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ERRATA:

The publisher/department name in the bibliographic reference cited immediately below the title of each GS report should read

Manitoba Industry, Economic Development and Mines instead of **Manitoba Industry, Trade and Mines**.

Manitoba Geological Survey 2003: The search for diamonds in Manitoba: an update; *in* Report of Activities 2003, Manitoba Industry, Trade and Mines, Manitoba Geological Survey, p. 239–246.



Summary

Although results from kimberlite indicator-mineral (KIM) surveys in the past 20 years have been promising, no discoveries of diamondiferous kimberlite have been announced in Manitoba. Diamondiferous kimberlites have been discovered in the adjacent provinces of Saskatchewan and Ontario, as well as in the Northwest Territories and Nunavut, and there is no fundamental geological reason to expect that kimberlites should not be present in Manitoba.

In order to provide geoscience support to the diamond exploration effort in Manitoba, the Manitoba Geological Survey (MGS) is in the process of compiling all geological data pertinent to kimberlites in Manitoba, including

- 1) compilation of a KIM database which will include all published indicator mineral data from regional and detailed MGS sampling programs;
- 2) resubmission of archived till samples for KIM and geochemical analysis;
- 3) a petrographic, geochemical and geochronological investigation of drillcore, from the Wekusko Lake area, that contains an intersection of possible kimberlite;
- 4) compilation of various provincial datasets in order to delineate anomalies with kimberlite potential; and
- 5) assessment of till stratigraphy in the Hudson Bay Lowland.

Regional surveys

The Manitoba Geological Survey is in the process of compiling existing regional KIM survey data (Fig. GS-31-1) by constructing an appropriate database to house the information. This compilation is necessary because the existing published data are in different formats and media. In their present form, the datasets cannot be manipulated to form a coherent package for release on the Internet, nor can they be combined with other datasets in a GIS. The goal of this compilation project is to bring all existing published data to an Internet map server (IMS) service that will be accessible through the departmental website.

The compiled database will house sample location data, preparation and reference data, as well as microprobe analyses of heavy mineral grains. It is anticipated that till geochemical data will be appended to the database in the future, as well as other indicator mineral data such as metamorphosed massive sulphide indicator minerals (MMSIM). Once complete, the database will be searchable by geographic area and/or mineral or chemical attributes. Several other query options are being investigated. Due to the relative scarcity of KIM data, the database is not intended for detailed exploration but rather will provide a regional context for exploration in Manitoba.

Regional till sampling programs tend to space samples on the order of tens of kilometres apart. These surveys provide background levels for comparison to results from follow-up detailed sampling. Detailed sampling programs tend to have a sample spacing of approximately 1km and concentrate on areas with perceived mineral potential.

A program of systematic till sampling and surficial geological mapping led by the Geological Survey of Canada began in northwestern Manitoba in 1983 and was continued in the 1990s by the regional National Geoscience Mapping Program (NATMAP) in west-central (NTS 63J/west half and 63K) and southeastern Manitoba (NTS 52E and L, 62H and I) (McMartin, 1993; McMartin and Pringle, 1994; Matile and Fulton, 1994).

Regional till sampling has also been conducted by Matile and Thorleifson (1997) in NTS mapsheets 53E, F, K, L, M, N and O and 63G, H, I, J, O and P in support of Operation Superior (Fedikow et al., 1997a, 1997b, 1998, 1999, 2000, 2001, 2002a, 2002b; Matile and Thorleifson, 1997). The main objective of these sampling programs was to map variations in chemical and mineralogical components of till, which may be related to bedrock mineralization, as an aid to mineral exploration within the area (Kaszycki, 1989).

The northwestern Manitoba till sampling program, initiated in 1983, was completed for five 1:250 000-scale map sheets (NTS 63N, 64B, C, F and G and portions of 63K and O) (DiLabio and Kaszycki, 1986; Kaszycki and DiLabio, 1986a, 1986b; Kaszycki and Way Nee, 1986, 1989a, 1989b, 1989c, 1990a, 1990b; Kaszycki et al., 1986, 1989). In conjunction with regional till sampling by Kaszycki (1989), detailed sampling programs were conducted in the vicinity of known deposits by the then Manitoba Department of Energy and Mines. These programs were conducted to help

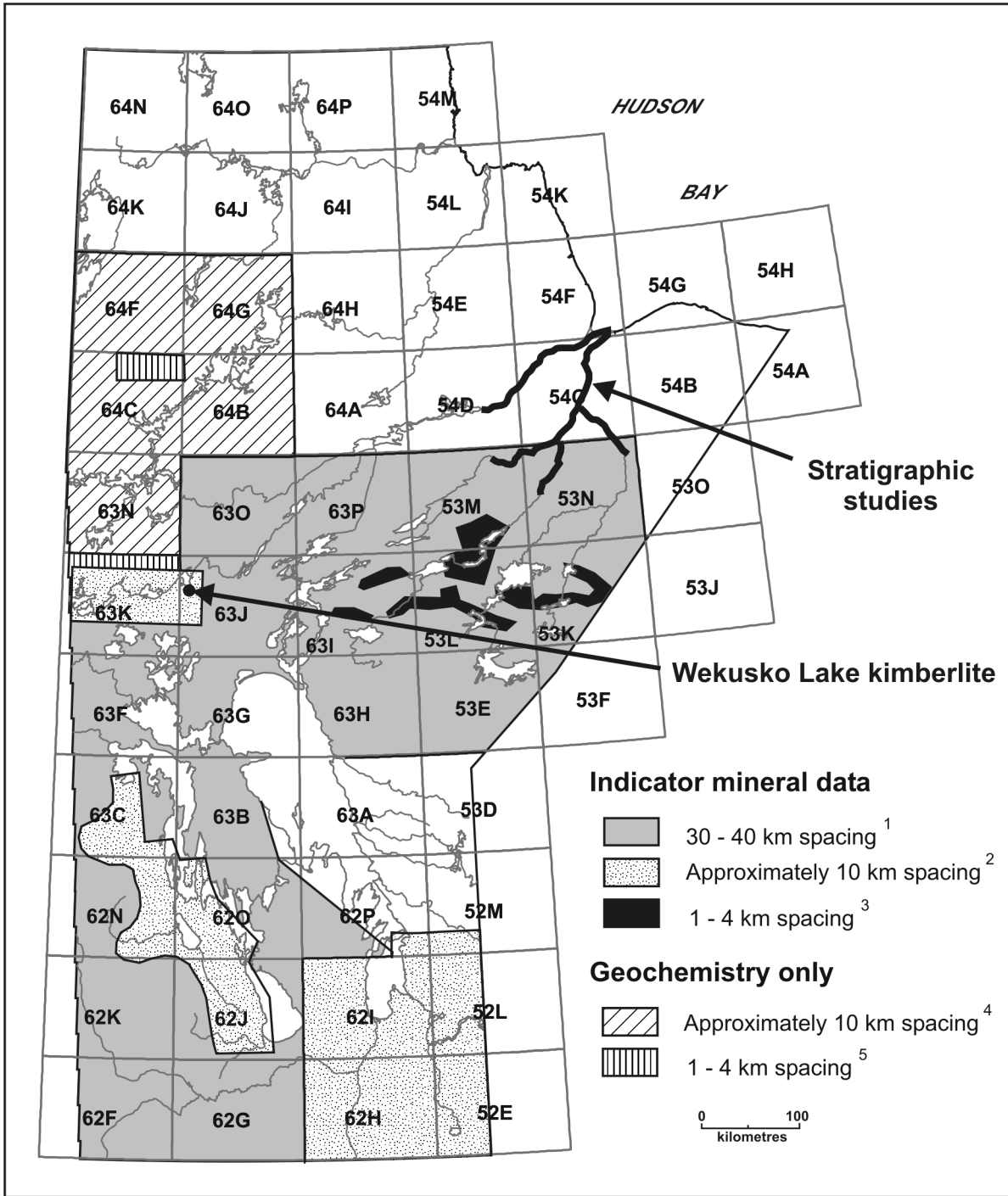


Figure GS-31-1: Regional study areas pertinent to diamond exploration in Manitoba, including stratigraphic studies (Nielsen and Fedikow, 2002), the location of the Wekusko Lake kimberlite (European Ventures Inc., 1993; Danielson and Christie, 1994), indicator mineral data: ¹Thorleifson and Garrett (1993), Thorleifson et al. (1994) and Matile and Thorleifson (1997); ²Thorleifson and Matile (1993), McMartin and Pringle (1994) and Matile et al. (1996); ³Henderson (1996), Fedikow et al. (1997a, 1997b, 1998, 1999, 2000, 2001, 2002a, 2002b), and geochemistry only studies: ⁴Kaszycki and DiLabio (1986a, 1986b), DiLabio and Kaszycki (1986), Kaszycki (1989) and McMartin et al. (1996); ⁵Nielsen and Fedikow (1987), Nielsen (1992) and Kaszycki et al. (1996).

evaluate the various types of mineralization within the region, and to understand the scale and form of glacial dispersion related to individual deposits (Nielsen, 1982, 1983, 1985, 1986a, 1986b, 1987a, 1987b; Nielsen and Graham, 1984, 1985; Nielsen et al., 1985; Nielsen and Fedikow, 1986, 1987; Nielsen and Gobert, 1988; Nielsen and Conley, 1991). Over 3000 samples were collected for these studies.

McMartin (1993) and McMartin and Pringle (1994) initiated a systematic drift prospecting program in the Shield Margin NATMAP project area (63K and 63J). Components of the study included textural, petrological and geochemical analyses of more than 1000 till samples, as well as trace element analysis of humus samples, and a regional KIM study (McMartin and Pringle, 1994).

Following this systematic approach of surficial geological mapping and regional till sampling, the MGS sampled the road-accessible portion of NTS 62P (in Manitoba's Interlake region) in conjunction with mapping of the mapsheet in the summer of 2003.

In order to support future diamond exploration activities, selected glacial till samples collected in the 1980s by E. Nielsen, I. McMartin and C. Kaszycki will be submitted for KIM and/or geochemical analyses. These samples are typically less than 2 kg in weight and will be evaluated as to their appropriateness by calibrating them against larger (20–25 kg) samples collected from orientation surveys completed in the Lynn Lake and South Indian Lake areas this summer. Results of these surveys will be used to guide analytical approaches for archival sample sets.

Results obtained during Operation Superior, a six-year multimedia project undertaken from 1996 to 2001 (Fedikow et al., 1997a, 1997b, 1998, 1999, 2000, 2001, 2002a, 2002b), provoked one of the most intense periods of exploration in Manitoba since the Thompson Nickel Belt rush in the 1950s. Following the release of the 1999 multimedia data as Open File Report OF2000-2 (Fedikow et al., 2000), permits totalling over two million hectares were taken out by 18 companies, primarily for diamond exploration. Although results from KIM surveys have been promising, there have been no publicly announced discoveries of kimberlite in Manitoba. Nevertheless, the data legacy of Operation Superior forms a key component of the new MGS KIM compilation in progress.

Till stratigraphy

During the 2001 and 2002 field seasons, till samples were collected from river sections in the northern Superior Province and adjacent Hudson Bay Lowland (Nielsen and Fedikow, 2002). This work was undertaken to provide a stratigraphic framework for diamond exploration by obtaining a better understanding of how till provenance and ice flow changed over time.

This work is being reassessed using techniques available through 3-D modelling. A 3-D model of the area sampled is being generated from the data obtained from the sampled river sections. Once modelled, each till stratum can be assessed independently to determine indicator-mineral trends on a layer-by-layer basis.

Bedrock geology

Ancient crust

Diamond producing areas in the Archean cratons (e.g., Slave and Kaapvaal) occur where ancient (>3.0 Ga) crust has been stable since the Paleoproterozoic. This association is suggested to result from the presence of thick, old Archean lithosphere (mantle root) below the stable ancient crust. Younger kimberlite magmas originate within the diamond stability field below the old and thick lithosphere. The locations of kimberlites in these areas have been linked to crustal-scale structures or zones of weakness that may have facilitated rapid kimberlite magma transport to the surface. Mafic dike swarms, terrane-bounding structures and craton margins have been identified as associations indicating areas of potential crustal-scale weakness.

In Manitoba, ancient crust has been suggested to be present in the northwest Superior craton margin, the adjacent Superior Boundary Zone (Böhm et al., 2000, 2003) and the North Caribou Terrane (Percival et al., 2002). It may also be tectonically buried beneath the Trans-Hudson Orogen, where the dominantly Neoproterozoic 'Sask Craton' has underthrust Paleoproterozoic rocks at ca. 1830 Ma (Lucas et al., 1996; Corrigan et al., 2003).

The northwest Superior craton margin hosts an ancient (~3.2 Ga) platformal supracrustal sequence (Assean Lake crust) indicating that parts of the craton (namely the Northern Superior Superterrane; Skulski et al., 2000) and/or the adjacent Superior Boundary Zone stabilized prior to 3.0 Ga and could be associated with a thick lithosphere. Current projects along the northern margin of the Superior Province have as their main goal the understanding of the crustal architecture and evolution of the region (Böhm et al., GS-12, this volume). They include 1) focussing on an understanding of a potential area of ancient crust at Gull Rapids (Böhm et al., GS-13, this volume), 2) studying major

terrane-bounding deformation zones along the Superior Boundary Zone (Kuiper et al., GS-14, this volume) and 3) investigating the metamorphic, structural and evolutionary history of a portion of the north Superior margin (Hartlaub et al., GS-15, this volume).

The North Caribou Terrane consists of Mesoarchean (>2.8 Ga) basement and platform/rift deposits (Thurston et al., 1991) but is dominated volumetrically by Neoproterozoic (mainly 2.74 to 2.69 Ga) granitic plutons (Stone, 1998). An examination of the southern margin of the North Caribou Terrane, one of the largest (approximately 400 by 800 km) blocks of Mesoarchean crust in the Superior Province, has identified areally significant ancient (>3.0 Ga) crust and overlying platform/rift deposits (ca. 2.98 Ga) (Percival et al., 2002). Although still in initial stages, the processing of LITHOPROBE-supported geophysical studies indicate crust beneath the North Caribou Terrane to be electrically resistive, similar to the Anton Complex which hosts diamondiferous kimberlite pipes in the Slave Province (I. Ferguson, pers. comm., 2003). The same study shows the upper mantle beneath the North Caribou to have similar electromagnetic conductance as the central Slave Province.

LITHOPROBE studies in west-central Manitoba, in conjunction with the Shield Margin NATMAP, identified Neoproterozoic crust tectonically thrust under younger Paleoproterozoic rocks of the Trans-Hudson Orogen. The extent of this Archean crustal segment is not well constrained but appears to underlie substantial portions of both Manitoba and adjacent Saskatchewan, including the area which hosts the Cretaceous Fort à la Corne kimberlite field. A crustal segment, of 'Sask Craton-like' affinity, the full extent of which has yet to be determined, also underlies the eastern Southern Indian Domain in northern Manitoba (Corrigan et al., 2003). The presence of this older buried crust beneath large areas of the Paleoproterozoic Trans-Hudson Orogen considerably improves the outlook for diamondiferous kimberlite pipes occurring in west-central and northern Manitoba.

Lineaments, structural anomalies and late alkaline intrusions

A project to compile data on structural anomalies and their possible relation to alkaline intrusions is underway as part of the overall evaluation of diamond potential in Manitoba. A variety of datasets have been compiled in a GIS to provide an interactive environment for analysis and synthesis. The datasets include

- total field aeromagnetic data,
- gravity data,
- mafic dike swarms,
- regional faults,
- lineaments derived from the 90 m digital elevation model of Manitoba,
- interpreted magnetic trend lines,
- distribution of KIM occurrences,
- known occurrences of alkaline and carbonatite intrusions and
- anomalous structural features.

The selected anomalous structural features focus on young deformation events that may have involved the Phanerozoic section. These include faulting in the Precambrian basement that is reflected in Phanerozoic strata and structural anomalies such as Limestone Point Lake, where Ordovician dolomites are highly deformed and lie 150 m below projected stratigraphic position.

The intent of this project is to identify crustal-scale structures that may suggest regions suitable for kimberlite exploration.

Wekusko Lake kimberlite

MGS is attempting to verify the occurrence of kimberlite that was reported in a diamond-drill hole from the Flin Flon Belt. In February of 1983, Falconbridge Limited intersected an unusual breccia in a drillhole (GBO-16) during exploration of the Golden Bounty property/Copperman property at the southwest end of Wekusko Lake (Assessment File 70569, Manitoba Industry, Trade and Mines, Winnipeg). The drillhole intersected greywacke, siltstone and mudstone belonging to the Burntwood Group (ca. 1.84 Ga), and 17 feet (5.2 m) of breccia with a "fine grained to medium grained matrix with up to 10% granule and pebble-sized fragments of dolomite, siltstone and mudstone". This breccia matrix was "soft and crumbly". The core was "extremely broken" and contained "occasional pyrope garnet". The core was subsequently identified as possible kimberlite. The presence of dolomite clasts, most likely sourced from

Paleozoic rocks, suggest a post-Precambrian age for this rock.

Follow-up drilling by European Ventures Inc. in 1994 intersected kimberlite in two drillholes (EPV 12A and EPV-5-93; Assessment File 73676, Manitoba Industry, Trade and Mines, Winnipeg) close to the original Falconbridge intersection. The kimberlite was described as a narrow dike, “fine to medium grained, brown” and containing diopside crystals and carbonate vugs. A 5-kg sample from this dike was sent for microdiamond analysis (Danielson and Christie, 1994). The microprobe analysis, which was undertaken by South African-based Scientific Services (Pty) Ltd., was reported in a July 26, 1994, press release by European Ventures Inc. (European Ventures Inc., 1993). The press release indicated the “presence of key diamond indicator minerals” including a “majority of garnets analyzed...classified as G9 with one G10 and one D1-type eclogitic garnet”. Because the sample was from a narrow dike the report on the micromodal analysis was considered to be “highly encouraging”.

In order to further assess the Wekusko occurrence, in 2003, the MGS endeavoured to conduct geochemical, isotopic and geochronological analysis of the kimberlite dike. Enquiries with European Ventures Inc. indicated that all the available kimberlite from their drillcore had been used in the 1994 microprobe analysis. Follow-up with Falconbridge Ltd. led to a search of their core storage facility at Anderson Bay near Snow Lake and the discovery by MGS staff of the original core from drillhole GBO-16. The core, which was jumbled and only partially intact, was reboxed and brought to Winnipeg for further examination. The section corresponding to the kimberlite intersection in drillhole GBO-16 was represented by a few 3 to 6 cm long remnants. A cursory examination of a thin section from one interval identified a composition with 70% crystalline carbonate, 20% phenocrysts of biotite (partly altered to chlorite), 5 to 8% opaque minerals (likely magnetite and pyrite) and 2% apatite. The sample does not correspond to the description of the kimberlite in the drill log of GBO-16, nor to the European Ventures Inc. sample sent for micromodal analysis. However, the absence of a foliation, the crystallinity of the carbonate, and the porphyritic texture of the sample is certainly unusual. Polished thin sections from this interval will be sent for microprobe analysis and, should mineral phases suitable for geochronology be identified, age dating will be done.

The greywacke, siltstone and mudstone of the Paleoproterozoic Burntwood Group, which directly hosts the kimberlite at Wekusko Lake, as well as the adjacent Paleoproterozoic felsic plutons and the younger cover of Phanerozoic sedimentary rocks, are all uniformly low in their aeromagnetic signature. These units are thus excellent candidates to use geophysics as a method to target potential kimberlite sites.

Economic considerations

By 2004, Canada is expected to supply 12% of the world’s diamonds (US\$7.9 billion), equalling South Africa in diamond production (Government of Northwest Territories, 2003). Production from the Ekati Diamond Mine™ in the Northwest Territories, operated by BHP Billiton, began in October 1998. The mine currently employs over 750 people, 78% of whom are northerners; 38% of the northerners are aboriginal. The mine is estimated to yield four to five million carats annually, with an average value of over US\$100 per carat and annual sales of US\$500 million. The Diavik mine (which opened in early 2003) and Snap Lake mine (scheduled to begin production in 2007) will add significantly to the existing diamond production from the Northwest Territories. The government of the Northwest Territories is promoting the development of a secondary diamond industry with downstream developments in rough sorting, gem cutting and polishing, polished grading, jewellery making and tourism. Increased training, employment and business opportunities for northerners are already being realized. Clearly, the discovery of diamondiferous kimberlites in Manitoba would potentially have similar benefits to both northern residents and the Manitoba economy in general.

Manitoba possesses bedrock geology containing similar Precambrian elements as neighbouring jurisdictions (Saskatchewan and Ontario) that have proven and potentially economic kimberlite fields.

- The Archean Superior Province in Manitoba is internally complex and contains at its northwest margin a distinct terrane comprising ancient (>3.0 Ga) supracrustal and intrusive rocks.
- The Paleoproterozoic Trans-Hudson Orogen is characterized by the buried ‘Sask Craton’ (ca. 2.4 Ga) at depth, suggesting that Archean lithosphere may be present beneath at least part of the orogen.
- The Superior–Trans-Hudson boundary in Manitoba is a first-order crustal-scale feature that is implicated in anomalous features in the overlying Phanerozoic succession, suggesting post-Precambrian reactivation.
- Late structures identified in the Precambrian are associated with documented alkaline intrusions and Phanerozoic deformation.

Published regional-scale KIM surveys have documented the widespread occurrence of key indicators, as well as a

potential indicator-mineral train in the Knee Lake area. These studies strongly suggest that kimberlitic sources occur in Manitoba—a suggestion that is further evidenced by the single documented occurrence of kimberlite at Wekusko Lake in the Flin Flon Belt.

The presence of a locally thick and complex till stratigraphy has proved to be a significant factor complicating effective diamond exploration in the province. Compilation of existing data from a number of surveys and agencies into a single database will provide explorationists, for the first time, with a comprehensive view of public-sector survey results. Coupled with ongoing analysis of till stratigraphy in the Hudson Bay Lowland, these data will provide important new information relating to diamond potential in Manitoba.

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