75-22

GEOLOGICAL SURVEY
PAPER 75-22

DEVELOPMENT OF A COMPUTER-BASED FILE ON OIL AND GAS POOLS

G.J. Dickie
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Published by the Geological Survey of Canada
Department of Energy, Mines and Resources, Ottawa

1975

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

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Price: $2.00 Catalogue No. M44-75-22

Price subject to change without notice

Information Canada
Ottawa
1975

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DEVELOPMENT OF A COMPUTER-BASED FILE ON OIL AND GAS POOLS

ABSTRACT

Oil and gas pools are definable mineral deposits on which geological measurements can be made. The geological data are syntheses of observations made in one or more wells in which the oil or gas is encountered, and may be either descriptive or quantitative.

The data recorded for each pool were grouped into six categories based on file design and data accessibility. These categories are: Identification and location, stratigraphic sequence, unconformity data, lithological data, geometry, and reservoir and production data. Difficulties arose in defining the location and shape of the pool and also in recording the lithology and stratigraphy of the reservoir and related rocks. The shape of the pool is defined by the dimensions and orientation of two orthogonal axes drawn within the pool. The location is taken at the well drilled nearest the intersection of the two axes. Lithology and stratigraphic sequence are based on the reservoir unit. The formal stratigraphic designation (group, formation, member) of units overlying and underlying the reservoir constitutes the stratigraphic sequence. A record of the lithology of the reservoir unit and of the rocks 100 feet (30.5 m) above and below the reservoir is satisfactory for regional analysis.

The major part of a file on 1 100 Cretaceous and Jurassic oil and gas pools in Alberta using this file design was completed in two years at a data collection cost of $5 500. File operation costs using the SAFRAS system have been minimal.

RÉSUMÉ

Les nappes de pétrole et de gaz sont des gîtes minéraux définissables sur lesquels il est possible d'effectuer des mesures géologiques. Les données géologiques sont la synthèse d'observations faites à partir d'un ou de plusieurs puits où le pétrole ou le gaz sont présents, et peuvent être qualitatives ou quantitatives.

Les données enregistrées pour chaque nappe furent regroupées en six catégories basées sur le type de fichier, ainsi que l'accessibilité des données. Ces catégories sont: identification et localisation, séquence stratigraphique, données de discontinuité, données lithologiques, géométrie ainsi que les données de réservoir et de production. Des difficultés ont été rencontrées dans la détermination de la forme et de la localisation des nappes, et aussi dans l'enregistrement de la lithologie et de la stratigraphie des réservoirs et des roches affiliées. La forme de la nappe est définie par la dimension et l'orientation de deux axes orthogonaux tracés à travers la nappe. La localisation est celle du puits le plus rapproché de l'intersection des deux axes. La lithologie et la séquence stratigraphique sont basées sur l'unité réservoir. La désignation stratigraphique formelle (groupe, formation, membre) des unités situées immédiatement au-dessus et au-dessous du réservoir constituent la séquence stratigraphique. L'enregistrement de la lithologie de l'unité réservoir et des roches situées jusqu'à 100 pieds plus haut et plus bas que le réservoir est suffisant pour l'analyse régionale.

La plus grande partie du fichier sur 1 100 nappes de pétrole et de gaz du Crétacé et du Jurassique en Alberta selon ce type de fichier fut complétée en deux ans au coût de $5 500 pour la collecte des données. Les frais d'opération du fichier, en utilisant le système SAFRAS, ont été minimes.

Manuscript received: 5 June 1973
Revised manuscript received: 30 October 1973
Manuscript approved for publication: 31 October 1973

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INTRODUCTION

The practice of organizing data files based on discrete occurrences of a valuable commodity (a deposit) is common to companies or agencies involved in the exploitation or regulation of natural resources. The main use of such files has been to control the production of the commodity and to provide an estimate of future potential reserves. For this purpose, the Alberta Energy Resources Conservation Board maintains a reserves and production data file which is based upon defined oil and gas pools, to permit monitoring of the progressive depletion of each pool as the oil or gas is produced. The large oil production companies also maintain similar files and exchange data with the Board.

Very few geological data are stored in these files. In exploration for oil and gas pools, where more geological data are used, the file systems are based on *wells* drilled in prospective geological basins. Experience with such systems in western Canada has been described by Buller (1964, 1972), Stauft (1966), and Fitzgerald and Gagnon (1970). In these systems there is a considerable amount of geological data stored, but it is difficult to synthesize the data from scattered wells to apply to each discrete hydrocarbon accumulation.

During the mid-sixties, Burk and Ediger (1966) and Brisbin and Ediger (1967) urged that computer-based geological files be set up with the *deposit* as the basic unit--in this case, the oil or gas pool. The reasons proposed by these authors for setting up separate files on oil and gas and other mineral deposits were that:

1. The widespread accessibility of the data would "...provide the basis for an increased understanding of the geological controls that govern the occurrence of known deposits..."; and
2. The files would enable more reliable predictions of future potential reserves of the mineral.

For these reasons, a study of oil and gas pools in Cretaceous and Jurassic reservoirs in Alberta was initiated. These pools are relatively well defined by drilling and occur in a variety of geological settings. Obviously, the inclusion of all oil and gas pools in western Canada will eventually provide a more complete data base for geological analysis.

Definition of the data to be collected and the actual data collection began in 1969 following a survey of previous studies of oil and gas pools. Data were collected for 1 100 pools from maps at the Alberta Energy Resources Conservation Board in Calgary, and from well-log files at Imperial Oil Enterprises Limited in Edmonton.

A computer-based filing system was implemented in 1970 in association with the University of Alberta Computing Centre and most of the data were entered into the system to create the CRETPET (CRETaceous PETroleum) file by late 1970. A brief summary of the CRETPET file building and application was presented by Dickie and Williams (1972). This paper is a full report on the project.

It is hoped that the CRETPET file will eventually become part of an integrated network of mineral deposit files in Canada as recommended by Brisbin and Ediger (1967). Recent progress by a national committee working towards this objective is summarized by Burk (1972) and Longe (1973).

Acknowledgments

Initial encouragement to design and build an oil and gas pool file came from C. F. Burk, Jr., Canadian Centre for Geoscience Data. The authors are grateful to Dr. Burk and to the Geological Survey of Canada for support of the research in the form of Special Grants for Computer Applications. Generous co-operation was afforded in the data collection process by the Alberta Energy Resources Conservation Board (particularly J. R. Pow) in allowing use of their pool isopach maps. Imperial Oil Enterprises Limited provided office accommodation and access to their lithologic file for some months while lithological data were being collected. The senior author was funded by an NRC scholarship for two years of the project. The authors thank their colleagues at the University of Alberta and those in the oil industry for comments and criticism. Ann Bartlett-Page, systems analyst, provided essential support in implementing the file system and in building the CRETPET file.

DEVELOPMENT OF CRETPET FILE

Alberta Oil and Gas Pool Data

Geometric, reservoir, and some geological data on major oil and gas pools in Alberta have been published by the Alberta Society of Petroleum Geologists (White, 1960; Century, 1967; Larson, 1969). Annual reports are published by the Alberta Energy Resources Conservation Board giving reservoir and production data on the oil and gas pools in the province, and the Geology Department of the Board keeps current isopach maps of most pools. These maps are not publicly available but were released for this study.

A significant aspect of the present project was the devising of ways for recording the available geological data in a computer-processable format, while retaining as much of the "sense" of the deposit as possible. Subsequently the recording format was to be evaluated and a set of standards recommended as a basis for future files containing geological data on oil and gas pools. The objective is consistent with that of the ad hoc Committee on Storage and Retrieval of Geological Data (Brisbin and Ediger, 1967).

Geological Measurements on Oil and Gas Pools

Measurements that can be made on oil and gas pools fall into two broad categories--geological and engineering, with a small degree of overlap between them. Geological measurements may be considered to be either stratigraphic (including stratigraphic sequence, lithology, and depositional environments), or structural (shape, size, elevation, and presence of geological structures). Certain reservoir and reservoir-fluid parameters including pressure, water saturation, salinity, and oil gravity are also important in considering the geology of a deposit. Such properties have been used frequently in classifying oil and gas fields and in attempting to determine the origin of the hydrocarbons.

Geological measurements made on any deposit may be either: 1. Descriptive, or 2. Quantitative.

1. *Descriptive* measurements have no definable frequency distribution and belong to an "open" system of measurement where no meaningful limits can be placed on their variation. Such properties conform to either the nominal or ordinal scales of

Krumbein and Graybill (1965), and lend themselves only to elementary statistical analysis.

As an example, the colour of the reservoir rock is not easily quantified and is generally recorded as one of a number of classes of colour. The relative percentages of reservoir rocks which fall into the different classes may be a useful statistic but the "mean colour" has very little significance. However, the colour of the reservoir rock may be useful in combination with other properties in indicating changes in the nature of the reservoir rock over an area.

It is therefore important that descriptive measurements be stored in readable and consistent forms so that they can be used as a basis for retrieval from the file and that when retrieved they can be easily recognized and understood. It has been found that one convenient form for recording and storing some types of descriptive data is the four-letter mnemonic code generated from the full name, by using the procedure suggested by Brisbin and Ediger (1967). In addition, the four-character code is the most efficient for some computer processing.

2. Many of the *quantitative* measurements made on oil and gas pools are also "open ended" (interval scale of Krumbein and Graybill) and apparently cannot be defined by any particular distribution function. Included in this group are the preferred azimuth (trend) of the pool, the location of the pool, the porosity of the reservoir rock, and others. Since it is difficult to define the distribution function of these variables, statistics such as mean and standard deviation have only limited significance and the variables must be treated carefully in such techniques as factor analysis. If the relative frequency distributions are known in detail, then the bias introduced can be accounted for.

Other quantitative measurements (those conforming to the ratio scale of Krumbein and Graybill) do approximate defined distribution functions but few of these are statistically confirmed by detailed studies. The one measure which has been studied in most detail is the size of the pool (McCrossan, 1969; Drew and Griffiths, 1964; Kaufmann, 1964). The conclusion generally derived from these studies is that different measures of size tend to be lognormally distributed. This conclusion was arrived at partly by analogy with other natural phenomena, which follow the lognormal distribution, and partly from graphical analysis of measurements.

Storage and Retrieval System

The design of any file is influenced by the nature of the storage and retrieval system used. Early machine-processable files were based on the 80-column punch card and the data were coded to fit the available space. For this study, it was desired to reduce system-imposed restrictions as much as possible because the oil and gas pool file was of an experimental nature and would require continued modification. The SAFRAS (Self-Adaptive Flexible-format Retrieval And Storage) system (Sutterlin and De Plancke, 1969) was adopted in the initial stages of file design because it promised flexibility in file building and data collection. After some adaptations were made to the original SAFRAS system at the University of Alberta Computing Centre (producing the UASAFRAS system), it proved to be successful at handling the data generated on the 1 100 oil and gas pools.

Data Organization in Oil and Gas Pool File

The basic units for which data have been collected and recorded for the file are the individual oil and gas pools, the "stations" in SAFRAS terminology (Sutterlin and De Plancke, 1969). The system allows up to 99 record types (a group of logically associated data items) to be defined for each station.

Data items describing an oil or gas pool fall into two logical groups:

1. The identification and location of the pool, the size and shape of the fluid accumulations and the properties of the fluid, and
2. The geology of the reservoir and associated rocks.

These groups were then further subdivided according to the association of items in the data collection process and the probable association of items in retrievals to be made from the file.

Location, size and shape. Measurements of pool geometry (areas, trends, thicknesses), as well as structural trends, were recorded together from geological maps of the Alberta Energy Resources Conservation Board, but reservoir parameters and fluid properties were derived from other sources and were recorded separately. Therefore, one record type was set up to contain the geometric measurements and structural data (record type 5) and another to contain the reservoir parameters and fluid properties (record type 6). Certain of the data items in record type 6 were located in summary publications (White, 1960; Century, 1967; Larson, 1969) which also contained technical data on the number of producing wells and well spacing. These technical data were included in record type 6 for convenience.

It was considered essential to retain the identification and location of the pool as a complete entity in record type 1 because a proper definition of the pool was needed at the beginning of the data list. However, these data were assembled after making many of the measurements on the pools and also after much of the stratigraphic and unconformity data had been compiled. Consequently, they had to be assembled from at least four data sources, a time-consuming process. Also, the SAFRAS system requires that a "type 1" record be present for each pool, and therefore no actual file-building on the computer could begin until the type 1 records had been encoded, i.e. until most of the data had been collected for each pool.

For SAFRAS-style system files, we recommend that type 1 records consist of data items readily available at the start of file-building.

Geology. Data on the geology of the reservoir were collected mainly from two sources--publications and lithologic well logs. The name of the reservoir unit is known from the definition of the pool, and therefore the stratigraphic sequence can be found in major stratigraphic summaries such as the *Geological History of Western Canada* (McCrossan and Glaister, 1964). The lithologic logs prepared by Canadian Stratigraphic Services Ltd., and made available for this study by Imperial Oil Enterprises Limited, Edmonton, were used to record the detailed lithology of the reservoir rock and the overlying and underlying sections. Because of this split in data access and also because of the differing definitions of lithologic and stratigraphic units discussed later, record type 2 was set up to contain the stratigraphic sequence data, and record type 4 for the lithological data.

The relationship of a pool to unconformities was considered important from the aspect of migration and accumulation of hydrocarbons. To maintain consistency in measurements about the stratigraphy at the unconformity, it was found necessary to refer to both the lithologic logs and to publications. Therefore, a separate record type (type 3) was defined to contain the unconformity data.

In summary, the data categories decided upon for the file were:

1. Identification and Location
2. Stratigraphic Sequence
3. Unconformity Data
4. Lithological Data
5. Geometric Data
6. Reservoir and Production Data.

Details of Data Collected for Each Pool

A complete list of the original data specifications for each pool is given in Appendix 1. Important and contentious features of the data collected are best discussed by record type.

Type 1: Identification and Location. The type 1 record is critical to the file system in that it identifies and locates the station, in this case, the pool, for which the data are recorded. The record is designed to contain often-used data in an accessible format and will probably be the record type referred to most often. Many of the data items were suggested by Brisbin and Ediger (1967). In Alberta the definition and identification of fields and pools by code number is done by the Energy Resources Conservation Board and the official pool designations of that body were followed as closely as possible. Data also included in the type 1 record refer to the type of hydrocarbons in the pool (oil or gas, or both), the regional tectonic setting, and published references to the pool.

Difficulties were encountered in determining the best way to record the locations of pools. Ideally, the entire, three-dimensional pool outlines could be digitized and used as pool locations. However, a simpler and less time-consuming method of location was used (with consequent loss of detail). Major and minor axes were defined for each pool (see type 5, Geometric Data) and one location was taken at the well drilled nearest the intersection of these axes (Figure 1). The use of well-site locations gives each pool an actual reference source--the suite of well logs against which data in the file can be checked. Provision was made to record locations both in terms of the Dominion Land Survey which is used by oil companies and the Energy Resources Conservation Board, and also in terms of latitude and longitude, which is a more universally applicable system. A second location, that of the well in which the maximum reservoir thickness was recorded, was also entered. This second location perhaps could be useful in studying the relation between stratigraphy and hydrocarbon accumulations in particular reservoirs.

Type 2: Stratigraphic Sequence Data. The stratigraphic sequence in which a hydrocarbon accumulation occurs can be defined by three units--the reservoir unit, the unit overlying the reservoir, and the unit underlying the reservoir. The definition of units laterally equivalent to the reservoir is rarely recorded and is difficult to identify accurately in a limited study. Hence, lateral equivalents are not included in the file.

The design of the file system allows for the creation of three records of type 2, one for each of the units referred to above (reservoir, underlying, overlying). One composite record for all data on the stratigraphic sequence would have been too long for convenient coding and for efficient manipulation of the file. The SAFRAS system, at the time of file building, was unable to search within a data field, and it was considered desirable that searches of the file could be made at different levels of the stratigraphic hierarchy. Separate fields were therefore defined for group, formation, member, and informal names, modifiers, and ages, for each stratigraphic unit encountered. Codes were developed using the system suggested by Cohee (1967): A four-letter mnemonic code for the name of the unit, a one-digit code referring to a modifier of the unit (U-upper, M-middle, L-lower), and a three-digit hierarchical code for the geological age of the unit.

The inferred depositional environment of each unit was recorded as two items--general and detailed--to allow more flexibility. A two-digit code represented the general environment (see Table 1) and space for a twenty-character alphanumeric string was reserved for detailed comment.

Type 3: Unconformity Data. A relationship between hydrocarbon occurrences and regional unconformities has been observed in most petroleum provinces. The actual effect of the unconformity on the generation and accumulation of oil and gas is not well understood but at least it is frequently the locus of porous aquifers through which basin fluids can migrate and within which they may be trapped. Because of this lack of definite knowledge, it was decided to record empirically whether the pool was related to an unconformity, the spatial relationship, and the stratigraphy across the unconformity.

The basic problem encountered was establishing a consistent standard for deciding whether a pool was "related" to an unconformity. At the risk of not recognizing some subtle connections between the unconformity and the pool, it was decided that a pool was "related" to the unconformity if the overlying, reservoir, or underlying lithology (as defined for record type 4) was in contact with an unconformity (see Figure 2). In practice, this meant that pools which were more than approximately 100 feet (m) vertically from an unconformity were considered unrelated to it.

The system for recording the stratigraphic units adjacent to an unconformity was the same as that used for the type 2 records.

Type 4: Lithological Data. The relationship between lithology and hydrocarbon occurrence is an important but indirect one in that the presence of particular lithologies does not necessarily indicate the presence or absence of oil or gas. However, certain lithologic characteristics such as clast composition, grain size, and sorting, are often good indicators of the ability of rocks to act as reservoirs or seals for an oil or gas pool. The purposes of a regional file on oil and gas pools would seem to be best achieved by recording lithologies of the reservoir rock and of the underlying and overlying rock units. If there is a rapid lateral facies change within the reservoir unit, the lithology laterally equivalent to the reservoir rock should also be recorded, but this was not possible because of limitations in availability of data.

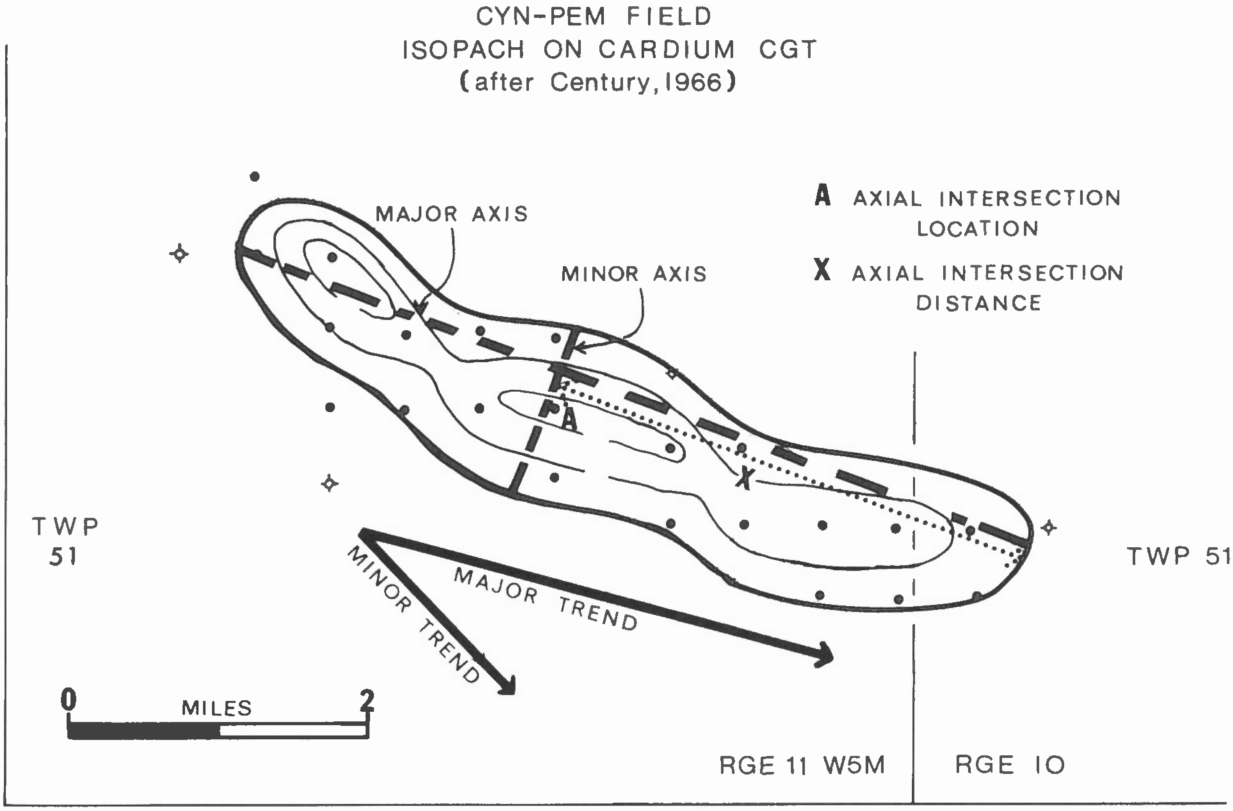


Figure 1. Size and shape measurements on oil and gas fields.

The method used to record lithological data was to locate the nearest available logged well to the pool, and to note:

1. The location,
2. Whether the well was inside or outside the pool boundaries, and
3. If outside, the distance from the well location to the pool boundary.

Once the well was defined, the reservoir unit was located on the lithologic log and the lithologies over an approximate 100-ft. (30.5-m) interval above and below the reservoir rock were taken as the overlying and underlying units respectively (Figure 2).

Discrete lithologies (e.g. sandstone, shale, etc.) were used as the basis for each record and provision was made to describe three discrete lithologies and their relative proportions from each of the overlying, reservoir, and underlying units. There are, then, nine possible type 4 records for each pool. However, the full nine lithologies are rarely recorded and usually between three and six records were sufficient to describe the lithology related to the pool.

Within each type 4 record, the first three data items identify the proportion of the particular rock type within the unit and the relation of the unit to the hydrocarbon accumulation (i.e. whether overlying, reservoir, or underlying). These three data items define the particular lithology thereafter described with respect to the oil or gas accumulation.

Standard terms are used to describe the details of the lithology (e.g. colour, grain size, mineral composition, cement, matrix) and these are recorded where possible in four-letter mnemonic codes (Table 2). These terms were designed to extract most of the data contained on recent lithologs published by Canadian Stratigraphic Services Ltd. However, many of the logs used were produced some time ago and are of poorer quality, so the descriptive lithological data are far from complete.

Table 1: Codes for General Depositional Environment

10	continental	20	intermediate	30	marine
11	alluvial fan	21	coastal plain	31	littoral
12	alluvial plain	22	lagoonal	32	near-shore
13	lacustrine	23	deltaic	33	stable shelf
				34	shelf-edge
				35	basin-edge
				36	basin-centre

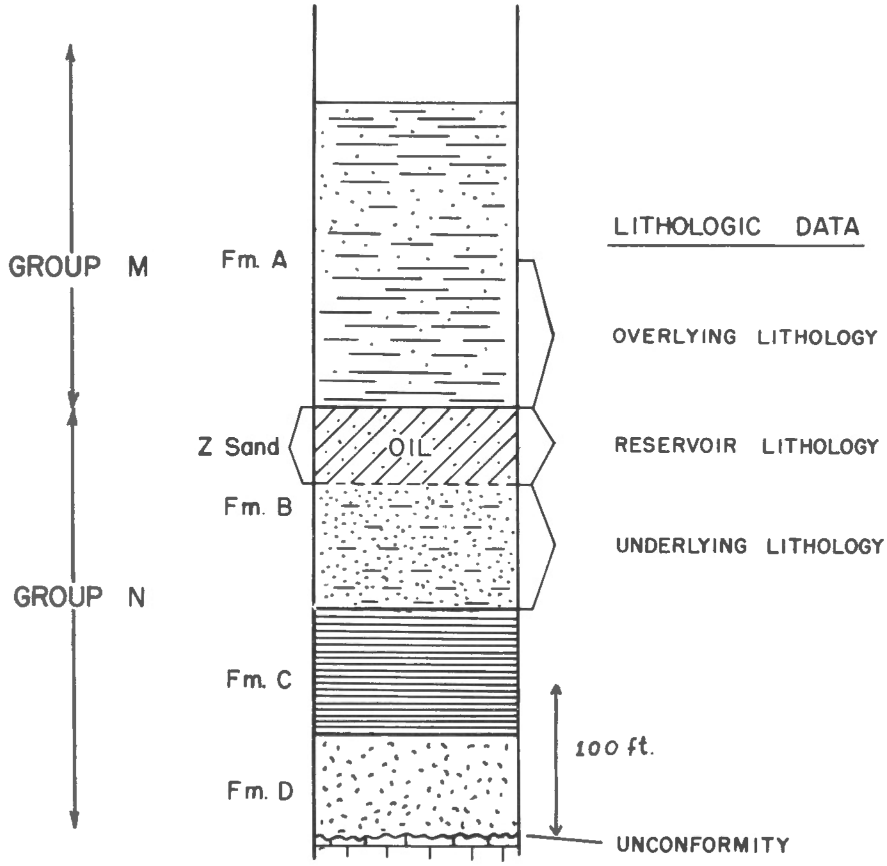
Type 5: Geometric Data. Because an oil or gas pool occupies three-dimensions in space, a method had to be designed which would characterize the size and shape of the pool with respect to all three axes. The pool outlines were taken from isopach maps prepared by the Geology Department of the Energy Resources Conservation Board. These outlines are projections of the margins of the pool on to a horizontal surface (see Figure 3); simplified in that the shapes of the upper and lower surfaces of the pool are not individually recorded.

Drew and Griffiths (1965) applied the measurements used in studies of sedimentary particle shapes to oil fields in the United States, considering each oil accumulation analogous to a single particle. Their approach was followed and modified for this study (see Figure 3).

Using the isopach projection of the pool, a major axis was defined as being the longest straight line that could be drawn within the pool outline. The length and azimuth of this line were measured. A minor axis was constructed as the longest straight line in the pool that could be drawn perpendicular to the major axis and its length was recorded. Also, the shape of the cross section along each axis (anticlinal, synclinal, undulating, etc.) was recorded by visually estimating the profile along the trace of the axis on the isopach. The distance from the point of intersection of the axes to the east end of the major axis was recorded to enable approximate reconstruction of the pool shape from the data in the file. Examples of the size and shape measurements are shown in Figure 3.

The plan area of the pool was measured by overlaying a grid of known unit areas on the isopach map and counting the grid units within the pool. The Conservation Board has official planimetered measurements of each pool area, and if the pool outline as defined publicly by the Board coincided with the geological pool outline, the official area was used.

Two values for oil and gas zone thickness were used to try to improve the accuracy of the parameter. Obviously, thickness



STRATIGRAPHIC DATA

OVERLYING GROUP :	Group M
OVERLYING FORMATION :	Formation A
RESERVOIR GROUP :	Group N
RESERVOIR FORMATION :	Formation B
RESERVOIR INFORMAL :	Z Sand
UNDERLYING GROUP :	Group N
UNDERLYING FORMATION :	Formation C

UNCONFORMITY

Pool is not related to unconformity

(Reservoir in Formation D would be related.)

Figure 2. Diagramatic columnar section.

varies over the entire pool but one definite value is the maximum oil or gas zone thickness. In determining an average thickness, the method used by the Conservation Board is to calculate volume and area with planimeter and find the average thickness from volume/area. For this project, the average thickness was estimated from the isopach maps and these estimates were checked frequently against the values obtained by the planimeter method. The deviation of the estimates from the calculated values was small, indicating that the procedure was acceptable.

The calculation of the position of the pool in the third or vertical dimension was recorded from the elevation with respect to sea level of the top of the reservoir interval at the axial intersection location. Measurements of pool geometry are shown on Figure 3 and summarized in Table 3.

Three structural elements, regional dip, folding, and faulting, were considered to have possible significance in the formation of an oil or gas pool. Such elements are best recognized in the subsurface on structural contour maps constructed on horizons adjacent to the reservoir rock. Regional dip measurements and fault directions are usually obvious on these maps but, particularly in the plains portion of the Western Canadian Sedimentary Basin, there are very few well-defined structural closures. Folds generally show up as "noses" on structural contours and the measurements of fold orientations were made on the basis of these minor anomalies on the contour maps (Figure 4). In the data specifications, provision was made for recording two such orientations, because the interaction of folding is often responsible for accumulations.

Type 6: Reservoir and Production Data. The data recorded for each pool in type 6 records are those parameters of the reservoir rock and of the contained fluids that reflect directly on the geology and hydrodynamics of the pool. The most widely-used figures are the in-place reserves of oil and gas for each pool, although porosity, water saturation, oil gravity, and initial pressure are also important. Most of these data were taken from Conservation Board files to maintian consistency.

The summary publications of White (1960), Century (1967), and Larson (1969) designate a trap type for each oil or gas pool. To include the sense of this item in the file, a very basic trap classification was set up (stratigraphic, structural, or combination) and each pool assigned to one type. Other data such as the number of producing wells, well spacing and "other products" are included in the publications referred to, and these were recorded, not for any immediate purpose, but because of their easy access and their possible use in summaries and displays.

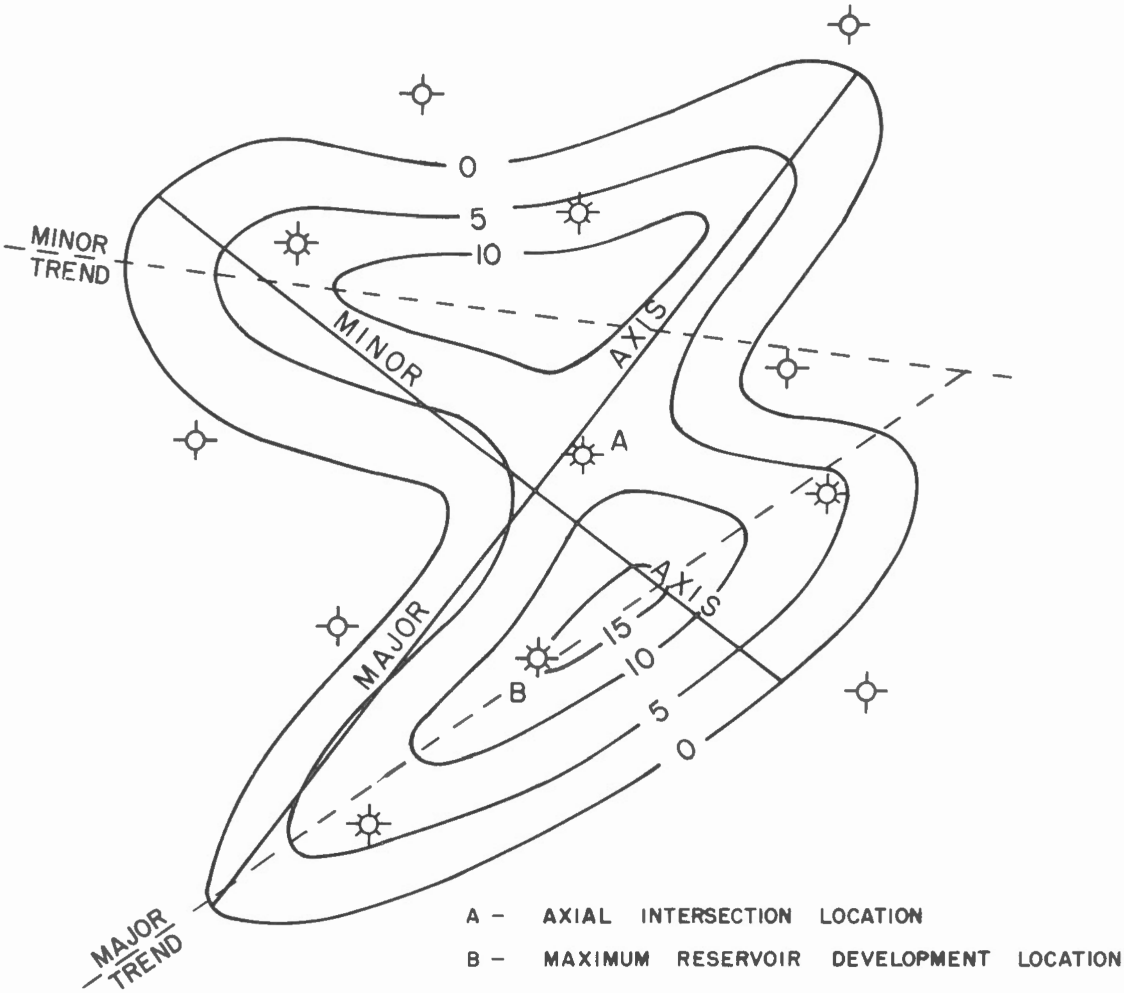


Figure 3. Diagrammatic gas pool isopach.

Data Collection and Management

The sequence of data collection was controlled largely by the availability of the data and the physical association of types of data items. Initially, the pool maps of the Energy Resources Conservation Board were made available for study by the authors and the detailed map measurements were carried out during July-August 1969, at the office of the Conservation Board. This phase resulted in the collection of geometric data on most of the Cretaceous pools in which two or more wells have been drilled.

Subsequent data collection at the Conservation Board by the senior author in February 1970 was aimed at recording as much data as possible on those pools not covered by geological maps (mostly small, one-well pools). The data for these were recorded on "strike-sheets", brief reports by the Board on minor oil or gas strikes. Later analysis of the total file (1 100 pools) revealed that while axial measurements were available for only 60 per cent of the poo the reserves in those pools accounted for 86 per cent of the oil reserves and 87 per cent of the gas reserves in the province. A total of 300 hours was spent by the senior author recording the geometric data, 225 hours on the pool maps and 75 hours on the strike-sheets.

Concurrently with the study on the Conservation Board pool maps, lithological data were being extracted from logs produced by Canadian Stratigraphic Services Ltd. and made available by Imperial Oil Enterprises Limited in Edmonton. These data were obtained by a technician with a little geological training and were recorded in a format designed for direct entry of the data into the UASAFRAS (University of Alberta version of SAFRAS) system file. Acquisition of the lithological data required six months work.

Literature Searches

The collection of stratigraphic and unconformity data on the Cretaceous pools was essentially a literature search through such comprehensive works as:

Geological History of Western Canada (McCrossan and Glaister, 1964)

Lexicon of Geologic Names in the Western Canada Sedimentary Basin and Arctic Archipelago (Alberta Society of Petroleum Geologists, 1960)

Oil Fields of Alberta (White, 1960)

Oil Fields of Alberta Supplement (Century, 1967)

Gas Fields of Alberta (Larson, 1969).

This search was carried out in May-June 1970, by a geological assistant and required some knowledge of geological terminology.

Table 2: Abbreviation Schemes for Lithological Data Collection

Data Item	Examples of Data		Abbreviations
CRYSTALLINITY	Crystalline		CRSL
	Granular		GRLR
(GRAIN) SIZE	> 4 mm	Pebble	PBBL
	2-4 mm	Granule	GRNL
	1-2 mm	Very coarse sand	VCSD
	0.5-1 mm	Coarse sand	CRSD
	0.25-0.5 mm	Medium sand	MDSD
	0.125-0.25 mm	Fine sand	FNSD
	0.0625-0.125 mm	Very fine sand	VFSD
	0.032-0.0635mm	Coarse silt	CRSL
	0.004-0.032 mm	Medium-fine silt	MFSL
	< 0.004 mm	Clay	CLAY
CLAST-COMPOSITION	Quartz		QRTZ
	Feldspar		FLDP
	Dolomite		DLMT
ACCESSORY-MINERALS	Chert		CHRT
	Glauconite		GLCN
FOSSIL-TYPE	Plant fragments		PLNT
	Fish scales		FSSC
	Ostracods		ORCD
SORTING	very good		VRGD
	good		GOOD
	moderate		MDRT
	fair		FAIR
	poor		POOR
ROUNDING	rounded		RNDD
	angular		ANGL
POROSITY TYPE	intergranular		IRGL
	intercrystalline		IRCL
	fracture		FRCR
	pinpoint		PNPN
	vuggy		VGGY
	intraskeletal		IRLL

Table 3: Measurements of Pool Geometry

Pool Feature	Data Measurement
Geometry	
AXES	MAJOR AXIS___longest straight line drawn in the pool outline (length and azimuth recorded). MINOR AXIS___longest straight line drawn in the pool outline perpendicular to the major axis (length recorded).
TRENDS	MAJOR TREND___predominant direction of elongation of pool outline. MINOR TREND___secondary direction of elongation.
AREA	POOL PLAN AREA___planimetered or estimated plan area.
THICKNESS	MAXIMUM RESERVOIR ZONE THICKNESS (if available) AVERAGE OIL ZONE THICKNESS AVERAGE GAS ZONE THICKNESS
Location	
POINT	AXIAL INTERSECTION LOCATION___location of well site nearest the intersection of major and minor axes. MAXIMUM RESERVOIR LOCATION___location of well site nearest the maximum reservoir thickness.
ELEVATION	PAY ZONE TOP ELEVATION___elevation w.r.t. sea level of the top of hydrocarbon zone at the axial intersection location.

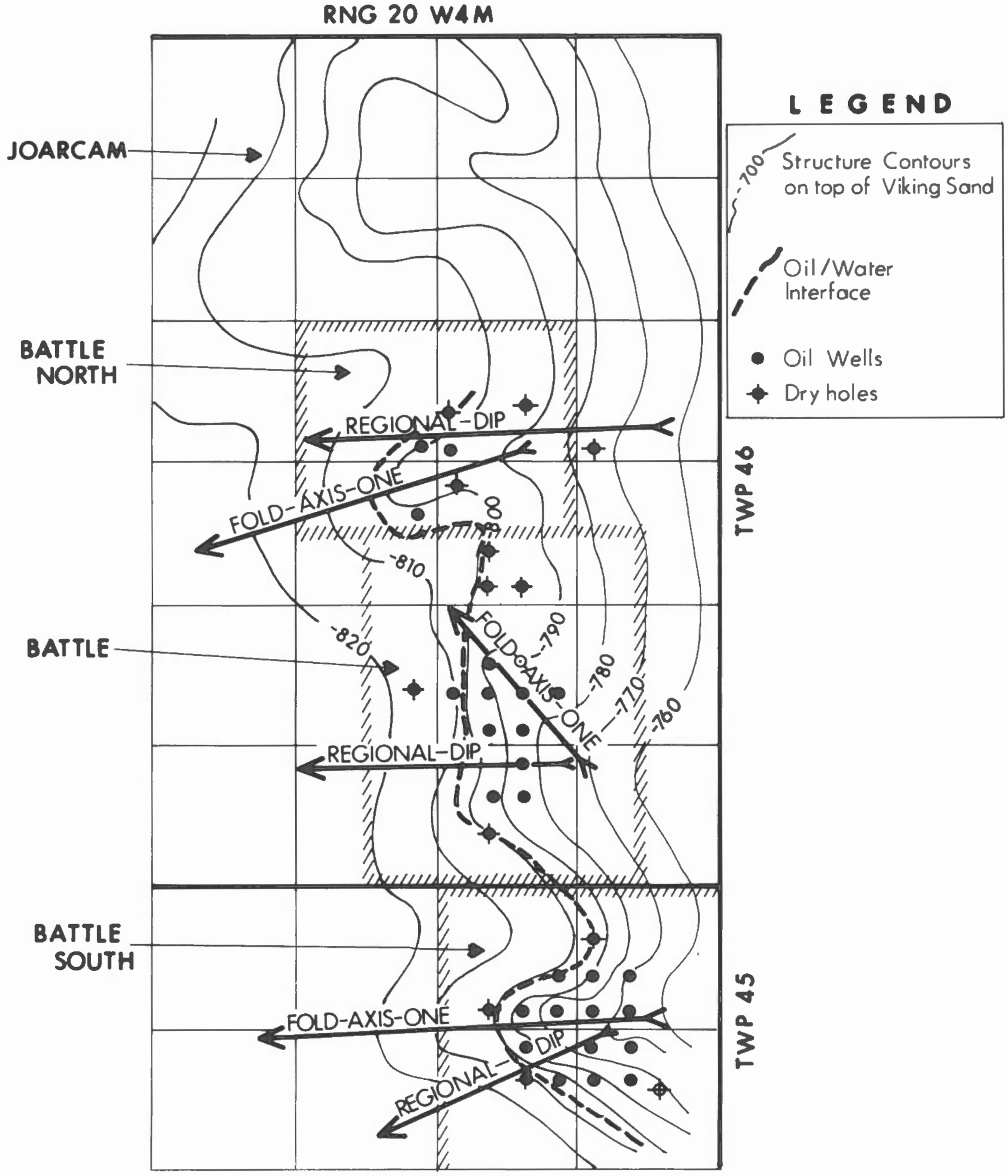


Figure 4. Structural measurements of Battle oil field (modified after White, 1960).

Data for record types 1 and 6 were accumulated simultaneously over a three-month interval (October-December 1970) from a number of reference sources by an assistant with no geological training because a minimum of interpretation was required. It was realized late in the data collection stage that all the type 1 records had to be coded before any actual file building could take place using the UASAFRAS system. In retrospect, coding the type 1 records late in the data collection phase was an error in the sequence of the operation and caused the construction of the file to be delayed by several months.

A summary of data collection timing and costs is presented in Table 4.

Keypunching

As the data for the different record types were coded, they were punched on 80-column cards and stored temporarily on magnetic tape. When all the data had been stored for all pools, the record types were sorted and card images were arranged according to the serial number of the pool for which the data were recorded. From this series of card images the UASAFRAS format file was built on another magnetic tape.

Keypunching the coded data required approximately 200 hours.

System Control

The establishment of the SAFRAS system on the IBM 360/67 computer at the University of Alberta Computing Services Department required the services of a part-time system analyst, Miss Ann Bartlett-Page, over a 12-month period. Subsequent development and extension of the UASAFRAS system into an interactive system was completed by Miss Bartlett-Page, and her assistance in making the CRETPET file operative was invaluable.

EVALUATION OF FILE DESIGN AND DATA COLLECTION

The first known attempt to build a computer-processable geological data file on petroleum accumulations in western Canada was reported on by Burk and Ediger (1966), and the success of the present project can be gauged by a comparison with that file. Burk and Ediger compiled data on about 600 non-associated gas pools and showed diagrammatically the availability of the basic data items recommended by the Committee on Storage and Retrieval of Geological Data (an **ad hoc** committee of the National Advisory Committee on Research in the Geological Sciences). Data on "pool geology" were not readily available from Provincial Government sources and from publications, and it was suggested that further attempts be made to collect and evaluate geological data on oil and gas pools.

The completeness of data collection for the CRETPET file can be seen in Appendix 1, where the amount of data in the file for each data field is recorded. File design is evaluated in terms of the ease of data collection and the efficiency of the file-building process in the UASAFRAS system.

Record Types

The establishment of six groups of associated data items (record types) has proved generally successful both for data collection and management. Two record types (type 3--unconformity data, and type 4--lithological data) were most in dispute because of the possibly unnecessary added storage required.

In the case of unconformity data, the use of a single record to contain all the data items relevant to the stratigraphy across the unconformity proved to be the most effective storage and retrieval arrangement.

The system for recording lithological data (type 4) proved too cumbersome for the amount of detail available. The maximum number of lithologies recorded for any pool was 6, and there are 1 855 type 4 records representing the lithologies of 578 pools, and average of 3-4 records per pool. Two planning mistakes were made. Making allowance for nine different lithologies per pool in the file design created pressure to fill in as much lithology data as possible. A considerable amount of data was then accumulated on the original format sheets by transcription from Canadian Stratigraphic Services lithologs. Too much detailed data was acquired at that stage to be handled effectively. The second mistake was changing the input format for the lithological data record. The original data sheets had to be reinterpreted and coded into the new format, effectively repeating the initial data collection. The redesigned format was clearer and more compatible with the rest of the file, but it is doubtful that the improvement was worth the work of the manual changeover. Experience with the UASAFRAS system has shown that the data could have been entered in the old format and later changed internally.

When it became apparent that large amounts of time would be needed to acquire and code the lithological data, it was decided to enter lithological data from the largest oil and gas pools first. Therefore the 578 pools in the file for which there are lithologic records are the largest in terms of reserves.

Table 4: Summary of Data Collection Costs

Data Type	Training of Collector	Period	Time	Cost Can. $
Geometric and Location (types 1 and 5)	Geological	July-August 1969	200 hours	$ 500
Lithologic (type 4)	Some geological	July-December 1969	6 months	$2 000
Location and Technical (types 1 and 6)	Geological	February 1970	75 hours	$ 200
Stratigraphic and Unconformity (types 2 and 3)	Some geological	May-June 1970	300 hours	$ 800
Preparation of Lithologic	Some geological	July-October 1970	300 hours	$ 800
Identification, Location, and Technical	Non-geological	October-December 1970	450 hours	$1 200
			Total	$5 500

Recommendations resulting from this experience in acquiring and entering lithological data into the file are:

1. Reduce the number of possible lithologies for each pool to six;

2. Reduce the number of data items in each type 4 record by 33 to 50 per cent.

3. Examine the reservoir lithology of the largest pools first; and

4. Record the underlying and overlying lithologies, only if available at the same source as the reservoir lithology.

Proposed Standard Data Specifications

Through experience in the collection and use of the geological data, a modified set of data specifications can be suggested for future file design. The major changes recommended are to the type 1 (identification and location) record and the type 4 (lithology) records, and the revised versions of these record types are listed in Appendix 2.

Type 1 Record. The Universal Transverse Mercator (UTM) coordinates, easting and northing, and the UTM zone number should be included for each pool. The display of data from the file on an X-Y plotter requires rectangular coordinates for each point (Kelly, 1972), and conversion of other coordinates for each plot is repetitious.

The inclusion of a second location (maximum reservoir development location) in the file has not been justified by the amount of use in subsequent analysis of the data. Also, the definition of the location of the maximum reservoir development as distinct from the maximum pay thickness can be difficult because many pool maps are constructed solely on the basis of pay thicknesses. For stratigraphic comparisons, the true maximum reservoir zone location might be useful, but if its definition is doubtful, then its value is reduced.

As an indicator of pool centre location, the axial intersection location is considered more reliable and is retained.

Type 4 Record. As was suggested previously, the maximum number of lithologies for each pool should be reduced to six allowing for two lithologies each for the overlying, reservoir, and underlying units. Similarly, many of the data items in the original specifications have been eliminated because the detail allowed for is not readily available in published form. The low collection rate for such items as accessory minerals, fossils, matrix and cement, and permeability prompted their removal. The geographic location of the source of the lithological data is not a likely parameter on which a search would be conducted, and therefore can be recorded more efficiently as one data field.

These alterations have reduced the size of the type 4 record by 33 per cent.

Other Record Types. The design of record types 2, 3, 5, and 6 seems satisfactory for the nature of data collected and analyzed to this time. Also the individual data items appear to be desirable and effective categories for the storage and retrieval of these types of data on oil and gas pools.

Uses of the CRETPET file. Preliminary examples of the application of a file on oil and gas pools were presented by Dickie and Williams (1972). A more extensive treatment of the results of size analyses and possible applications in exploration and economic assessment appears in Dickie and Williams (1973).

RECOMMENDATIONS

A computer-based file of data on the geological features of oil and gas pools is practical to build, and can be used both as a tool for petroleum exploration and to evaluate the petroleum potential of an area. Although the CRETPET file included only the 1 100 Cretaceous and Jurassic pools of Alberta, it was designed to accommodate data on petroleum occurrences in all types of reservoir rocks. A logical expansion of the file would be to incorporate data on oil and gas pools in the Mississippian and Devonian Systems, which alone comprise 60 per cent of the petroleum reserves in Alberta. Also, oil and gas occurrences in Manitoba, Saskatchewan, British Columbia, and the Yukon and Northwest Territories should be included to provide a complete inventory for the Western Canada Sedimentary Basin.

The CRETPET file contains data extant on 1 100 pools to February, 1970, and we recommend that provision be made for revising file, possibly every 4-5 years. Major changes are not likely to be required for each revision but projections and predictions will be more accurate if the data are current.

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Appendix 1

Data specifications for CRETPET file, following notational conventions of SAFRAS system (Sutterlin and De Plancke, 1969)

*0101 IDENTIFICATION AND LOCATION

No.	Data item names	Field width	No. of dec.	Alpha or numeric	% of Data collected
01	INSTITUTION	004		A	100
02	REFERENCE-NUMBER	010	00	N	100
03	PROVINCE	044		A	100
04	AUTHORITY	020		X	100
05	FIELD-NAME	020		X	100
06	FIELD-CODE	003	00	N	100
07	POOL-NAME	002		X	100
08	FORMATION-CODE	003	00	N	100
09	POOL-CODE	003	00	N	100
10	AXIAL-LOCATION-LAT	004	05	N	100
11	AXIAL-LOCATION-LONG	005	05	N	100
12	AXIAL-LOCATION-LSD	002	00	N	100
13	AXIAL-LOCATION-SEC	002	00	N	100
14	AXIAL-LOCATION-TWP	003	00	N	100
15	AXIAL-LOCATION-RGE	002	00	N	100
16	AXIAL-LOCATION-MER	001	00	N	100
17	AXIAL-LOCATION-PRECISION	001	00	N	100
18	MAX-RESERVOIR-LOCN-LAT	004	05	N	100
19	MAX-RESERVOIR-LOCN-LONG	005	05	N	100
20	MAX-RESERVOIR-LOCN-LSD	002	00	N	100
21	MAX-RESERVOIR-LOCN-SEC	002	00	N	100
22	MAX-RESERVOIR-LOCN-TWP	003	00	N	100
23	MAX-RESERVOIR-LOCN-RGE	002	00	N	100
24	MAX-RESERVOIR-LOCN-MER	001	00	N	100
25	MAX-RESERVOIR-LOCN-PRECISION	001	00	N	100
26	POOL-TYPE	004		A	100
27	REGIONAL-TECTONIC-ELEMENT	020		X	100
28	RELATED-TO-UNCONFORMITY	003		A	100
29	REFERENCE-TEXT-ONE	025		X	
30	REFERENCE-TEXT-TWO	025		X	
31	REFERENCE-TEXT-THREE	025		X	

*0203 STRATIGRAPHIC DATA

No.	Data item names	Field width	No. of dec.	Alpha or numeric	R	O	U
01	STRAT-POSITION-OF-UNIT	001		A	98	94	68
02	STRAT-UNIT-GP-NAME	004		A	96	94	66
03	STRAT-UNIT-GP-MOD	001		X	96	92	58
04	STRAT-UNIT-GP-AGE	003	00	N	96	94	66
05	STRAT-UNIT-FM-NAME	004		A	58	24	38
06	STRAT-UNIT-FM-MOD	001		X	00	00	00
07	STRAT-UNIT-FM-AGE	003	00	N	58	24	38
08	STRAT-UNIT-MBR-NAME	004		A	06	00	06
09	STRAT-UNIT-MBR-MOD	001		X	00	00	00
10	STRAT-UNIT-MBR-AGE	003	00	N	06	00	06
11	STRAT-UNIT-INFORMAL-NAME	004		A	32	28	04
12	STRAT-UNIT-INFORMAL-MOD	001		X	04	00	00
13	STRAT-UNIT-INFORMAL-AGE	003	00	N	32	28	04
14	GENERAL-DEPOS-ENVIRONMENT	002	00	N	48	66	50
15	DETAILED-DEPOS-ENVIRONMENT	020		X	12	20	04

R - RESERVOIR UNIT O - OVERLYING UNIT
U - UNDERLYING UNIT

*0301 UNCONFORMITY DATA

No.	Data item names	Field width	No. of dec.	Alpha or numeric	% of Data collected
01	UNCONFORMITY-TYPE	004		A	000
02	POOL-RELATION-TO-UNCONF	004		A	100
03	RELATED-UNCONF-RELIEF-FEATURE	004		A	002
04	VERTICAL-DISTANCE-FROM-UNCONF	003	00	N	023
05	UNIT-ABOVE-UNCONF-GP-NAME	004		A	100
06	UNIT-ABOVE-UNCONF-GP-MOD	001		X	100
07	UNIT-ABOVE-UNCONF-GP-AGE	003	00	N	100
08	UNIT-ABOVE-UNCONF-FM-NAME	004		A	055
09	UNIT-ABOVE-UNCONF-FM-MOD	001		X	000
10	UNIT-ABOVE-UNCONF-FM-AGE	003	00	N	055
11	UNIT-ABOVE-UNCONF-MBR-NAME	044		A	004
12	UNIT-ABOVE-UNCONF-MBR-MOD	001		X	000
13	UNIT-ABOVE-UNCONF-MBR-AGE	003	00	N	004
14	UNIT-ABOVE-UNCONF-INF-NAME	004		A	026
15	UNIT-ABOVE-UNCONF-INF-MOD	001		X	002
16	UNIT-ABOVE-UNCONF-INF-AGE	003	00	N	026
17	UNIT-BELOW-UNCONF-GP-NAME	004		A	075
18	UNIT-BELOW-UNCONF-GP-MOD	001		X	031
19	UNIT-BELOW-UNCONF-GP-AGE	003	00	N	075
20	UNIT-BELOW-UNCONF-FM-NAME	004		A	053
21	UNIT-BELOW-UNCONF-FM-MOD	001		X	000
22	UNIT-BELOW-UNCONF-FM-AGE	003	00	N	053
23	UNIT-BELOW-UNCONF-MBR-NAME	004		A	008
24	UNIT-BELOW-UNCONF-MBR-MOD	001		X	000
25	UNIT-BELOW-UNCONF-MBR-AGE	003	00	N	008
26	UNIT-BELOW-UNCONF-INF-NAME	004		A	000
27	UNIT-BELOW-UNCONF-INF-MOD	001		X	000
28	UNIT-BELOW-UNCONF-INF-AGE	003	00	N	000

% calculated for the 251 pools related to an unconformity

*0409 LITHOLOGIC DATA

No.	Data item names	Field width	No. of dec.	Alpha or numeric	% of Data collected	
01	ROCK-TYPE	004		A	41	62
02	PROPORTION-OF-LITHOLOGY	002	02	N	41	62
03	RELATION-TO-POOL	001		A	41	62
04	STRATIGRAPHIC-UNIT-GROUP	008		X	41	62
05	STRATIGRAPHIC-UNIT-FM	008		X	15	23
06	STRATIGRAPHIC-UNIT-MEMBER	008		X	02	03
07	STRATIGRAPHIC-UNIT-INFORMAL	008		X	04	06
08	COLOR	004		A	35	53
09	CRYSTALLINITY	004		A	40	60
10	UPPER-SIZE-LIMIT	004		A	19	29
11	MEDIAN-SIZE	004		A	32	48
12	LOWER-SIZE-LIMIT	004		A	17	26
13	CLAST-COMPOSITION-ONE	004		A	38	57
14	CLAST-ONE-PROPORTION	002	02	N	06	09
15	CLAST-COMPOSITION-TWO	004		A	10	15
16	CLAST-TWO-PROPORTION	002	02	N	01	02
17	ACCESSORY-MIN-ONE	004		A	26	39
18	ACCESSORY-MIN-TWO	004		A	11	17
19	FOSSIL-TYPE-ONE	004		A	07	11
20	FOSSIL-TYPE-TWO	004		A	01	02
21	FOSSIL-TYPE-THREE	004		A	00	00
22	MATRIX-TYPE-ONE	004		A	09	14
23	MATRIX-ONE-PROPORTION	002	02	N	00	00
24	MATRIX-TYPE-TWO	004		N	00	00
25	MATRIX-TWO-PROPORTION	002	02	N	00	00
26	CEMENT-TYPE-ONE	004		A	14	21
27	CEMENT-ONE-PROPORTION	002	02	N	01	02
28	CEMENT-TYPE-TWO	004		A	02	03
29	CEMENT-TWO-PROPORTION	002	02	N	00	00
30	SORTING	004		A	08	12
31	ROUNDING	004		A	09	14
32	POROSITY-TYPE	004		A	12	18
33	POROSITY-PERCENT	002	00	N	09	14
34	PERMEABILITY	004	00	N	00	00
35	LITHOLOGIC-DATA-SOURCE	025		X	37	56
36	LITHOLOGIC-DATA-LOCN-LAT	004	05	N	37	56
37	LITHOLOGIC-DATA-LOCN-LONG	005	05	N	37	56
38	LITHOLOGIC-DATA-LOCN-LSD	002	00	N	37	56
39	LITHOLOGIC-DATA-LOCN-SEC	002	00	N	37	56
40	LITHOLOGIC-DATA-LOCN-TWP	003	00	N	37	56

41	LITHOLOGIC-DATA-LOCN-RGE	002	00	N	37	56
42	LITHOLOGIC-DATA-LOCN-MER	001	00	N	37	56
43	LITHOLOGIC-DATA-LOCN-PREC	001	00	N	00	00
44	LITHOLOGIC-DATA-IN-POOL	003		A	03	05

% calculated for 148 pools with recorded lithologies

9 - % of data possible with 9 records per pool
6 - % of data possible with 6 records per pool

*0501 GEOMETRIC DATA

01	MAJOR-AXIS-LENGTH	004	02	N	054
02	MAJOR-AXIS-STRIKE	003	00	N	050
03	MAJOR-AXIS-SECTION-SHAPE	004		A	050
04	MINOR-AXIS-LENGTH	004	02	N	054
05	MINOR-AXIS-SECTION-SHAPE	004		A	050
06	AXIAL-INTERSECTION-DISTANCE	004	02	N	048
07	POOL-PLAN-AREA	005	03	N	096
08	MAX-RESERVOIR-THICKNESS	005	01	N	010
09	MAX-OIL-ZONE-THICKNESS	005	01	N	048
10	AVG-OIL-ZONE-THICKNESS	005	01	N	096
11	MAX-GAS-ZONE-THICKNESS	005	01	N	050
12	AVG-GAS-ZONE-THICKNESS	005	01	N	098
13	DEPTH-TO-PAY-AT-AX-INTRSECT	005	00	N	000
14	PAY-ZONE-TOP-ELEVATION	005	00	N	098
15	REGIONAL-DIP	005	01	N	088
16	REGIONAL-DIP-DIRECTION	003	00	N	088
17	FOLDING-TYPE-ONE	004		A	026
18	FOLD-AXIS-ONE-STRIKE	003	00	N	024
19	FOLD-AXIS-ONE-PLUNGE-DIR	003	00	N	016
20	FOLD-AXIS-ONE-PLUNGES	002	00	N	000
21	FOLDING-TYPE-TWO	004		A	004
22	FOLD-AXIS-TWO-STRIKE	003	00	N	004
23	FOLD-AXIS-TWO-PLUNGE-DIR	003	00	N	004
24	FOLD-AXIS-TWO-PLUNGE	002	00	N	000
25	FAULT-TYPE	004		A	002
26	FAULT-PLANE-STRIKE	003	00	N	002
27	FAULT-PLANE-DIP-DIRECTION	003	00	N	000
28	FAULT-PLANE-DIP	002	00	N	000
29	POOL-TREND-ONE	003	00	N	050
30	POOL-TREND-TWO	003	00	N	024

*0601 TECHNICAL DATA

01	RESERVOIR-POROSITY-FRACTION	003	02	N	100
02	WATER-SATURATION-FRACTION	002	02	N	100
03	WATER-SALINITY-PPM	006	00	N	000
04	BCF-GAS-IN-PLACE	007	02	N	100
05	MMBBLS-OIL-IN-PLACE	008	03	N	100
06	AOU0GRAVITY	002	00	N	096
07	INITIAL-PRESSURE	004	00	N	098
08	TOTAL-PRODUCING-OIL-WELLS	004	00	N	058
09	TOTAL-PRODUCING-GAS-WELLS	004	00	N	058
10	WELL-SPACING-ACRES	004	00	N	048
11	TRAP-TYPE	004		A	056
12	OTHER-PRODUCTS-ONE	020		X	000
13	OTHER-PRODUCTS-TWO	020		X	00

A ALPHABETIC DATA

N NUMERIC DATA

X ALPHANUMERIC DATA

Appendix 2

PROPOSED STANDARD DATA SPECIFICATIONS OIL AND GAS POOLS

No.	Data item names	Field width	No. of dec.	Alpha or numeric
***0101**	**IDENTIFICATION AND LOCATION**			
	INSTITUTION	04		A
	REFERENCE-NUMBER	10		N
	PROVINCE	04		A
	AUTHORITY	20		X
	FIELD-NAME	20		X
	FIELD-CODE	03		N
	POOL-NAME	20		X
	FORMATION-CODE	03		X
	POOL-CODE	03		X
	AXIAL-LOCATION-LAT	# 02	05	N
	AXIAL-LOCATION-LONG	# 03	05	N
	# AXIAL-LOCATION-UTM-NORTHING	09		N
	# AXIAL-LOCATION-UTM-EASTING	08		N
	# AXIAL-LOCATION-UTM-ZONE	03		N
	AXIAL-LOCATION-LSD	02		N
	AXIAL-LOCATION-SEC	02		N
	AXIAL-LOCATION-TWP	03		N
	AXIAL-LOCATION-RGE	02		N
	AXIAL-LOCATION-MER	01		N
	AXIAL-LOCATION-PRECISION	01		N
	POOL-TYPE	04		A
	REGIONAL-TECTONIC-ELEMENT	20		X
	RELATED-TO-UNCONFORMITY	04		A
	REFERENCE-TEXT	25		X
***0203**	**STRATIGRAPHIC DATA**			
	As in Appendix 1			
***0301**	**UNCONFORMITY DATA**			
	As in Appendix 1			
# *0406	**LITHOLOGY**			
	ROCK-TYPE	04		A
	PROPORTION-OF-LITHOLOGY	# 00	02	N
	RELATION-TO-POOL	01		A
	STRAT-UNIT-GROUP	08		X
	STRAT-UNIT-FORMATION	08		X
	STRAT-UNIT-MEMBER	08		X
	STRAT-UNIT-INFORMAL	08		X
	COLOUR	04		A
	CRYSTALLINITY	04		A
	UPPER-SIZE-LIMIT	04		A
	MEDIAN-SIZE	04		A
	LOWER-SIZE-LIMIT	04		A
	CLAST-COMPOSITION-ONE	04		A
	CLAST-ONE-PROPORTION	# 00	02	N
	CLAST-COMPOSITION-TWO	04		A
	# ACCESSORY-MIN	04		A
	# FOSSIL-TYPE	04		A
	# MATRIX-TYPE	04		A
	# MATRIX-PROPORTION	# 00	02	N
	# CEMENT-TYPE	04		A
	# CEMENT-PROPORTION	# 00	02	N
	SORTING	04		A
	POROSITY-TYPE	04		A
	POROSITY-PERCENT	02		N
	LITHOLOGIC-DATA-SOURCE	25		X
	LITHOLOGIC-DATA-LOCN-LAT	02	05	N
	LITHOLOGIC-DATA-LOCN-LONG	03	05	N
	# LITHOLOGIC-DATA-LOCN-DLS	11		X
	LITHOLOGIC-DATA-IN-POOL	03		A
***0501**	**GEOMETRIC DATA**			
	As in Appendix 1			
***0601**	**TECHNICAL DATA**			
	As in Appendix 1			

Suggested changes to data specifications