



Digital Compilation of Ooidal Ironstone and Coal Data, Clear Hills—Smoky River Region, Northwestern Alberta

Digital Compilation of Ooidal Ironstone and Coal Data, Clear Hills – Smoky River Region, Northwestern Alberta

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Abstract

This report summarizes the digital data compiled for the Clear Hills - Smoky River region during mid to late 2004. The Clear Hills - Smoky River region is defined as extending from Township (Tp) 101 south to Tp 74, and from Range (Rg) 16 W5th west to Rg 13 W6th. In contrast, the northern part of this region, referred to as the Clear Hills in this report, extends just north of the town of Worsley (Tp 85), north to Tp 101.

The digital compilation shows there are:

- 1) Sixty-six (66) publicly available assessment reports, on file with the Alberta Geological Survey (AGS) as of mid 2004, containing pertinent information about prior exploration conducted within the Clear Hills - Smoky River region.
- 2) Thirty-seven (37) AGS publications or maps, plus 19 Geological Survey of Canada (GSC) publications or maps, and over 141 other publications and theses that potentially contain useful information for the Clear Hills - Smoky River region compilation. In general, most of the publications discuss the geology of northwestern Alberta in a regional context; a much smaller number specifically provide data and information about the Bad Heart Formation and the immediately underlying and overlying lithostratigraphic units.
- 3) A total of 340 diamond-drill and auger mineral exploration holes, 230 coal holes, a minimum of 5432 water wells and more than 18 019 oil/gas wells drilled in the Clear Hills - Smoky River region. In summary with respect to these sources of information:
 - a) 198 of the 340 diamond-drill and auger holes contain data or information about the Clear Hills ooidal ironstone, and 8 of the diamond-drill and auger holes contain information about coal in the Clear Hills region;
 - b) 96 of the 146 exploratory coal holes drilled in the Clear Hills area (i.e., north of and including Tp 85) intersected coal, whereas the other 50 coal exploratory holes within the Clear Hills area are not coal bearing;
 - c) 11 exploratory coal holes contain 'ferruginous intercepts' that may reflect the Bad Heart Formation ooidal ironstone;
 - d) 80 water wells intersected the Bad Heart Formation oolitic iron-bearing unit or ironstone and 109 water wells intersected coal; and
 - e) a minimum of 1972 oil/gas wells contain information about the stratigraphic interval above the top of the 'Main Cardium Sand' interval, which is a well recognized unit that is a few tens of metres below the Bad Heart Formation and equates to Alberta Energy and Utility Board pick ID 1750. Having said this, only 162 oil/gas wells contain stratigraphic pick information specifically about the Bad Heart Formation.

Finally, this compilation provides a series of digital files in various formats that tabulate the compiled data. These files include an ArcExplorer project file that permits the data to be viewed without the need for purchase of proprietary Geographic Information System (GIS) software, as well as GIS shapefiles that can be read by and loaded into ESRI GIS compatible GIS software. Data and information about these files are included on the two compact disks (CDs) accompanying this report: CD 1 contains the report and compiled digital files; CD 2 contains the GIS Shapefiles.

1 Introduction

This report provides a digital overview of the compilation of publicly available information pertaining, primarily, to the Bad Heart Formation and more specifically to the potential iron resource(s) in the ooidal ironstone units within this formation, and (b) secondarily, with respect to the potential coal resources in the Clear Hills to Smoky River region in northwestern Alberta.

Figure 1 shows the area encompassed by the compilation, referred to in this report as the ‘Clear Hills – Smoky River region.’ The compilation area encompasses about 620 townships, or about 42,000 km², and is within National Topographic System (NTS) map areas comprising the northwestern corner of NTS 83N, the north half of NTS 83M, the west half of NTS 84C and 84F, and approximately all of NTS 84D and 84E. More specifically, the compilation extends from about the Botha River – Naylor Hills area in the north to just south of the Spirit River to Bad Heart River intersection with the Smoky River in the south, and west from the north-trending segment of the Peace River to the Alberta – British Columbia border. That is, from the northern margin of Township (Tp) 101, south to the south margin of Tp 74, and from the east margin of Range (Rg) 16 W5th, west to about Rg 13 W6th.

The larger Clear Hills – Smoky River region is subdivided into two parts:

- 1 the Clear Hills region defined as extending from the northern margin of Tp 101 south to the south margin of Tp 85, and from the east margin of Rg 22 W5th west to the Alberta – British Columbia border; and
- 2 the remaining southern and eastern portion being called the ‘Smoky River region’ (Figure 1).

The Clear Hills region encompasses that area north of Worsley, Alberta, in which prior work has identified there is potential for an iron resource of over one billion tonnes with an average grade of about 34% total iron (Hamilton, 1980). As well, there is believed to be potential for thermal coal resources in some parts of the Clear Hills region.

Regarding the stratigraphic interval of primary interest in the Clear Hills – Smoky River region, the units are all Late Cretaceous (i.e., mid Campanian to mid Maastrichtian, or from about 95 to 70 million years old). In summary, from base to top, the stratigraphic sequence comprises:

- (a) Smoky Group, which can be further subdivided into Kaskapau (lowest unit), Cardium, Muskiki, Bad Heart and Puskwaskau (uppermost unit) formations, and the overlying
- (b) Wapiti Formation (Green and Mellon, 1970).

The Bad Heart Formation contains the ooidal ironstones of potential economic interest (Mellon, 1962; Hamilton, 1980).

2 Methodology for the Compilation

2.1 Overview

The digital compilation was primarily conducted from mid-August until early November 2004, with some supplemental checking of data sources done during the first half of 2005. Various AGS search engines and metadata sources identified and tabulated the pertinent publications, maps, publicly available assessment reports and other documents pertaining to the Clear Hills oolitic iron resource in northwestern Alberta, and the immediately overlying and underlying geological units. From that list of publications

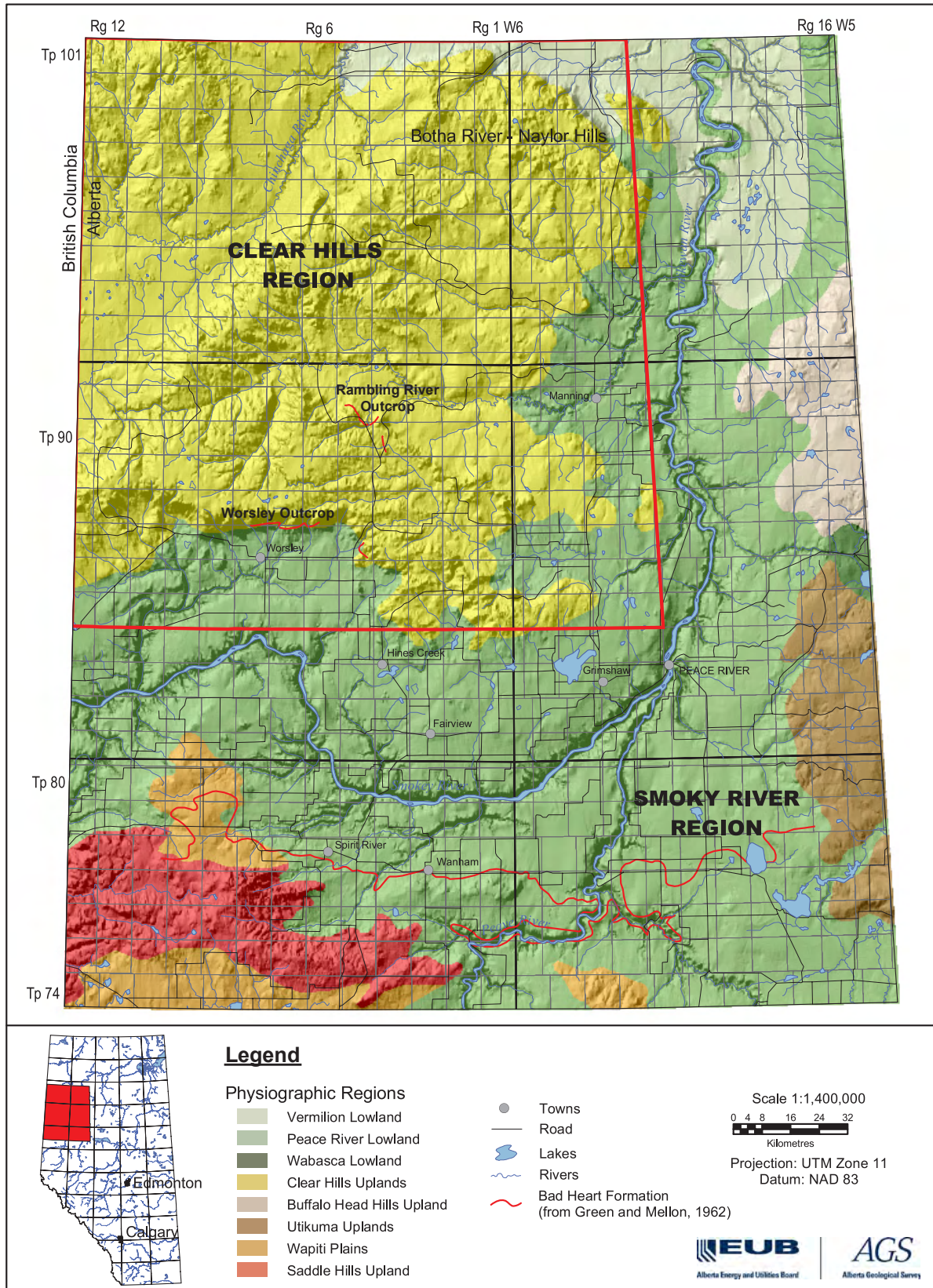


Figure 1. Location, Clear Hills—Smoky River region.

and maps, those containing information relevant to the digital compilation for the Clear Hills - Smoky River region ooidal ironstone resources and, the overlying coal resources were identified.

In general, outcrop of the Bad Heart Formation in northwestern Alberta is scarce, generally being much less than 1 per cent, especially within the Clear Hills region where the percentage exposure is even smaller. The best exposures of the Bad Heart Formation, including the type section, occur along the Smoky River near its intersection with the Bad Heart River about 100 km southwest of the town of Peace River (Figure 2). In the Clear Hills, the best natural exposures of the Bad Heart Formation ooidal ironstone are along the Rambling River, about 50 km northeast of the village of Worsley (Figure 1). However, at this locale the entire Bad Heart Formation section is not exposed, as is the case along the Smoky River.

Figure 2 shows the known outcrops of the Bad Heart Formation; these outcrops are largely taken from Kidd (1959), but have been supplemented from other sources on file with the AGS. These other sources include information from assessment reports and from field visits made by various AGS staff to the Clear Hills area during the past few years. Finally, also shown on Figure 2, are selected outcrops of 'ooidal ironstone' reported by Kidd (1959) that are now known not to be Bad Heart Formation. For example, the outcrops of thin ooidal ironstone that occur along the Peace River near Dunvegan Crossing are believed to be actually within the lowermost Kaskapau Formation (Dr. C. Stelck, pers. comm., Nov. 2004; Plint, 2000), which is stratigraphically below and hence older than the Bad Heart Formation ooidal ironstones.

The raw data in this report were assembled and compiled into digital form from the following sources:

- a) Sixty-six publicly available (as of fall 2004) assessment reports on file with the Alberta Geological Survey contain information about prior exploration conducted within the Clear Hills – Smoky River region. Selected summary details about these assessment reports are included in the appended bibliography as a Word document on CD 1; as well, a listing of all publicly available assessment reports is on the AGS website at <http://www.ag.gov.ab.ca/publications/PUBDB/MNAS.shtml>.
Only 39 of these 66 assessment reports contain spatially related data, with 15 containing most of the data and information pertinent to ooidal ironstone. These 15 assessment reports are those by McDougall (1954), Edgar (1961, 1962, 1963, 1964a, 1964b, 1964c, 1964d), McCord (1964), Wickens (1966), Boulay (1995, 1996), Liddle (2000), Owens (2001) and Bladek (2002).
- b) The digital compilation identified 340 diamond-drill and auger drillholes that have been drilled for mineral exploration purposes within the Clear Hills – Smoky River region. In addition, the compilation identified 230 coal exploratory holes, a minimum of 5432 water wells and at least 18 019 oil or gas wells that have been drilled in the Clear Hills – Smoky River region. However, although there is a large number of water and oil/gas wells, most of these wells do not contain data or information pertinent to either ooidal ironstone or coal. Further information about these holes and wells are provided in Sections 2.2.4 to 2.2.7.
- c) There are at least 37 AGS publications, 19 Geological Survey of Canada (GSC) publications and more than 141 other of publications, including theses, containing potentially useful information about the Bad Heart Formation or coal resources within the Clear Hills – Smoky River region (these are listed in the bibliography on CD 1).
- d) The information assembled during this compilation is included on the two CDs. The digital files are of several types (Table 1), which are described in greater detail in Section 2.3.

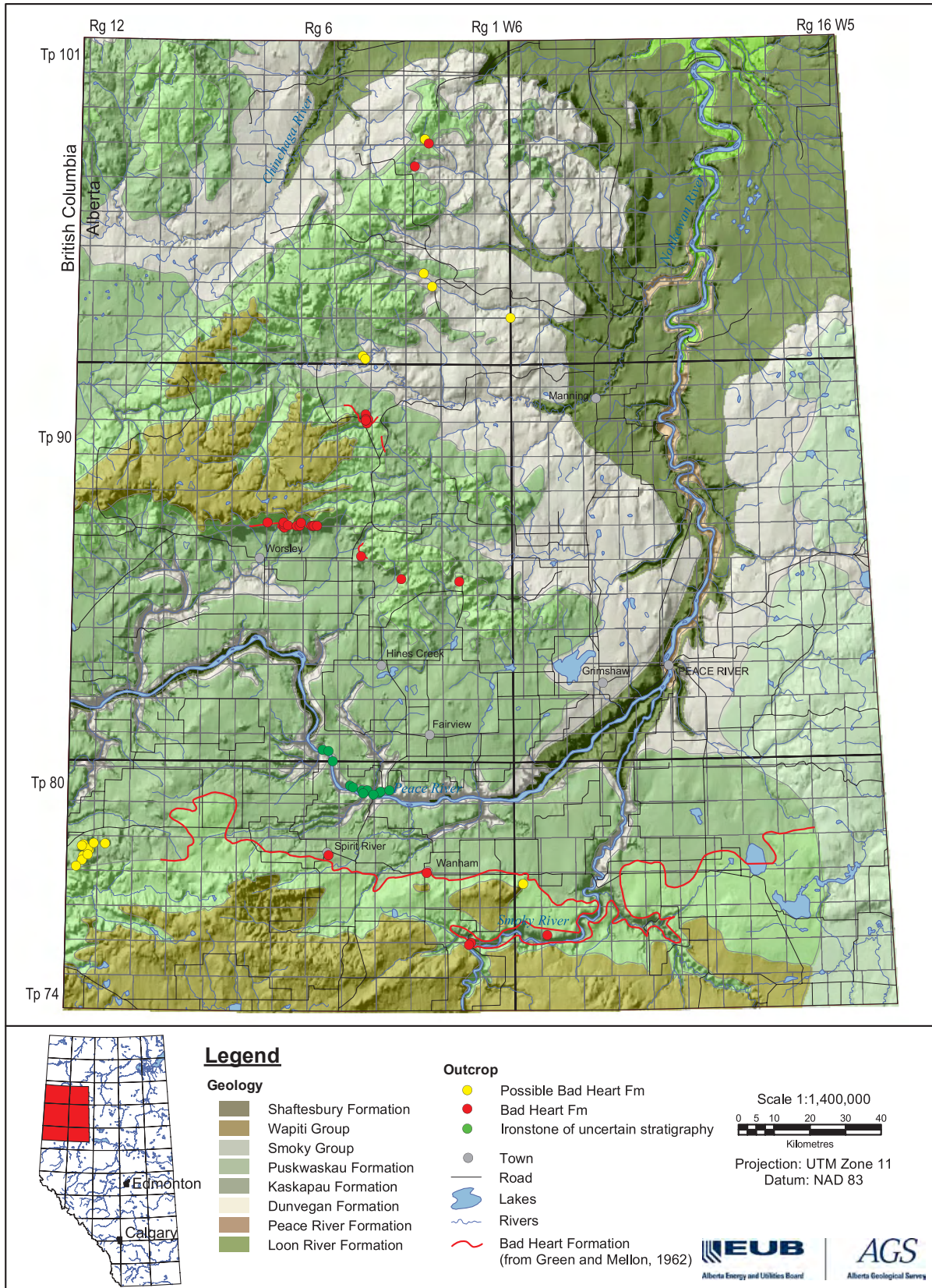


Figure 2. Geology of study area with known outcrops of Bad Heart Formation (modified after Kidd, 1959).

In summary, CD 1 contains the report, data and other digital files, except for the GIS Shapefiles, which are on CD 2.

Table 1. Summary 1 of subdirectories and files on the CDs

CD	Subdirectory Name	File Types Within Each Subdirectory
1 and 2	Root	Readme and metadata files, Geo-Note 2005-05.
1	Access_Files	Microsoft Access database file; the data in the Excel file format were converted to a database.
1	ArcExplorer_Files	ArcExplorer 'aep' project file, plus selected GIS files needed for the ArcExplorer project. Also included are ArcExplorer freeware and instructions for installation and viewing.
1	Excel_Files	Microsoft Excel files; the file type used for the initial capture of digital data and information.
2	GIS_Shapefiles (except two files)	GIS shapefiles that can be imported into any ESRI-compatible GIS software.
2	GIS_Shapefiles	Two satellite imagery GIS shapefiles.
1	Assessment_ Report_Lithologs	Drillhole lithologs scanned as JPGs from assessment reports.
1	PDF_Files	Adobe Acrobat PDFs: summary of stratigraphic picks from the AGS oil/gas well database.
1	Word_Files	Microsoft Word files; these include a) the bibliography for the Clear Hills – Smoky River region (as of October 2005) and b) data on the 189 water wells from the Clear Hills area containing information either about coal and/or ferruginous intercepts.

¹A more detailed description of the digital files is in Section 2.3.

²GIS is the acronym for Geographic Information System.

2.2 Summation of Specific Publications and Data of Interest

Many publications about the geology of northwestern Alberta, especially concerning the development of the Peace River Arch and the Phanerozoic stratigraphy of the region, are important to hydrocarbon and coal exploration. However, far fewer publications contain information specifically about the Bad Heart Formation, or its stratigraphic equivalent, the Marshybank Member of the Wapiabi Formation, and in particular, the ooidal ironstones that exist within the Bad Heart Formation.

The publications deemed of particular interest regarding the Bad Heart Formation or for general geological overview purposes include:

2.2.1 AGS Publications

Of greatest interest, chronologically from the oldest, are the reports by Kidd (1959), Mellon (1962), Green and Mellon (1962, 1970), Samis and Gregory (1962), Bertram and Mellon (1975), Hamilton (1980), Ozaray (1982) and Olson et al. (1999).

2.2.2 GSC Publications and Maps

The reports by the Geological Survey of Canada (GSC) about the Bad Heart Formation, and the

equivalent Marshybank Member, tend to be more regional in extent and mainly encompass the geology extending from westernmost Alberta into British Columbia. However, of greatest interest are the reports by McLearn (1919, 1926), Stott (1960, 1961, 1963, and 1968), Burk Jr. (1963) and Núñez-Betelu et al. (1999).

2.2.3 Other Publications of Interest

Other publications, including theses, that provided information about the regional geology in general or about the Bad Heart Formation in particular include:

- 1) Regional geology: Cant (1988), Cant and O'Connell (1988), O'Connell et al. (1990), and O'Connell (1994).
- 2) Bad Heart Formation and its ooidal ironstones: Lenz (1956), Colborne (1958), Petruk et al. (1974, 1977a, 1977b), Clear Hills Regional Planning Commission (1976), Petruk (1977), Norris and Plint (1988), Plint et al. (1990), MT Environmental Systems Inc. (1996), Donaldson (1997), Donaldson et al. (1998, 1999) and Collom (2001).
- 3) Coal resources that overly the Bad Heart Formation within the Clear Hills region: the best summary report is by the Energy Resources Conservation Board (1993).

2.2.4 Diamond-Drill and Auger Holes Identified from the Assessment Reports

This report identifies 298 diamond-drill holes and 42 auger holes from the assessment records that occur within the Clear Hills – Smoky River region (Figure 3). During the compilation, the location accuracy of each hole was estimated from the available records; in general, the location accuracy of the diamond-drill and auger holes ranges from tens of metres or less up to, in some cases, a kilometre or more. The estimated accuracy for each hole is tabulated in the 'PREC(m)' column in Excel file "*CHI_GN2005-05_Compilation_DA_Holes.xls*" on CD 1; that is, the PREC(m) column contains a value of plus or minus 'x' metres from the Universal Transverse Mercator (UTM) hole location used in the compilation.

About 80 per cent of the 340 diamond- and auger-drill holes have reasonably precise coordinates in UTM that were estimated to be 100 m or less. However, the remaining 20 per cent have lower precision locations ranging from about 300 m to 1.1 km. This is due to:

- some holes lack specific location details in the assessment reports (e.g., the hole location is only reported to exist within a section, which is 1 mile by 1 mile, or quarter-section, but the precise location within this area is not provided), or
- hole collar locations were digitized using ArcGIS from scanned maps, but it was difficult to accurately georeference the scanned map. Regardless of the hole accuracy, all diamond-drill and auger holes are shown in the ArcExplorer project and are in the associated GIS shapefiles. The GIS shapefiles, in contrast to the ArcExplorer project file, can be used to query the hole location to identify those holes with high versus low hole-location accuracy.

Regarding the information available from these 340 diamond-drill or auger holes:

- 1) 198 holes contain information about the Clear Hills ooidal ironstone (in Figure 4 the holes that intersected ironstone or 'iron' are shown as red circles);
- 2) 8 holes contain coal information; these holes are shown on Figure 5 with the coal exploratory holes that contain coal;

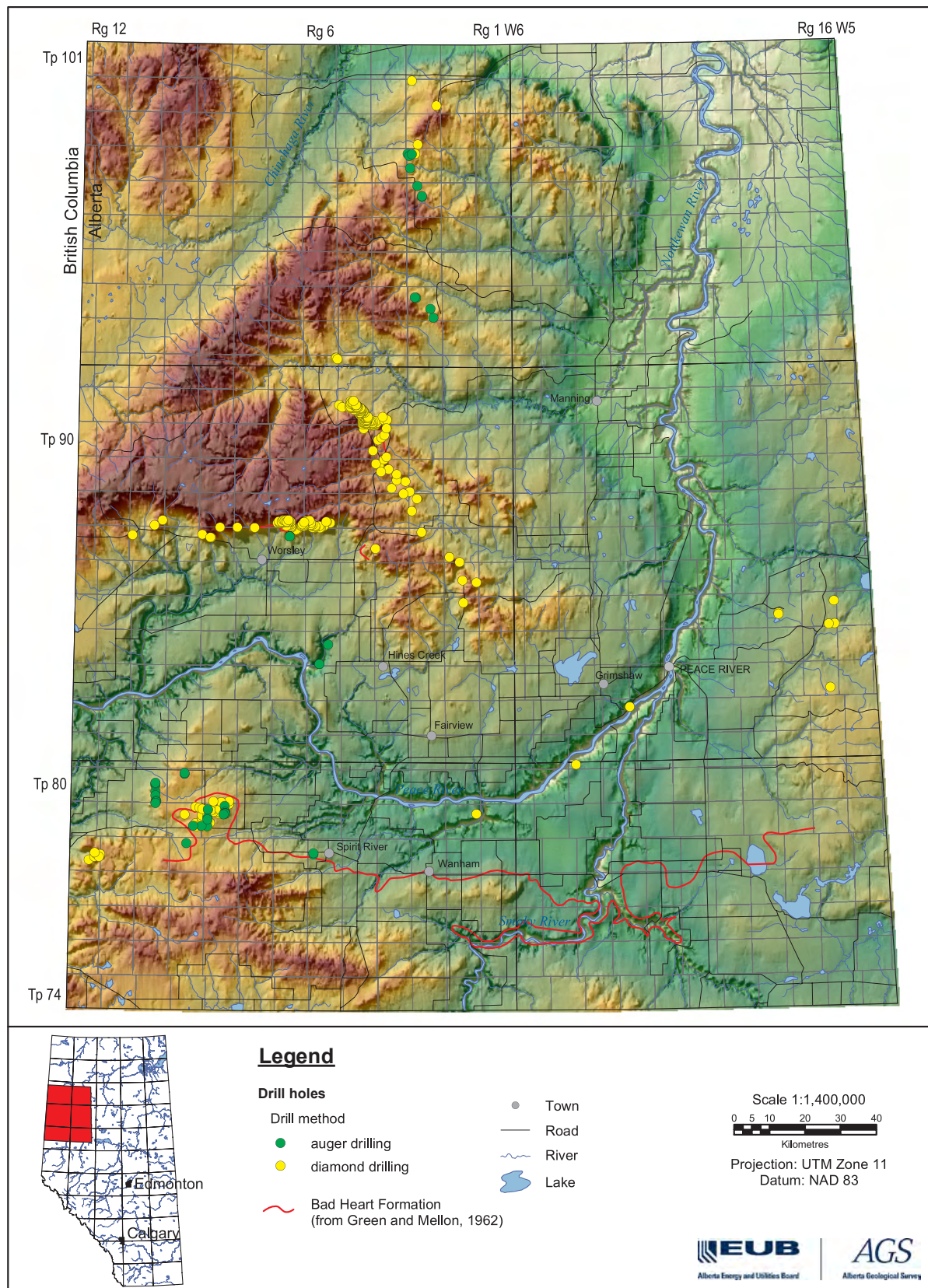


Figure 3. Diamond drill and auger holes.

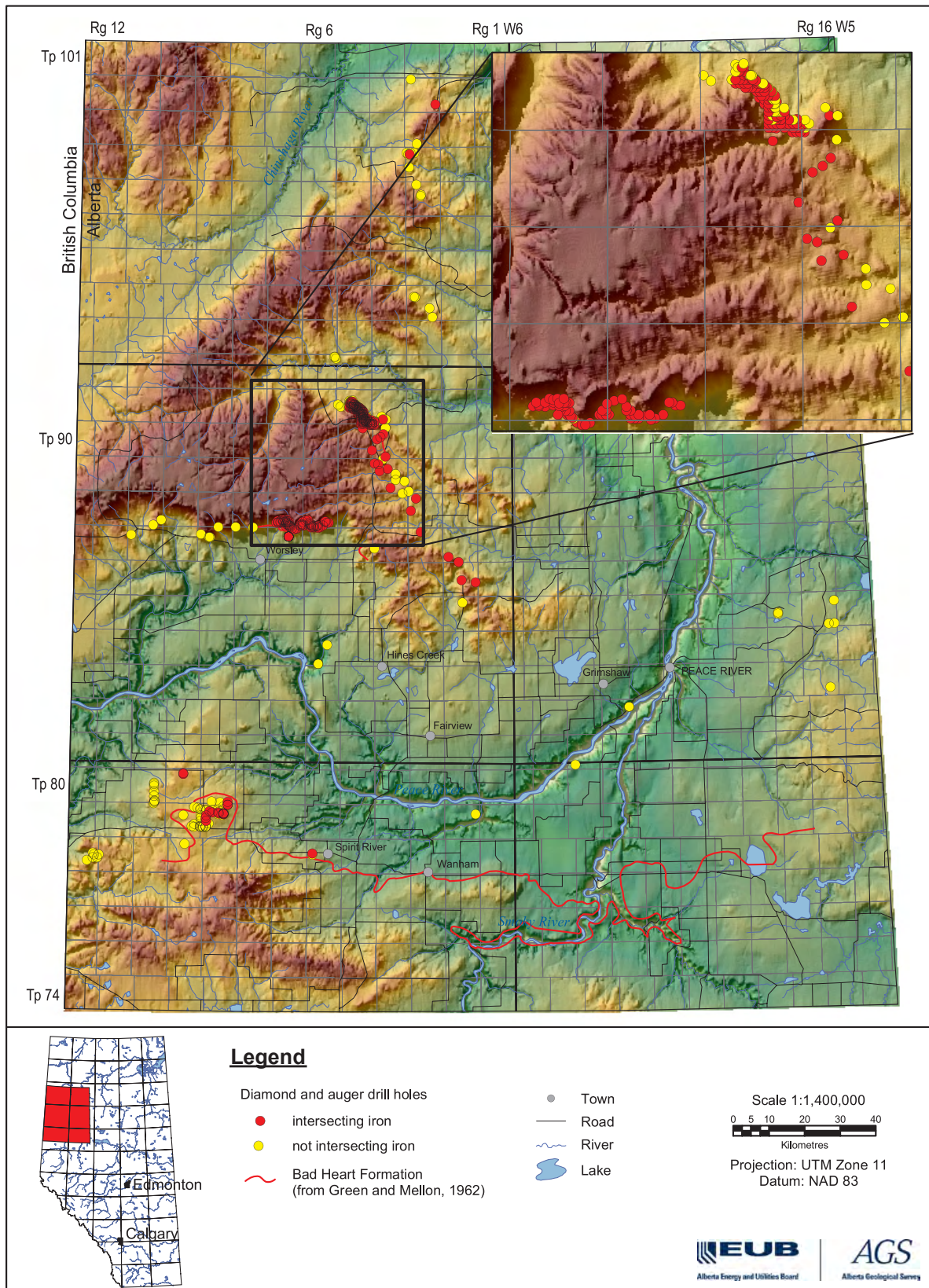


Figure 4. Diamond and auger drillholes with iron indicated.

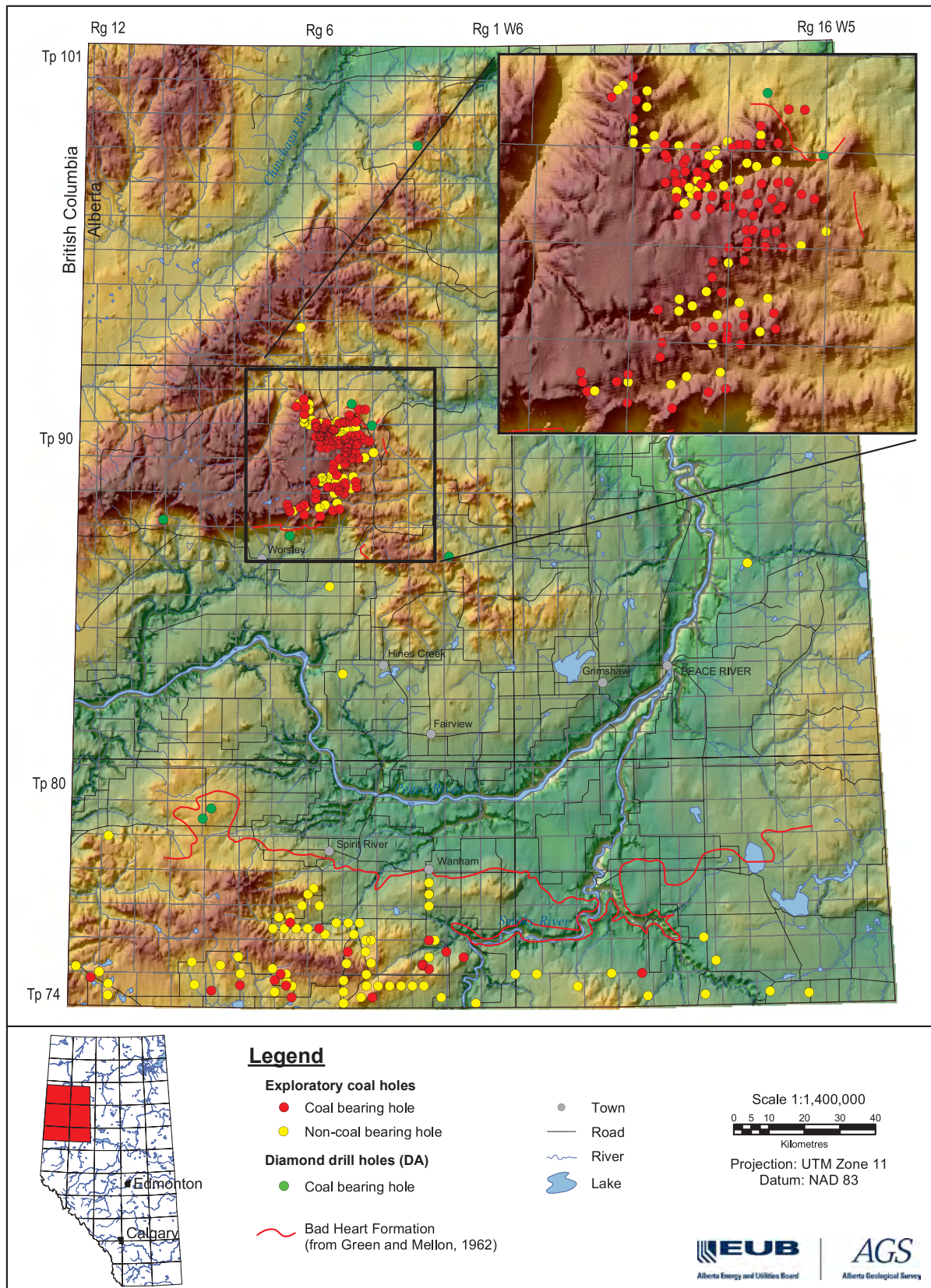


Figure 5. Exploratory coal holes.

- 3) only 332 of the 340 diamond-drill and auger holes have lithologs or description about the downhole stratigraphy. The 8 holes without lithologs are 19630001-1 to 19630001-5 inclusive, and 20020006-1 to 20020006-3 inclusive; these are from the assessment reports by Edgar (1962) and Bladek (2002), respectively. As well, the Excel table and Access database both contain fields indicating whether a hole has a litholog.
- 4) Finally, where such exist in the assessment records, assays or other geochemical results have been tabulated in the digital database files.

On Figures 3 and 4, all 340 diamond-drill and auger holes are shown for completeness, including the 20 per cent that have inexact collar locations.

2.2.5 Coalholes

Coal information for the Clear Hills – Smoky River region came from three sources:

- (1) AGS microfiche holdings,
- (2) the Alberta Energy and Utilities Board (EUB) coal database; and
- (3) historical coal-related data on file at AGS.

The AGS microfiche contains lithologs and some geophysical logs for 65 coal exploratory holes. In contrast, the EUB coal database contains a more complete record. In fact, the EUB coalhole database indicates that 206 exploratory coalholes have been drilled in the Clear Hills – Smoky River region and 96 are coal-bearing. The EUB database contains all 65 coalholes identified at the AGS, but the lithologs from the AGS coal microfiche provided supplemental information for this report.

Finally, Wylie Hamilton (AGS Emeritus Geoscientist, pers. comm., October 2004) from his historical files provided information on 24 other coalholes drilled in the Clear Hills region, 18 of which intersected coal. Twenty-two of these holes were drilled in 1961 and two were drilled in 1974; for some reason, none of these 24 holes is in the AGS coal microfiche database, or in the EUB coal database. Thus, these sources indicate 230 coal exploratory holes have been drilled in the Clear Hills – Smoky River region.

Figure 5 shows the location of all 230 coal exploratory holes in the Clear Hills – Smoky River region, with the coal-bearing ones shown as red circles.

Of these 230 coal exploratory holes

- 1) 146 have been drilled in the Clear Hills region north of Tp 85, with the other 84 holes drilled in the Smoky River region, and mainly south of the Peace River (Figure 5);
- 2) 96 of the 146 holes drilled in the Clear Hills region have coal intersections;
- 3) 18 of the 84 exploratory coalholes drilled within the Smoky River region (i.e., outside of the Clear Hills region) intersected coal;
- 4) 11 of the exploratory coalholes intersected ‘ferruginous intercepts’ that may be due to the Bad Heart Formation ooidal ironstone. All of these 11 ferruginous coalholes are north of Tp 85 within the Clear Hills region, and they are depicted as green circles on Figure 5. Further study of these coalhole logs is needed to assess whether they will provide information about the Bad Heart Formation ooidal ironstone.

2.2.6 Water Wells

The EUB/AGS water well database indicates there have been at least 5432 wells drilled for water in the Clear Hills – Smoky River compilation region. Note that the existing EUB/AGS water well database is current only to about end of 2002 and is a modified version of the 2002 Alberta Environment water well database that was imported into 'Earth fx data model' software (information about this software can be found at <http://www.viewlog.com/earthfx/default.asp>) to produce a Microsoft Access database to allow for better querying. The selected water well identifiers can then be used to obtain Water Well Drilling Reports from the Alberta Environment website at <http://www3.gov.ab.ca/env/water/groundwater/>. The Water Well Drilling Reports are essentially 'drillers interpretative logs' of the subsurface stratigraphy that was intersected; as a result there is no consistent methodology for recording stratigraphic picks or lithologies. Thus, one must examine each Water Well Drilling Report to determine if it contains information of interest.

During this compilation, the EUB/AGS modified water well database was searched to identify wells containing information about iron-bearing or coal-bearing intercepts in the driller's water well lithologs. The specific search terms used were "oolitic," "rusty," "ferruginous," "red-brown," "ironstone," "ore," "iron" and "coal." As a result, 189 water wells within the Clear Hills region were identified as being of possible importance. The Water Well Drilling Reports for these 189 wells are included on CD 1 as Word files.

With specific respect to iron, 80 of these 189 water wells contain information about a possible 'ironstone' intercept (Figure 6). Selected data from these 80 water wells were compiled and the pertinent Water Well Drilling Reports are in subdirectory "*\Word_Files\Water_Well_Logs\Iron_Bearing*" on CD 1.

The remaining 109 water wells contain information about coal resources. The pertinent water well reports with coal information are on CD 1 in subdirectory "*\Word_Files\Water_Well_Logs\Coal_Bearing*."

Further study of the water wells in the Clear Hills is needed. For example, use of different 'search criteria' may identify other water wells that will contain useful information about the Bad Heart Formation ooidal ironstone, or about potential coal resources within the Clear Hills area. As well, a more detailed review of the 189 water well reports found by the search criteria used in this report, may identify added information of interest to the Bad Heart Formation, ooidal ironstone and coal in the Clear Hills.

2.2.7 Oil and Gas Wells

The EUB oil/gas well database of September 2003, which was the most current version available to the AGS during this compilation, indicates:

- 1) 18 019 oil and gas wells have been drilled in the Clear Hills – Smoky River region to September 2003, with 4498 wells having been drilled in the Clear Hills region north of and including Tp 85 (Figure 7);
- 2) 1972 of the 18 019 oil/gas wells contain at least some stratigraphic information (i.e., stratigraphic 'picks') within the interval 'Main Cardium Sand' (EUB pick ID 1750) to base of 'drift' (EUB pick ID 0010);
- 3) 1067 of the 18 019 oil/gas wells contain at least some stratigraphic information or 'picks' from the interval labelled 'Bad Heart Formation' (EUB pick ID 1660) to base of drift (EUB pick ID 0010); and

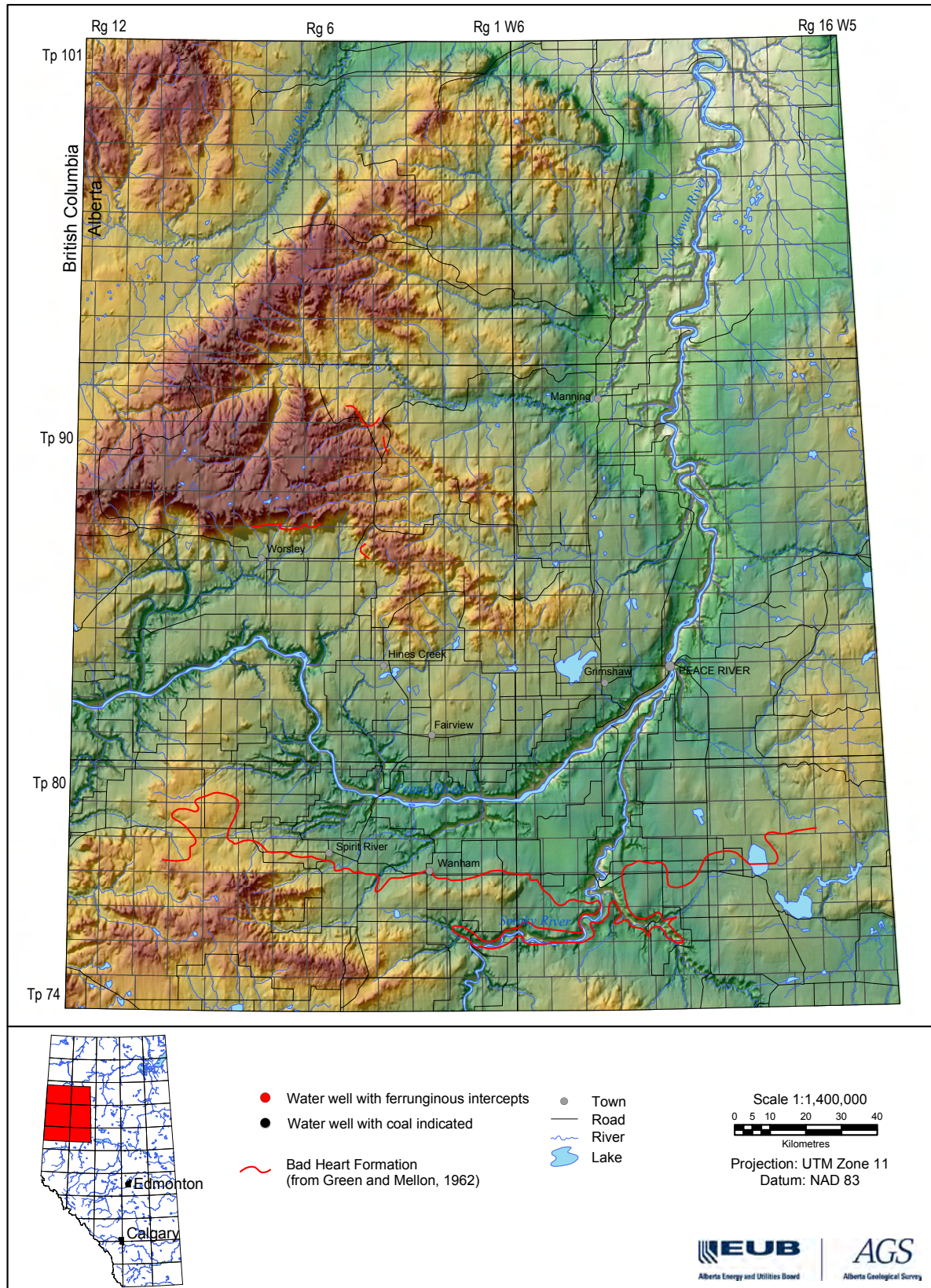


Figure 6. Water wells with ferruginous and coal intercepts.

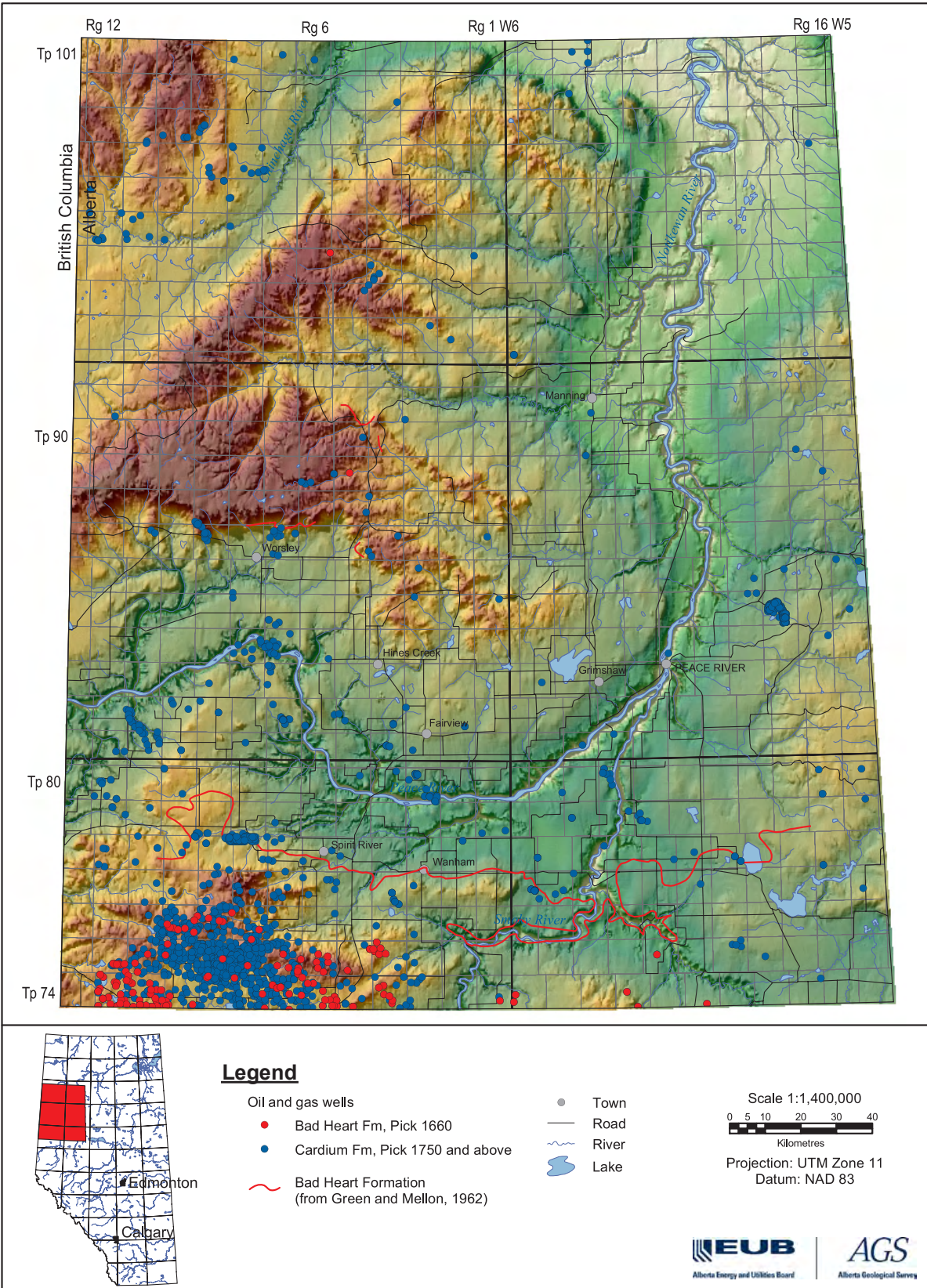


Figure 7. Oil and gas wells.

- 4) with specific respect to the oil/gas wells that contain information about the Bad Heart Formation (EUB pick ID 1660), there are 162 such wells of the 18 019 in the Clear Hills - Smoky River region (on Figure 7 these oil/gas with Bad Heart Formation picks are shown as red circles). In fact, almost all of the 162 oil/gas wells with Bad Heart Formation picks are in the Smoky River region south of the Peace River, whereas only 2 of the wells with Bad Heart Formation intercepts are in the Clear Hills region north of and including Tp 85; these two oil/gas wells are named 00/02-21-089-05W6M (Phil 'A' No. 1) and 00/07-35-095-06W6M (Aquit Chinchaga Husky).

Further study of the oil/gas well lithologs and geophysical logs, with data about ooidal ironstone or coal, is needed to assess whether they will provide useful information in understanding the geometry and spatial distribution of the Bad Heart Formation ooidal ironstone resource or the coal resources in the Clear Hills area. In this context, a separate query was done in mid-2005 to evaluate the availability of geophysical logs in oil/gas wells within the Clear Hills region. This query searched for all publicly available oil/gas wells as of mid-2003 that had surface collar elevations starting at about 755 m above sea level (asl) or higher. This elevation was chosen because the Bad Heart Formation in the Clear Hills is believed to mainly lie above this elevation (e.g., north of Worsley, the Bad Heart Formation crops out at an elevation of about 800 m asl). In summary, this query gave the following results:

- 1) As of mid-2003, there were 1626 oil/gas wells with surface collar elevations at 775 m asl or higher in the Clear Hills region;
- 2) For these 1626 oil/gas wells, 657 have geophysical logs in digital form, whereas the remaining logs are in raster or hardcopy form;
- 3) For the 657 oil/gas wells with digital logs, there are 109 wells where the geophysical logging starts above 775 m asl, and at least 86 wells have geophysical logs in the interval ranging from 1000 m asl to 800 m asl, hence these 86 wells should provide information for the Puskwaskau/Bad Heart/Kaskapau (P/BH/K) formations stratigraphic interval;
- 4) For the other 969 oil/gas wells that only have raster or hardcopy geophysical logs, 820 have surface collar elevations above 800 m, thus some or all of these wells may have geophysical log information that straddles the P/BH/K stratigraphic interval. However, each well needs to be manually inspected to confirm whether they have geophysical logs that straddle the P/BH/K stratigraphic interval of interest; as of October 2005, this inspection has not been completed.
- 5) Finally, there probably has been further oil/gas well drilling in the Clear Hills region since mid-2003, hence an up-to-date query of the currently publicly available oil/gas well geophysical logs may identify other wells with downhole geophysical data available for the interval 775 m asl and higher.

Based on the above, it seems likely that at least a few tens of oil/gas wells exist in the Clear Hills region that have some geophysical log information for the P/BH/K stratigraphic interval of interest. Such logs could be used to evaluate:

- (a) the stratigraphy of the Bad Heart Formation and adjacent units in the Clear Hills region;
- (b) whether ooidal ironstone exists locally within the Bad Heart Formation; and
- (c) the coal potential of the overlying Wapiti Formation within the Clear Hills region.

2.3 Summation of the Digital Files With This Report

The digital files that accompany this report, and which are the primary result of the digital compilation, are summarized below.

2.3.1 Excel Files

Data from the assessment reports and other publications were initially compiled into nine Excel workbooks; the individual files can be found on CD 1 in the subdirectory “\Excel_Files,” and are named

- CHI_GN2005-05_Compilation_Abbreviations.xls (1 sheet)
- CHI_GN2005-05_Compilation_Bibliography.xls (1 sheet)
- CHI_GN2005-05_Compilation_Coal.xls (4 sheets)
- CHI_GN2005-05_Compilation_DA_Holes.xls (6 sheets)
- CHI_GN2005-05_Compilation_Geophys.xls (3 sheets)
- CHI_GN2005-05_Compilation_OilGaswells.xls (3 sheets)
- CHI_GN2005-05_Compilation_Outcrops.xls (2 sheets)
- CHI_GN2005-05_Compilation_Samples.xls (5 sheets)
- CHI_GN2005-05_Compilation_Waterwells.xls (3 sheets)

Details on the contents of each file, including an explanation of the data captured and the abbreviations used, are in “CHI_GN2005-05_Compilation_Abbreviations.xls.” Abbreviations are used consistently in all files

2.3.2 Access Files

The final Excel files were used to prepare a Microsoft Access database, named “Clear_Hills_Comp.mdb.” This file is on CD 1 in the subdirectory “\Access_Files.”

The database has the following tables:

- TBL_Abbreviations
- TBL_CHI_Bibliography
- TBL_CHI_Coal
- TBL_CHI_Coal_Assays
- TBL_CHI_DA
- TBL_CHI_DA_Assays
- TBL_CHI_Geophys
- TBL_CHI_OilGaswells
- TBL_CHI_OilGaswells_Formation_Picks
- TBL_CHI_Outcrops
- TBL_CHI_Samples
- TBL_CHI_Samples_Assays
- TBL_CHI_Waterwells
- TBL_CHI_Waterwells_Drilling_Reports

The field names, field descriptions and abbreviations used in the Access database match those in the Excel files.

2.3.3 Word Files

A list of selected references has been compiled into a bibliography that is included as a Microsoft Word file on CD 1. This bibliography should be considered as a work in progress and is current only to October 2005.

2.3.4 Geographic Information System (GIS) Files

Using all or selected parts of the Access database, a suite of GIS shapefiles were prepared in ArcGIS for use in ArcExplorer and ArcGIS. In summary, these shapefiles comprise

1) ArcExplorer Files

ArcExplorer is a free GIS data viewer. The software, including brief instructions for its installation and use, are included on CD 1 in the subdirectory "*\ArcExplorer_Files\ArcExplorer_Freeware*." The software can also be downloaded and installed from <http://www.esri.com/software/arcexplorer/>.

On CD 1, in subdirectory "*\ArcExplorer_Files\ArcExplorer_Project*," there is an ArcExplorer project file named CHI_ST~1.AEP. This file has several 'themes' (layers) that can be turned on or off by the radio buttons beside each. The themes can be grouped into three categories:

- 1) geology and related themes prepared by AGS;
- 2) selected data compiled from assessment reports and other sources; and
- 3) base map or physiographic information.

In general, the descriptor title for each theme is self-explanatory.

Regarding the base map information, the AGS cannot supply detailed physiographic data (at scales larger than 1:1 000 000), including the Alberta Township System (ATS) township-range-section grid. Therefore, a static, background base map image has been provided to enhance viewing of the compilation data. If more detailed physiographic and ATS grid digital data are needed for use with the GIS shapefiles, these must be purchased from AltaLIS Ltd.; information is on their website at www.altalis.ca.

2) GIS Shapefiles

The AGS used ESRI ArcGIS (version 9.0) for creating GIS datasets in shapefile format. Information about ESRI, its software and generally about GIS, can be found at <http://www.esri.com/>. Although the GIS shapefiles were produced using ESRI ArcGIS, they can be used in other GIS software applications if they support importing ESRI-format shapefiles.

Twenty-one shapefiles were prepared for the Clear Hills – Smoky River compilation region, with some shapefiles having added ArcExplorer themes. The GIS shapefiles can be grouped into three broad categories comprising: (a) nine shapefiles of geology and related items that were prepared by the AGS, which total includes two shapefiles of selected satellite imagery; (b) eight shapefiles from selected data that were compiled from assessment reports and other sources, and (c) four shapefiles of base map or physiographic

information at 1:1,000,000 scale that the AGS is permitted to publicly distribute for free. The GIS shapefiles in this report are summarized in Table 2. All shapefiles are on CD 2, including the two satellite imagery shapefiles (“CHI_L7_irs_u11” and “CHI_L7_irs_srtm_u11”). Table 2 also provides some supplemental explanatory comments about each shapefile.

Note that shapefile “CHI_Proposed_Road_u11” shows the location of a secondary access road that the Municipal District of Clear Hills is building or planning to build in the near future to access the western part of the Clear Hills region. The proposed location of this new access road was provided to the AGS courtesy of the Municipal District of Clear Hills (MD No. 21).

Current maps that show the metallic, industrial mineral and coal dispositions for the Clear Hills – Smoky River region may be obtained from the Alberta Department of Energy (ADOE) website at www.energy.gov.ab.ca. Information about the regulatory aspect of minerals within Alberta can be found on the ADOE website at <http://www.energy.gov.ab.ca/1193.asp>, with information about the current status of mineral permits and mineral leases at <http://www.energy.gov.ab.ca/2741.asp>. Similarly, general information about coal can be found at <http://www.energy.gov.ab.ca/446.asp>, with current status of coal permits and coal leases at <http://www.energy.gov.ab.ca/2934.asp>.

To create the two satellite imagery shapefiles, a Landsat image was fused with Indian Remote Sensing satellite (IRS) imagery (“CHI_L7_irs_u11”), and a Landsat 7 image was fused with both IRS and Shadow Radar Topographic Mission (SRTM) digital elevation model imagery (“CHI_L7_irs_srtm_u11”) for the entire Clear Hills – Smoky River region. The images were generated in Enhanced Compression Wavelet (ECW) format to reduce file size.

The ECW format satellite imagery files are not viewable with the ArcExplorer freeware, because the ECW extension for ArcMap is required. This extension has been included on CD 1 in the subdirectory “\GIS_files\ArcGISwithCompressorV2.0_Beta1_14May04.exe.”

Although the ECW satellite imagery files have been significantly reduced in byte size, they are still high-resolution images (6 m pixel definition) and are best viewed by zooming into a small area to see details or by printing onto plotter paper.

Table 2. GIS shapefiles and ArcExplorer themes in the compilation

Geology and Related Items Prepared by the AGS (all shapefiles clipped to compilation boundary)		
Shapefile	Additional ArcExplorer Theme	Description
CHI_Geology_u11		Geology taken from AGS Map 236
CHI_Structures_u11		Faults and lineaments compiled from all published sources by the AGS in northwestern Alberta (see Pana et al., 2001 for an explanation)
CHI_Physiography_u11		Physiographic Regions of Alberta
CHI_Bad_Heart_Fm_u11		Outline of Bad Heart Formation after Green and Mellon (1970)
CHI_Proposed_Road_u11		New road proposed for Clear Hills Municipal District
CHI_Boundary_Large_u11		Polygon boundary for Clear Hills – Smoky River compilation region
CHI_Boundary_Small_u11		Polygon boundary for Clear Hills area
CHI_L7_irs_u11		Landsat 7 image for Clear Hills - Smoky Region fused with IRS (see explanatory text below); file is on CD 2 of 2
CHI_L7_irs_srtm_u11		Landsat 7, IRS image fused with Digital Elevation Model (see explanatory text below) ; file is on CD 2 of 2

(Note: continued on next page)

Table 2 (Continued). GIS Shapefiles and ArcExplorer Themes in the Compilation

Compilation from Assessment Reports and Other Sources

Shapefile	Additional ArcExplorer Theme	Description
CHI_DA_Holes_u11		Diamond-drill and auger holes compiled from AGS mineral assessment reports
	Iron	Diamond-drill and auger holes with iron intercepts
	Coal	Diamond-drill and auger holes that have intersected coal
CHI_Coal_u11		All exploratory coal holes compiled from the EUB coal database and W. Hamilton records
	Iron	All exploratory coal holes that have ferruginous intercepts
	Coal	Exploratory coal holes that intersected coal versus those that did not.
CHI_Waterwells_u11		All water wells that have intersected iron
CHI_Samples_u11		All pertinent samples compiled from assessment reports
	Assays	All samples for which there are assay or geochem results
CHI_OilGaswells_u11		All oil and gas wells in the compilation region
	BadHeart	All oil and gas wells with pick 1660 (Bad Heart Formation) identified
	Cardium	All oil and gas wells with pick 1750 (Cardium Formation) and above identified
CHI_Geophysics_u11		Aeromagnetic and ground anomaly locations
CHI_Geophysics_contours_u11		Aeromagnetic contours given as polygons
CHI_Outcrops_u11		All outcrops of Bad Heart Fm identified from AGS reports and files, assessment reports and publications as of September 2005

Base Map data at 1:1 000 000 scale¹ (all shapefiles clipped to compilation boundary)

Shapefile	Additional ArcExplorer Theme	Description
CHI_Towns_U11		All towns in study area
CHI_Roads_U11		All roads in study area
CHI_Rivers_U11		All rivers in study area
CHI_Lakes_U11		All lakes in study area

¹Additional base map data at larger scales (such as 1:250 000, 1:50 000 or 1:20 000) may be obtained from AltaLIS Ltd. at www.altalis.ca.

2.3.5 Assessment Report Lithologs

A total of 332 diamond-drill and auger hole lithologs from selected mineral assessment reports on file at the AGS were scanned and saved as JPGs. The litholog file names are listed on CD 1 Excel file “*CHI_GN2005-05__Compilation_DA_Holes.xls*.” These lithologs contain down-hole stratigraphy or drilling progress reports for the 332 of 340 diamond-drill and auger holes that have such information in the mineral assessment report, or in the drill sections associated with the assessment report (e.g., in assessment report 19540001 by McDougall, 1954). The JPGs were named using the assessment report number followed by the individual hole identifier (e.g., 19540001_E1.jpg refers to hole ‘E1’ in assessment report ‘19540001’).

2.3.6 PDF Files

In addition to the PDF of this Geo-Note in the root directory, there is a PDF file of 162 selected GeoWell Standard Reports with Bad Heart formation pick 1660 identified. This file is on CD 1 of 2 in the Subdirectory\File:

“\OilGaswells_with_BadHeart_Pick1660.”

This PDF contains the oil/gas well logs, or selected parts, for the 162 wells identified within the Clear Hills – Smoky River region that specifically refer to Bad Heart Formation pick 1660.

3 Preliminary Discussion of Unknowns Regarding the Clear Hills Ironstone and Coal Resources

In general, there has been little geoscientific work and only small amounts of exploration done regarding the Clear Hills ironstone or coal resources in the Clear Hills region since the mid 1970s. At that time, several unresolved or unknown aspects acted to make both exploration and development of these resources economically unattractive. However, recent increases in demand and price of iron for steelmaking has heightened interest in the Clear Hills region as a potentially large iron reserve, as well as for coal for thermal power generation. Nonetheless, there remain many unknowns about the ooidal ironstone resource in the Bad Heart Formation and the overlying coal resources. This compilation does not specifically address these unknowns, although the data may partially assist in doing so.

3.1 Geological Concerns

Some of the geological concerns or unknowns about the Clear Hills region that should or may need to be addressed in order to foster increased exploration and development, follow.

3.1.1 Stratigraphy and Stratigraphic Correlations

The Bad Heart Formation, in the vicinity of Smoky River and in the subsurface to the south and west, has been relatively well studied as documented in the theses or papers by Collom (2001), Donaldson (1997), Donaldson et al. (1998, 1999), and Plint et al. (1990). These workers have studied the lithostratigraphy and bio-stratigraphy of the Bad Heart Formation in the Smoky River region, and have interpreted or speculated on this unit’s allomembers and sequence stratigraphic correlations. As well, both Donaldson (1997) and Collom (2001) made inferences about the stratigraphic correlation between the exposed Bad Heart Formation south of the Peace River (i.e., from outcrops along the Smoky River, and near the

hamlets of Wanham and Spirit River) and the much less poorly exposed Bad Heart Formation and ooidal ironstones that crop out locally within the Clear Hills (e.g., north of the hamlet of Worsley and along the Rambling River).

Nonetheless, the stratigraphic details within the Clear Hills remain poorly known. These include a lack of detailed and systematic lithostratigraphic sections, and the little understood lithostratigraphic, bio-stratigraphic and sequence stratigraphic correlations both within the Clear Hills region, and to the south with the Bad Heart Formation exposures that are south of the Peace River. Examples of the current uncertainty about Bad Heart Formation stratigraphy include

- a) MacLearn (1919) defined the Bad Heart Formation as being a sequence of sandstones with contained ironstones that crop out along the Smoky River near its intersection with the Bad Heart River.
- (b) In the Clear Hills, Mellon (1962) and Hamilton (1980) suggested the Bad Heart Formation, including the contained oolitic unit(s), stratigraphically overlies the Kaskapau Formation and is overlain by the Puskwaskau Formation.
- c) Donaldson (1997), based on several detailed stratigraphic sections he measured along the Smoky River, both south and east of its confluence with the Bad Heart River, showed the 'Bad Heart sequence' comprising a lower massive ooidal ironstone and an upper thinner and less massive ooidal ironstone. Donaldson (1997) and Donaldson et al. (1999) suggested that the upper ironstone is in fact part of the base of the overlying Puskwaskau Formation, and correlated the lower massive ooidal ironstone with the massive Bad Heart Formation ooidal ironstone sequence that crops out along the Rambling River in the Clear Hills. As well, Donaldson et al. (1999) suggested the Bad Heart Formation was underlain by Muskiki Member, and thus the Kaskapau Formation had been eroded in the Clear Hills.
- d) Most recently, Collom (2001) suggested the lower massive ooidal ironstone that occurs along the Smoky River should be assigned to the top of the underlying Kaskapau Formation. As a result, if both Donaldson (1997) and Collom (2001) are correct, this means the Bad Heart Formation along the Smoky River would only comprise a few metres of sandstone that occur between the lower and upper ooidal ironstones, and thus might also throw into doubt the correlation of the lower massive ooidal ironstone along the Smoky River with a seemingly similar lithological sequence in the Clear Hills region.

Therefore, further detailed stratigraphic work, including detailed lithostratigraphic sections with associated bio-stratigraphic data, is needed in the Clear Hills region to correctly interpret the sequence stratigraphy correlations between the Bad Heart Formation there with that south of the Peace River.

3.1.2 Geometry and Grade of the Oolitic Ironstone and Coal Resources

Although the geometry of the Clear hills ironstone deposit(s) has been inferred by some workers (e.g., Figure 4, Green and Mellon, 1962; Figure 14, Donaldson et al., 1999), these interpretations are based on little substantive data about either the geometry or shape (i.e., width, length and thickness) of the various ooidal ironstone units or beds, or about the grades of iron and other metals within the ooidal ironstones. This is true for both the geometry of the ooidal ironstone resource back from the outcrop edge north and south of the Smoky River, and within the Clear Hills region. Although exploration in the late 1950s and early 1960s for ooidal ironstone along the southern and eastern margins of the Clear Hills indicated there was at least a billion tonnes of resource with an average grade between 32% and 35% iron (Hamilton, 1980), much of the detailed exploration data are lost, hence these estimates cannot be verified. In any case, the available resource estimates probably are not acceptable under the current guidelines for

resource and reserve reporting provided by the Canadian Institute of Mining & Metallurgy (CIM; see website <http://www.cim.org/committees/StdApprNov14.pdf>). As well, because most of the exploration drilling done in the 1950s and 1960s was near the outcrop or subcrop edge of the Clear Hills ooidal ironstone, the global, in-ground ironstone inferred resource could be substantively larger than 1 billion tonnes. Regardless, at this time there is a definite lack of data to define a potentially economic reserve portion of whatever resource does exist.

Thus, further geological, geochemical and geophysical studies are needed to define the geometry and grade variations of the ironstone resource within the Clear Hills – Smoky River region. However, only systematic and reasonably detailed exploration, especially drilling, will provide the information needed to define any existing reserve.

With respect to coal resources, the ERCB Reserves of Coal report for Alberta of December 1993, which is the most recent available, suggested there are about 240 million tonnes of lignitic ‘A’ coal in two main seams in Late Cretaceous Wapiti Formation that overly the Bad Heart Formation within the Clear Hills region. However, this estimate is speculative and further work is needed to refine the geometry and quality of the coal resource estimates to assist with the possible definition of a recoverable coal reserve. Identification of a coal resource/reserve is needed because coal could be important for development of power co-generation to assist with any on-site mining or metallurgical recovery of iron from the ironstone resource.

3.1.3 Geochemistry Variations and Potential for Co-Product ‘Sweetspots’

Olson et al. (1999) suggested the Clear Hills – Smoky River Bad Heart Formation may contain potential co-products that might act as ‘sweeteners’ during future recovery of iron from the ooidal ironstone resource. Some of the possible co-product elements with ‘elevated’ concentrations indicated by the data in the 1999 report include vanadium, arsenic, manganese, zinc, plus possibly gold, cobalt, chromium, molybdenum, nickel, phosphorous, lead, antimony, tungsten and the rare earth elements. As well, the assessment report by Boulay (1995, 1996) suggested there were anomalous concentrations of gold spatially associated with the Bad Heart Formation ooidal ironstones in the Botha River – Naylor Hills area in the northern part of the Clear Hills region.

Thus, further study and data are needed to assess whether the Bad Heart Formation ooidal ironstones in the Clear Hills – Smoky River region have elevated concentrations of some elements, in addition to iron, that in places might enhance the economic favourability of the ironstone for development. Alternatively, from a negative perspective, it is uncertain whether elevated concentrations of some elements may be ‘deleterious’ for iron ore metallurgical processing and recovery.

3.1.4 Faults and Their Relationship to the Coal and Ooidal Ironstone Resources

Several, predominantly northwesterly and northeasterly trending, faults are inferred in the subsurface in the Clear Hills region (Pana, 2001; pers. comm., 2005). However, the details as to whether they exist, and if present, their strike, dip and age of predominant activity, are largely uncertain. Further, for those faults that do exist, did any of them have an affect on the depositional environment of the Bad Heart Formation and, in particular, the genesis of the ooidal ironstones. If so, this could have ramifications for both the geometry and geochemical grades within the ooidal ironstone resources.

3.1.5 Spatial Relationship Between Coal and Ooidal Ironstone Resources

Both coal and ooidal ironstone resources exist within the Clear Hills region. However, the details of the spatial distribution of the ooidal ironstone resources, versus the overlying coal resources, are poorly understood at present. Such information is important because where ironstone and coal resources coincide, these could be favoured locales for delineation of an ooidal ironstone reserve and a potentially mineable co-incident coal reserve for power generation.

3.1.6 Thickness and Stratigraphy of the Overlying Overburden and Bedrock Units

At present, both the thickness of the overburden and bedrock sedimentary units, and their internal stratigraphy, that overly the coal and ooidal ironstone resources are poorly known in the Clear Hills region. This information has important ramifications for both exploratory drilling to test the ironstone and coal resources, and for development of potential open-pit versus underground resources and reserves.

3.2 Other Issues and Concerns

In addition to the geological aspects needing further information to be resolved, there are a few other issues that require study to facilitate exploration and development of both the ooidal ironstone and coal resources within the Clear Hills region.

3.2.1 Lack of Geological Mapping

There is a lack of detailed surficial and bedrock mapping in the Clear Hills region and this is hampering exploration for and definition of the ooidal ironstone and coal resources and reserves. For example, there has been no detailed surficial overburden mapping in the Clear Hills, and the only bedrock mapping is at 1:500 000 scale (Green and Mellon, 1962, 1970).

As well, the Clear Hills region has had no systematic surficial geochemical sampling to aid in identifying locales with both an ironstone resource and potential geochemical ‘sweetspots’.

Concerning geophysical mapping, some relatively detailed aeromagnetic coverage (with lines spaced about 400 m or one-quarter mile apart) has been flown in the Clear Hills region, but this has been done mainly in support of oil and gas exploration. As well, all of the data are either proprietary or not publicly available at low cost. AGS has on file an airborne, high-resolution, aeromagnetic (HRAM) survey dataset for the Clear Hills, which was donated by Fugro in 2002 (information about this company is at <http://www.fugro.com/>, and their Canadian operation at <http://www.fugroairborne.com.au/datasales/nex/canada.shtml>). However, the line spacing for this donated HRAM survey data is low resolution at 800 m (½ inch equals half mile). If publicly available, detailed aeromagnetic, gravity and electromagnetic geophysical survey data were available for the Clear Hills region, these data would enhance the understanding of the geology of this region, including possible delineation of the ooidal ironstone and coal resources. As well, it could assist in the exploration for other commodities, such as diamondiferous kimberlites.

3.2.2 Metallurgy – Complex or Not?

The ooidal ironstones within the Bad Heart Formation in the Clear Hills – Smoky River region are of the ‘minette type’ as defined by Gross (1965, 1967 and 1968). In the past, the mineralogy and metallurgy of

the Clear Hills ooidal ironstone have been suggested as being “*complex*” (Mellon, 1962; Petruk, 1977; Petruk et al., 1974, 1977a, 1977b; Hamilton, 1980). As a result, this complex metallurgy hampered the development of a potential iron mine.

More recently, however, Dr. Qi Lui (professor of metallurgy, University of Alberta, Edmonton, pers. comm., 2005) suggested there have been some significant advances during the past 30 years in the processing of minette-type iron ore. As a result, the metallurgy of the ooidal ironstones in the Clear Hills – Smoky River region needs to be reassessed.

3.2.3 Economic Studies

Economic studies are needed to determine

- who the main or most likely worldwide competitors of iron ore production are and where they are located;
- who the main consumers of iron ore are and where they are located;
- what iron grade and product type the main iron ore consumers want, and can it be produced from the Clear Hills ooidal ironstone, or can the ironstone be upgraded to be desirable by possible consumers;
- whether an iron mine in the Clear Hills is feasible only by surface mining via open pit(s), or is it possible an underground iron mine could be competitive;
- what impact transportation freight costs have on iron ore development in the Clear Hills region; and
- whether Alberta’s abundant and diverse supply of energy resources can be used to leverage the development of the Clear Hills ironstones.

These are a few of the questions an economic study might address to provide information that will assist in the exploration and development of the Clear Hills ooidal ironstones.

4 Conclusions and Recommendations

The compilation documented in this report has assembled a large amount of data about the Bad Heart Formation, ooidal ironstone and coal resources from assessment reports, the EUB/AGS coalhole and oil/gas well databases, the Alberta Environment water well database, and other publications, maps, documents or databases containing information about the Clear Hills - Smoky River region.

All of the data about ooidal ironstone or coal resources in the Clear Hills – Smoky River region have been compiled digitally into a series of Microsoft Access and Excel files, JPGs, PDFs, an ArcExplorer project and a suite of ESRI-compatible GIS shapefiles. These files are on the two CDs accompanying this report.

To conclude, the compiled data now need further evaluation and interpretation to provide meaningful new information and knowledge that will enhance and encourage further mineral and coal exploration in the Clear Hills – Smoky River region of northwestern Alberta.

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