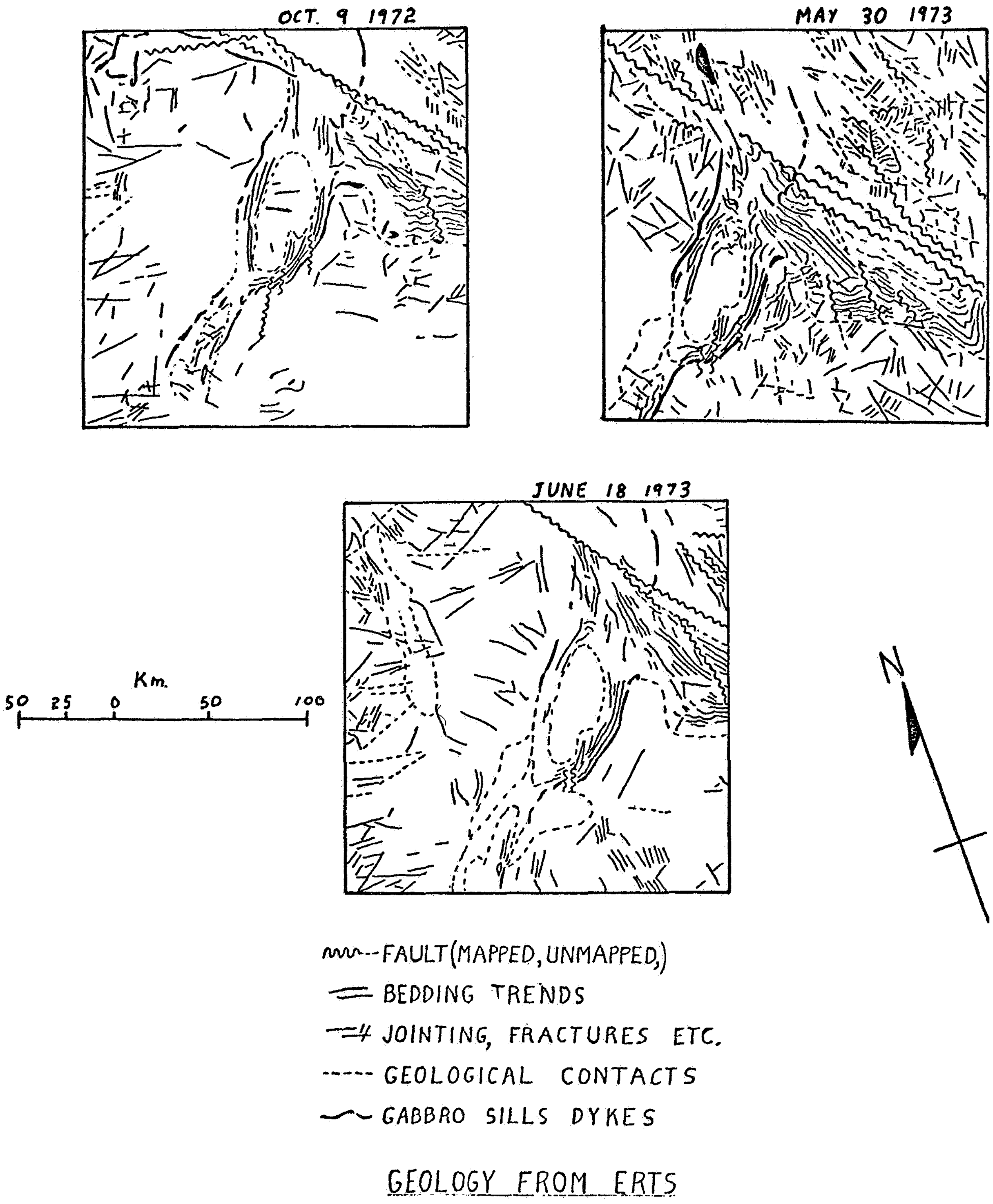

Figure 3. Structural geology from ERTS. Interpretations showing variation in interpretable structural details for three different seasons. Bathurst Inlet, N.W.T.

Observations:

Validation of the interpretations was based on published data (Fraser 1964, Tremblay 1968, Bird 1961, Douglas 1968, Prest et al 1967) which are compiled at small scale in (figure 1). The degree of correlation between the ERTS data and the existing maps was found to vary depending on the type of geological feature that was being studied. The ability of ERTS to record geological data through the seasons can be summerized, from this study as follows:

1. Structure:

As other investigators have reported, ERTS data record structural details, commonly revealing high correlation with existing maps, or, in many cases augmenting them. There is however a difference in what can be seen in images for each of the seasons (figure 3). These seasonal differences are in the amount and type of structural detail. As can be seen in the structural interpretations for the three seasons (figure 3), the larger structural features were recorded in all seasons. However, it is obvious that the May 30 image has the greatest amount of information. On the other hand, the May 30 image required a longer time for interpretation relative to the October image.

Seasonal feature-enhancement is the primary reason for the differences in structure which were interpreted for the three seasons. The three types of seasonal enhancement of structure which were found in this study are:

1.1 Shadow enhancement which occurs in October when the angle of sun elevation is quite low (Gregory 1973). The sun elevation for the image used in this study was 25^{o}, however elevations as low as 3^{o} have been used in other areas.

1.2 Residual snow enhancement is found in the May image with the last snows of winter remaining in shaded and low-lying areas.

1.3 Drainage pattern enhancement can be found in the June image with melt waters filling the drainage system, and outlining joints, faults, fractures, and topographic lineaments.

When the recorded data were compared with the ground truth, it was found that many structural features could be identified in addition to those on the maps.

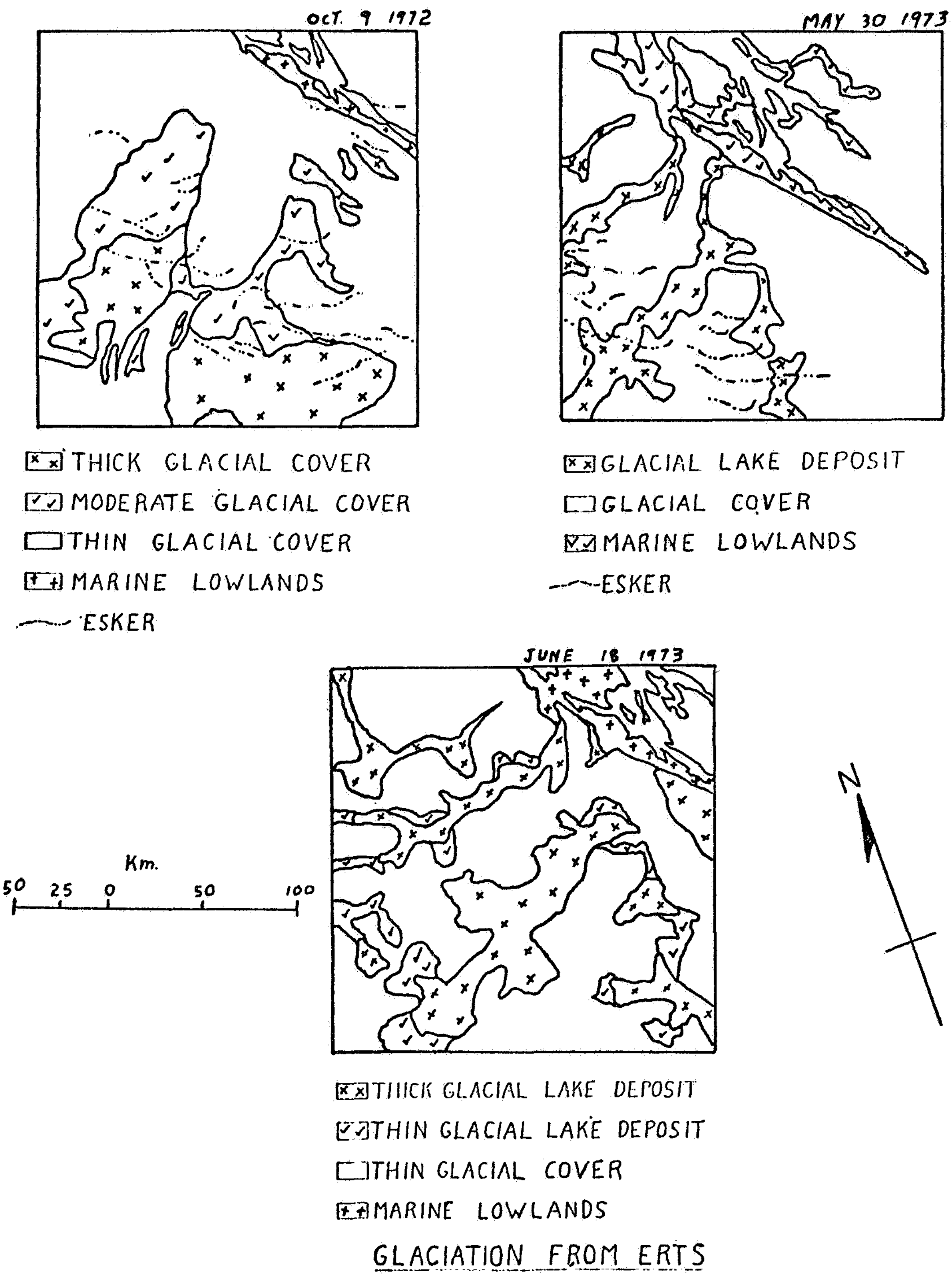

Figure 4. Glacial geology from ERTS. Interpretations showing variation in interpretable glacial observables for three different seasons. Bathurst Inlet, N.W.T.

Thus it would appear that selected ERTS images comprise an excellent basis for mapping structural feature, and that a temporal study of structure provides additional information at little extra cost.

2. Glacial Deposits:

The Glacial Map of Canada (Prest et al 1967) which is a compilation of airphoto interpretations for the whole country was the source of ground truth for this part of the interpretation. As can be seen in (figure 4), each of the seasonal images recorded a different distribution of surficial materials. The reasons for these differences are believed to represent different types of seasonal feature-enhancement. Some of these are the same as those for structure, but vegetation is tentatively considered to provide an additional type of enhancement.

2.1 In the October image, the low sun angle enhances the eskers and moraines. The blanket of snow also helped enhance the morainal material by cutting out other "Terrain noise".

2.2 Residual snow enhancement is prominent in the May image, especially for drumblin fields and esker swarms. Note also the first signs of new vegetative growth which seem to be related to the distribution of marine and lacustrine clay deposits. This apparent relationship between the lush vegetative growth and clay deposits possibly is caused by a higher content of nutrients in the clay, and abundance of water as a result of poor drainage in the clays.

2.3 In the June image the vegetative enhancement is a lot more prominent and along with drainage patterns gives a good outline of the marine and lacustrine clay deposits.

Without this temporal analysis a lot of information about the glacial deposits of the area would have been lost even though ERTS had recorded it.

3. Lithology:

As it has been observed by Chagarlanudi (1973) and many others, ERTS will, in most cases, give only a fair to poor picture of the true lithological distribution. Most lithological information is gained from ERTS data by the identification and extrapolation of geomorphological features. All the seasonal feature enhancements previously mentioned will help in identifying geomorphological feature and, therefore, lithological features. Thus depending on the abundance of outcrop it may be possible for a person without prior knowledge of the area to prepare from an ERTS image a rapid though tentative analysis of the distribution of rock types. If some ground truth is available, it may be possible to prepare a preliminary, small scale geological map.

Conclusions:

1. Nearly all geological studies of ERTS images can benefit to some degree by a temporal analysis.

2. Temporal analysis will probably be very useful in other disciplines.

3. Four types of seasonal feature-enhancement were found in this study. They are: shadow enhancement, residual snow enhancement, drainage pattern enhancement, and vegetative enhancement.

4. Analysis of such seasonal changes in observables can increase the amount of information that can be derived from ERTS data, or help to enhance one type of data.

5. The amount of information which can be obtained from ERTS data can be maximized by doing a temporal analysis and afterwards compiling the individual interpretations into a composite interpretation.

6. Temporal analysis will increase the already proven ability of ERTS to record structural data. This new perspective and detail may help to solve the geological problem of the long-hypothesized link between ore deposits and lineaments.

7. The most significant temporal changes are those related to glacial deposits; therefore, the study of such deposits will benefit from temporal analysis.

8. Where formations are reasonably well exposed ERTS data can be used to prepare a preliminary map, especially if some ground truth is available to assist in identifying rock types.

References

1.	J. B. Bird	"Bathurst Inlet N.W.T." Department of Mines and Technical Surveys Geographical Branch Memoir #7.
2.	P. Chagarlamudi	"Correlation of Geology, Geophysics and Satellite Imagery Information in the Stoney Rapids Area N. Sask." Unpublished.
3.	R. J. W. Douglas (1968)	"Geological Map of Canada 1:5,000,000" Map # 1250 A.
4.	J. A. Fraser (1964)	"Geological Notes on Northeastern District of Mackenzie" Geological Survey of Canada paper 63-40.
5.	A. F. Gregory (1973)	"Preliminary Assessment of Geological Applications of ERTS-1 Imagery From Selected Areas of the Canadian Arctic". ERTS-1 Symposium on Significant Results. March 5 - 9 1973, Vol.#1 Sec. A.
6.	V. K. Prest D. R. Grant V. N. Rampton (1967)	"Glacial Map of Canada 1:5,000,000" Map #1253 A
7.	L. P. Tremblay (1968)	"Preliminary Account of The Goulburn Group N.W.T. Canada" Geological Survey of Canada paper 67-8