IMPLEMENTING GEOMATICS TECHNOLOGY FOR AGGREGATE EXPLORATION, NORTHEAST BRITISH COLUMBIA

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ABSTRACT

Leveraging the spatial data resources of the Province of British Columbia and industry partners, geomatics technologies and techniques have been successfully implemented in the exploration for construction aggregates in Northeast BC. The pairing of GIS and GPS technology on laptop computers allows for real-time navigation and for morphometric and vegetative analysis methods to be tested and refined in the field. High resolution orthophotos and LiDAR DEMs enable precise navigation to features of interest and for the discovery of geomorphic features and systems not apparent using traditional photogrammetric methods. Handheld PC data collection and nightly compilation and distribution has ensured that the entire project team is familiar with all exploration activity and that an up to date record of locations visited is maintained. Information on the locations of digital photographs taken and samples collected is also available from the relational database into which the data from the handheld PCs is downloaded.

The integration of these technologies has provided improvements in efficiency as well as in the ability of geologists to identify potential aggregate sources in the field.

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INTRODUCTION

In June 2003, the Province of British Columbia initiated the Oil & Gas Development Strategy, which outlined four key pillars to the Oil & Gas Industry in British Columbia: Roads, Royalties, Service Sector and Regulation. In response to an increase in demand for gravel and a chronic shortage of supply, a group was formed within the Ministry of Energy and Mines (MEM) to explore for suitable construction aggregate deposits in northeast BC (Figure 1) to support the upgrade and construction of oil and gas roads. This paper reviews the geomatics technologies and data that have been used in this program.

Aggregate shortages elsewhere in the province have been addressed by utilizing sources such as bedrock quarries and dredged river gravels. In northeast British Columbia, however, large fluvial systems capable of transporting sands and gravels appropriate for construction aggregate are geographically limited. Incompetent local sandstone and shale bedrock are unsuitable for crushing. As a result, expensive solutions such as transporting aggregates into the region 400 km by train and then 50 km by truck have been utilized.

From the outset, MEM has researched and implemented new technologies and used innovative datasets to assist in office and field based data collection, analysis, visualization, and presentation. This has resulted in significant success both in improving

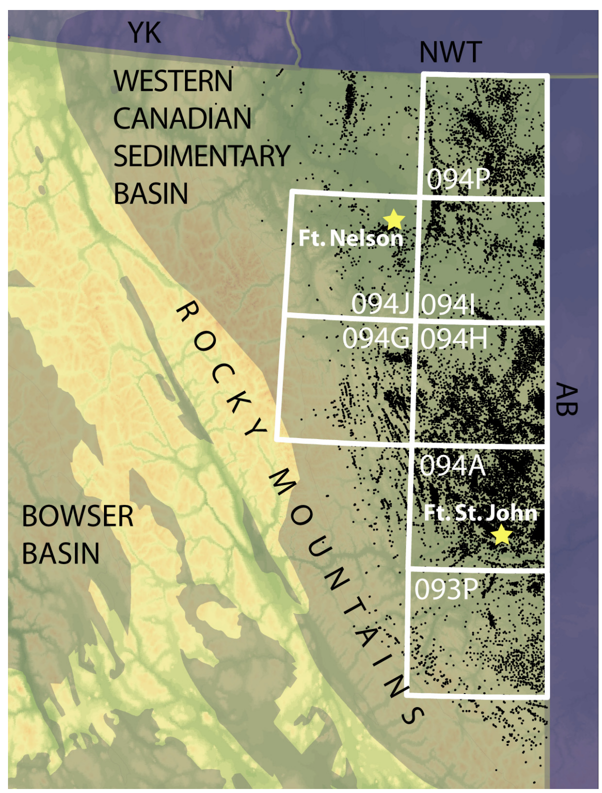

Figure 1. Location of study area. Aggregate inventory and exploration activities are currently taking place in seven 1:250 000-scale NTS map areas. Oil and gas wells drilled to date are shown in black.

operational efficiencies and in discovering resources which otherwise may not have been found. This success has also been due to the collaboration between federal and provincial government agencies and industry partners and the contributions of high quality data from all parties involved.

AGGREGATE EXPLORATION

Construction aggregate exploration is a field that combines the disciplines of Quaternary geology, geomorphology, geotechnical engineering and geophysics, and focuses on a process based examination of surficial geology. Conceptually, aggregate exploration can be thought of as having three discrete but interrelated stages or components:

1. Office based interpretation includes:
    a. Examination of existing literature (e.g. geological reports),
    b. Air photo interpretation,
    c. Compilation of spatial data sets,
    d. Identification and compilation of areas with aggregate potential, and
    e. Preparing maps for fieldwork.
2. Fieldwork:
    a. Field-checking or ground-truthing of areas thought to have aggregate potential,
    b. Sampling of prospects to confirm presence/absence of granular material, and
    c. Detailed geotechnical evaluation of aggregate quality and quantity.
3. Office based data compilation, analysis, visualization, and presentation:
    a. Compiling and reviewing field observations,
    b. Analysis and mapping of data,
    c. Refinement of interpretations, and
    d. Publishing results.

Various geomatics technologies are implemented in all three stages. These allow for enhanced interpretations and refined analysis both in the office and in the field. Several innovative techniques and data sets have been used, some of which are summarized by Best *et al.* (2004) and Demchuk *et al.* (2005, this volume).

GEOMATICS TECHNOLOGY

The utility of hardware and software technology, regardless of application, is dependent on how it is implemented. Making technology work requires an understanding of research questions that need to be answered and in the case of aggregate exploration, an understanding of geologic and geomorphic processes as well. It is also important to understand, from a geomatics perspective, what data are suitable for a given application.

In the discussion that follows, hardware and software, data, and data processing and analysis, as they apply to aggregate exploration, will be addressed separately. In cases where commercial hardware or software are described, alternative solutions to those used by MEM in northeast BC will be mentioned.

Hardware and Software

The backbone to the systems implemented is a Geographic Information System (GIS) which allows for the combination and analysis of spatial data and geo-rectified imagery. ArcGIS (ESRI) is the corporate GIS standard for the Province of BC and thus the vast majority of data available from the provincial data warehouse is available in ESRI format (shapefile / coverage / SDE). ArcGIS was therefore the obvious choice for use in project activities. Some alternative options to this software would be AutoCad Map, MapInfo, Manifold GIS or GlobalMapper, which are other commercially available GIS packages that allow for the visualization and analysis of a wide range of spatial data. PC laptop computers have been configured with ESRI ArcGIS 8.2, and ArcView 3.2 and equipped with mobile AC/DC power inverters to allow for use away from standard AC power in the field.

Navigating in the plains region of northeast BC is challenging as the area is largely forested, has subdued topography and few natural landmarks suitable for establishing accurate locations. To overcome this difficulty, real-time tracking software on the laptop computers is used in combination with a GPS to provide consistent, accurate positional information (Figure 2).

The DNR Garmin extension (Minnesota DNR) was used in conjunction with ESRI ArcView 3.2 GIS software and Garmin Handheld GPS units (Figure 2). Although used almost exclusively for this project, this is not the only option for real-time tracking capabilities. For example, GlobalMapper and ESRI ArcGIS 8.3+ GIS, in conjunction with any NMEA compliant GPS unit, provide similar functionality.

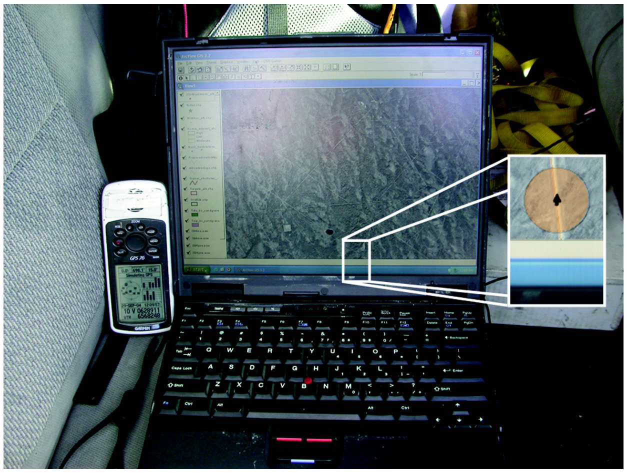

Figure 2. Laptop and GPS with tracking system enabled, arrow shows present location on orthophoto in the GIS.

The benefits of real-time tracking are two-fold. Firstly, it enables field crews to identify their location quickly and accurately at any time. At the same time, field crews are able to examine digital orthophotographs and other spatial data sets while making and recording observations from the ground. Secondly, centerlines for newly constructed roads, not existing in the spatial data sets collected prior to the field season, can be mapped using the tracking system. This has resulted in an up-to-date and accurate digital record of the road network in northeast BC.

For field data collection, handheld personal digital assistant computers are used. A Palm OS based solution, running Pendragon Forms data collection software, was chosen, similar to that developed by Gilbert *et al.* (2001a, 2001b). A relational database developed by the Alberta Geological Survey (Fenton *et al.*, 2002) has been modified and is used to record information on geomorphic and geologic characteristics of field stations, paleo-flow direction, sample locations, photo numbers and locations. Data is downloaded into a MS Access database at field camps and distributed to all laptop computers frequently, giving field crews the most up-to-date information for use in analysis and interpretation of other spatial data sets in the GIS and for the planning of future traverses.

Other field data collection solutions are available. For example, ESRI ArcPad software and PocketPC hardware provide similar functionality, as well as additional features such as a 'light' GIS on the PocketPC itself. This implementation is described by Irwin (2003).

Data

Prior to the field season, spatial data and imagery are collected from the large (>2 terabyte) data holdings of the Province of British Columbia. This includes:

- 1:20000 scale base mapping (hydrography, hypsography, transportation)
- Public and resource roads
- Digital orthophotography
- Landsat 7TM satellite imagery
- 1:20000 vegetation mapping
- 1:20000 digital elevation models
- Bedrock geology
- Crown tenure (including aggregate reserves)
- Water well location and lithology
- Aggregate potential mapping

Data held by private companies are also compiled and includes:

- Petroleum industry "rathole" drilling information
- Petroleum industry water well drilling information
- 2 m spacing, Light Detection and Ranging (LiDAR) elevation models
- Petroleum industry seismic shothole drilling information

Data Processing and Analysis

Data is standardized and compiled into a comprehensive GIS database, used to identify potential aggregate targets prior to field investigations. This information is then transferred to the laptop computers to be taken to the field. The same systems used in the office to generate potential aggregate targets are used in the field for ground-truthing.

Techniques used to identify potential aggregate deposits from the datasets compiled include:

- analysing the relationship between vegetation and ground conditions
- reprocessing elevation model data (LiDAR and traditional DEM) to automate delineation and classification of raised landforms
- classifying multiple, independent, sub-surface data sets to identify areas where gravel was concurrently identified.

There are anecdotal reports of a link between stands of lodgepole pine (Pinus contorta var. latifolia) and sand and gravel deposits. This phenomena was observed in the field on several occasions. Attempts to identify sand or gravel by navigating to stands of pine as identified by digital vegetation data has met with mixed results, however. The distribution of lodgepole pine stands appears to be a result of the adaptability of the species and its colonizing ability after fire (Ministry of Forests, 2005). Vegetation characteristics of known sand and gravel deposits continue to be examined and recorded.

By far the two most beneficial data sets used thus far have been the digital orthophotography and LiDAR. The ability to have a 'birds eye view' of a location while observing it from the ground has proved to be invaluable. The ability of the LiDAR to penetrate vegetative cover is also crucial in providing the ability to identify subtle features not always apparent using traditional photogrammetric methods. More information on the use of LiDAR in aggregate exploration can be found in Demchuk et al (2005, this volume).

CONCLUSIONS

Real-time navigation allows for field geologists to gain a more thorough understanding of the characteristics of the region and the relationship between the appearance of features on aerial photographs and on the ground. It also allows for quicker and easier navigation to features of interest observed in aerial photographs or LiDAR data. Digital field data collection allows for frequent updating of progress in the field and rapid compilation of data in the office. Over 1000 field stations and sample locations and several thousand digital photographs have been collected to date and are managed in a relational database.

There exists an exciting potential to further improve on the hardware used in aggregate exploration by implementing new technologies, particularly for field data collection. Five discrete pieces of technology are used in this program; GPS, PDA, digital camera, GIS and laptop computer. While it would be possible to use only a PDA with ArcPad (ESRI) GIS software, with an attached GPS receiver and digital camera, this is not a suitably robust system at the present time. Bluetooth enabled hardware may improve the connectivity between discrete hardware pieces in the short term. We believe, with the current popularity of location-based service provision in the business geomatics industry, a hardware solution integrating communications (cell phone), GPS, digital photography, GIS and a PDA will be available in the near future.

Ultimately the technologies described have helped in the discovery of six deposits with an estimated resource of more than 5 million m3 of sand and gravel and 24 additional prospects with the potential to host significant quantities of granular material (Ferbey *et al.*, 2005, this volume). Prior to the initiation of the aggregate exploration program, there was thought to be little or no remaining aggregate reserves.

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