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No. 8080

PEL 43 Eromanga and Simpson Basins

PROGRESS AND TECHNICAL REPORTS

Nobjade Pty Ltd

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7th Floor
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ENVELOPE 8080

TENEMENT: PEL 43; Eromanga and Simpson Basins

TENEMENT HOLDER: Nobjade Pty Ltd

CONTENTS

END OF CONTENTS

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000003

NOBJADE PTY LIMITED
a wholly owned subsidiary of
GREAT SANDY OIL N.L.

A P P L I C A T I O N

FOR

A R E A   C

SIMPSON DESERT REGION
SOUTH AUSTRALIA

SEPTEMBER 1989

Nobjade Pty Limited
C/- A R Conolly & Co.
1st Floor
44 Margaret Street
SYDNEY NSW 2000
Tel: (02) 290-3288 Fax: (02) 290-2615

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ENCLOSURE

1. NAMES OF COMPANIES APPLYING FOR THE AREA

Nobjade Pty Limited
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44 Margaret Street
Sydney NSW 2000
Australia

Phone: (02) 290-3288
Fax: (02) 290-2615

DynOil Incl
Suite 500
333 West Hampden
Englewood, Colorado
USA 80110

Phone: (303) 762 0430

2. DESCRIPTION OF THE AREA BEING APPLIED FOR

AREA C - as shown on Enclosures

Being a Region in the Simpson Desert of South Australia of approximatly 6,500 sq. km.

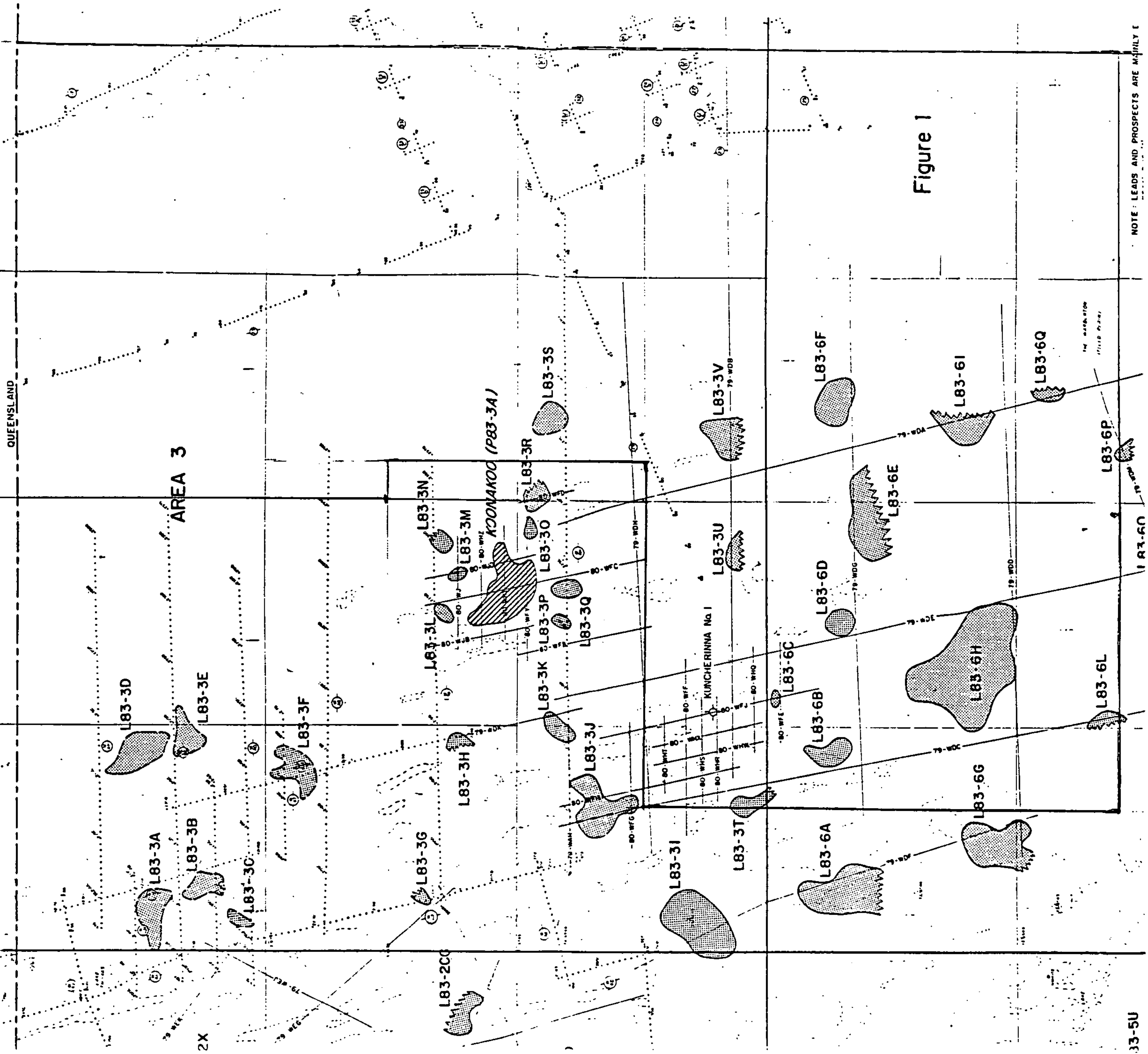
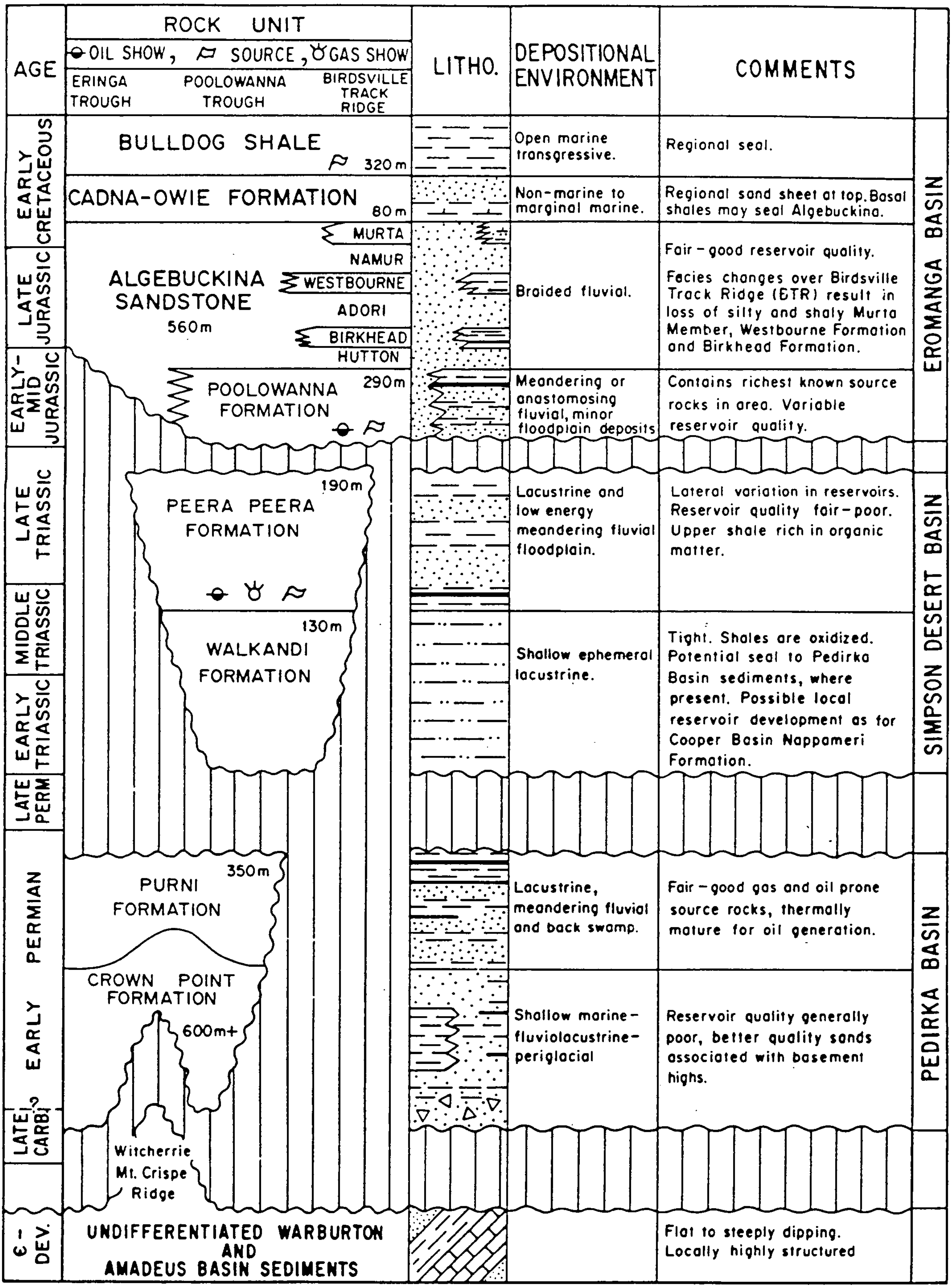

QUEENSLAND
AREA 3
KOONAKOO (P83-3A)
KUNCHERINNA No. 1
L83-3A
L83-3B
L83-3C
L83-3D
L83-3E
L83-3F
L83-3G
L83-3H
L83-3I
L83-3J
L83-3K
L83-3L
L83-3M
L83-3N
L83-3O
L83-3P
L83-3Q
L83-3R
L83-3S
L83-3T
L83-3U
L83-3V
L83-6A
L83-6B
L83-6C
L83-6D
L83-6E
L83-6F
L83-6G
L83-6H
L83-6I
L83-6L
L83-6P
L83-6Q
L83-2CC
79-WDA
79-WDB
79-WDC
79-WDE
79-WDF
79-WDG
79-WDH
80-WFC
NOTE: LEADS AND PROSPECTS ARE MAINLY

Figure 1



350m Max. known thickness.

ERINGA TROUGH, PEDIRKA AND SIMPSON DESERT BASINS

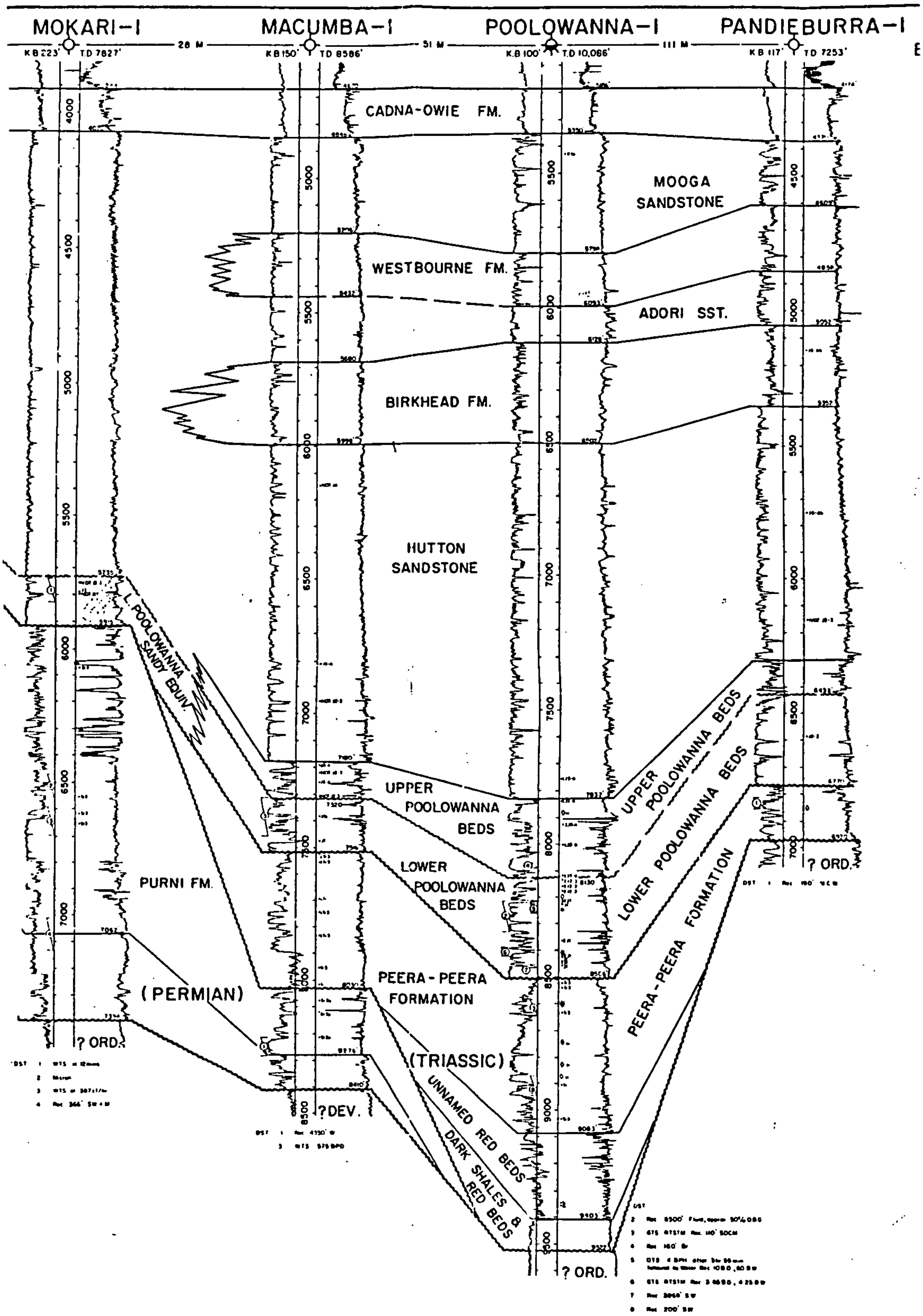

MOKARI-1
MACUMBA-1
POOLOWANNA-1
PANDIEBURRA-1
CADNA-OWIE FM.
MOOGA SANDSTONE
WESTBOURNE FM.
ADORI SST.
BIRKHEAD FM.
HUTTON SANDSTONE
L. POOLOWANNA SANDY EQUIV.
UPPER POOLOWANNA BEDS
LOWER POOLOWANNA BEDS
PURNI FM.
(PERMIAN)
PEERA-PEERA FORMATION
(TRIASSIC)
UNNAMED RED BEDS
DARK SHALES & RED BEDS
? ORD.
? DEV.

Figure 3

3. EXPLORATION PHILOSOPHY AND PROGRAMME

The joint venture intends to use a combination of geological geochemical, seismic, magnetic, and gravity techniques in year one to find at least two targets for a seismic survey in year two, so that a well can be drilled in year three of the permit.

If this programme is successful, more seismic and geochemical work in year four would lead to another well in year five of the permit.

A review of all the currently existing data indicates that oil should have been generated from both Triassic and Jurassic source rocks in the central part of the Pooloowanna Trough which underlies the permit.

Unfortunately the reservoirs penetrated in the Kuncherinna I well in both the Jurassic and Triassic sequences were tight downgrading the prospectivity of the deeper parts of the Pooloowanna Trough.

Our exploration philosophy will be to search for more porous reservoirs in the shallower Jurassic sands away from the Kuncherinna I well region towards the Birdsville Track Ridge.

This corresponds to the area that extends North-South along the Birdsville Track Ridge and covers most of the eastern half of Area C. This also corresponds to that region in Area C which has had the least amount of exploration.

We intend to cover this region with regional soil-gas surveys in year one. This technique has been particularly successful in the Simpson Desert Region in the Northern Territory in EP2 where soil-gas anomalies located some large subsurface structures.

Some areas of potential structural closure have already been found during earlier seismic surveys. These structural leads will be assessed with soil-gas surveys, as we are convinced that any fairly large structural accumulation of oil and gas should have miscroseeps associated with it at the surface.

During year two, 100km of seismic will be run in the areas of greatest potential. We believe that two grids of 50km each will be sufficient to delineate structural closure on the best two leads generated from the first years programme.

As the exploration risk in this region is exceptionally high and the targets are probably small to moderate in size we are using lower cost geochemical surveys along with the past seismic coverage to find good hydrocarbon leads.

We will also be using the results of our early exploration efforts to encourage larger companies to join us in our exploration programme as soon as possible.

4. PROPOSED PROGRAMME OF EXPLORATION

Year 1

During Year 1 of the permit the applicant proposes to conduct a thorough review of the existing geological and geophysical data pertinent to the area.

In particular the regional gravity and magnetic data will be reinterpretated and some of the old seismic reprocessed. This will enable us to run soil-gas surveys over the most prospective leads. In all, up to 750 line km of soil-gas survey will be run (enclosure 2).

Year 2

Contingent on the results of the Year 1 programme we propose to run 100 line km of seismic over the best two structural leads with anomalous surface hydrocarbons.

Year 3

Drill one well to a target in the Jurassic.

Year 4

The applicant proposes to perform further detailed seismic and/or geochemical surveys, in order to delineate a prospect to drill in the following year.

Year 5

Contingent on the results to the end of Year 4 the applicant proposes to drill one well to a target in the Jurassic Section.

5. PROPOSED EXPENDITURE

Year I	Geological and geophysical review	25,000
	Soil gas survey (up to 750 line km)	100,000
	Total	$125,000
Year II	100 line km of seismic	$375,000
Year III	Drill one well to Jurassic target	$800,000
Year IV	Seismic and geochemistry	$300,000
Year V	Drill one well	800,000
	Total	$2,400,000

6. JOINT VENTURE PARTICIPANTS

	Working Interest
Great Sandy Oil N.L. (Operator)	50%
DynOil Inc.	50%

7. TECHNICAL AND FINANCIAL ABILITY OF THE APPLICANTS TO CARRY OUT THE PROPOSED PROGRAMME

Nobjade Pty Limited

Nobjade Pty Limited is a wholly owned subsidiary of Great Sandy Oil N.L., an independent public Australian petroleum exploration company, owned by Mr Alan R Conolly and Dr John Conolly, formerly of Sydney Oil Company Ltd.

Mr A Conolly and Dr J Conolly also own Petrofocus Pty Limited, an Australian company initially established in 1984 to develop soil gas alkane techniques as used in the search for hydrocarbon accumulations (see enclosed company brochure). In 1985 the subsidiary Petrofocus Exploration Inc. was established in Calgary (Canada), and in 1986 Petrofocus USA Inc. was set up in Denver. Through the use of soil gas survey techniques these subsidiaries have identified prospects and, in joint ventures with other oil companies and investors, have purchased leases and petroleum permits in both Canada and the USA, and drilled a number of exploration wells.

7.1 Technical Team

7.1.1 Sydney

Alan Robert Conolly

Senior partner in legal practice in Sydney for over twenty years. Was responsible for corporate fund raising from 1978 to 1987 for Sydney Oil Company Limited, of which he was chairman. In 1987 raised $16 million and led the drilling of 26 wildcat wells in the last six months of that year, mainly in Queensland.

Dr John R Conolly

Over twenty five years experience in basin analysis and geological interpretation of sedimentary environments in both the surface and subsurface, and in the past fifteen years has been exploring for oil and gas in many different areas of the world. Graduated with a Ph.D. from the University of New South Wales in 1963 and subsequently worked as a Research Scientist and Professor of Geology of Columbia University in New York, Scripps Institute of Oceanography, Louisiana State University, University of South Carolina and the City College of New York. Employed by BP Alaska and subsequently set up an independent consultant practice in Connecticut in 1974 searching for hydrocarbons on the continental shelf of the USA. Formerly a Director of Sydney Oil Company Limited and Sydney Oil Company Drilling and Exploration Trust.

Charles Furr

Thirteen years petroleum exploration experience. Graduated B.Sc. in Geology (1975) from the University of Bristol. During 1975-1979 was a mud logging engineer/wellsite geologist working in the North Sea, Nigeria and Morocco. Immigrated to Australia in 1979 and joining the consulting group J M Blumer and Associates in early 1980 as a wellsite/operations geologist. Gained experience in project management, basin analysis, financial and risk analysis, seismic interpretation and computer programming. Has been with Petrofocus since 1987 and has been responsible for conducting soil gas alkane surveys in the Eromanga, Surate, Georgina, Otway and Gippsland Basins and manages Petrofocus operations in Australasia.

Darryl Kingsley

Sixteen years petroleum exploration experience. Graduated from the University of New England in 1971 with B.Sc majoring in geophysics and mathematics. Worked for Layton Geophysical Consultants and later Layton Geophysical Consultants and later Layton Geophysical International as a Geophysicist and manager of the Canberra office until 1980. Became an independent consultant in late 1980, specialisting in seismic interpretation projects. Worked for a number of companies, but formed a long term association with Sydney Oil Company and was responsible for the technical supervision of a number of exploration permits, including those in the Cooper/Eromanga Basins. Has experience in seismic interpretation in most of the oil prospective basins in Australia.

7.1.2 Calgary, Canada

Don Holmes

Twenty two years experience as a petroleum geologist in Canada and a number of overseas locations. Graduated B.Sc. in Geology in 1964 from the University of Alberta, and M.Sc (Sedimentology) in 1972 from the University of Calgary. From 1965 to 1972 worked for Atlantic Richfield in Canada, and from 1972 to 1975 as a consultant engaged in developing exploration prospects in Northern Alberta carbonate and sandstone trends. From 1975 to 1978 worked as a senior geologist and project leader with the Oil Service Company of Iran In developing new exploration prospects and in reservoir studies of Iranian oilfields. Since 1978 Mr Holmes has consulted on geological studies of petroleum prospects and basinc evaluations, including work in Erotic Canada, Iran, Ghana, Madagascar, Indonesia and Turkey. Was engaged in 1985 as manager and consultant for Petrofocus Exploration Inc. in Canada, a subsidiary of Petrofocus Pty Limited of Sydney.

7.1.3 DynOil Inc. - Denver, USA

DynOil Inc. was founded in Denver, Colorado, in early 1982 as a small aggressive private oil and gas exploration and development company. Its sole owner, Tom G Robinson, has considerable oil and gas experience (25 years) from major company training to exploration manager for large and small independent companies. After selling off production to become debt free, and making major overhead and personnel cuts, DynOil continues to be in good financial standing, viable and aggressive, even in the downturn in our industry.

Although DynOil's staff is now small, reflecting in part the state of the business, we have the capability to generate quality oil and gas prospects - co-ordinating seismic and geo-chemistry with proven exploration techniques. Also DynOil provides geological wellsite and other technical supervision in almost every prospect we participate in. DynOil prefers to use the individual expertise of a number of consultants to utilise skill and experience in specific areas in order to maximise potential return and reduce overall risk.

DynOil's usual method of operation is first, to review data and generate the geological prospects. This is followed by acreage acquisition, co-ordination and interpretation of any seismic or geo-chemistry deemed necessary and making arrangements for an operating company who will handle drilling/producing operations and accounting. We are also responsible for compiling a complete package of pertinent geological maps and information. By continual management and supervision of "outside" expertise, DynOil is able to accomplish more in less time, with reward of finally seeing a prospect drilled. Besides generating our own prospects, DynOil occasionally screens and participates in other drilling opportunities through other independent geologist or oil companies that work in areas of our own geological knowledge.

DynOil works the Mid-Continent area which comprises western and central Kasas, Oklahoma Panhandle and south eastern Colorado. These are the areas where DynOil has a high economic success rate and where most of the staff has accumulated many years of experience. Drilling depths vary from 2500' to 8000' with reserves of up to 250,000 B.O. per field and/or 5.0 BCF gas per field. Multiple pay zones are the rule rather than the exception, with new field discoveries ranging from 1/2 million barrels up to 3 million barrels per field. Specific active plays include the Morrow Sandstones in southwest Kansas, Arbuckle and Simpson in south central Kansas, Lansing and St Louis (plus Morrow) in the western and central Oklahoma Panhandle and shallow gas in south central Kansas. DynOil is also actively pursuing Niagaran reef targets in souther Michigan where Mr Robinson was part of the Mobil exploration team that made the first discovery in reefs in southern Michigan.

DynOil, with our ability and expertise, feels the time is right to expand into Australia with the association of Alan and John Conolly and Great Sandy Oil. DynOil's many years of experience in finding hydrocarbons and providing financing for prospects should compliment Great Sandy Oil in joint Australia projects.

Tom Robinson

Twenty five years experience in the petroleum exploration industry in the USA and Canada. Graduated in 1958 with a Business and Management Degree from the Claremont Men's College, California and in 1961 with a professional degree in Geological (Petroleum) Engineering from the Colorado School of Mines. After spending four years with the US Army Engineers joined Mobil Oil Corporation in 1964 worked in the Production Development Section and the Exploration Department. From 1972 to 1974 was Divisional Manager for Vanderbilt Resources handling all geological activities from Texas to Canada.

Joined Consolidated Oil and Gas in 1974 as Exploration Manager and in 1978 became an independent geologist working partime for Montgomery Exploration responsible for the initiating, supervising and selling of geological prospects in the Mid-Continent of the USA. Formed DynOil Inc. in 1982 as a small, private oil and gas explorer. He is the President of the corporation and the controlling stockholder. DynOil generates geologic ideas, purchases acreage, co-ordinates seismic and geochemistry and markets a finished drilling prospect.

8. PETROLEUM POTENTIAL OF THE APPLICATION AREA

8.1 Regional Setting and Access

Area C lies in the Simpson Basin region of South Australia. The area of interest is underlain by the Jurassic to Cretaceous Eromanga Basin and the Triassic Simpson Desert Basin.

Access to the area is via the Birdsville Track. Movement in the Simpson Desert is hampered by the presence over much of the area of parallel north-west trending seif dunes often many kilometres in length and over 15m high. The region is covered by the Pandie-Pandie and Gason 1,250,000 geological sheets.

8.2 Exploration History

Up until the 1950's only reconnaissance geological were conducted in the region. Since then aeromagnetic, gravity and seismic surveys have been employed to provide regional and semi-detailed coverage. The latest phase of exploration commenced in 1979 and included semi-detailed and detailed seismic.

Only one exploration well has been drilled in the area Kuncherinna-1 drilled in 1982. Hydrocarbon shows occurred in the Jurassic Poolawunna sandstones and Peera Peera Formation. A DST from the Poolawunna recovered only slightly oil-flecked drilling mud.

8.3 Geological Setting and History

There is little well control in the area and very little is known about the pre-Triassic sequence. However, Pre-Triassic sediments sediments may underlie the magnetic anomaly situated in the centre of Area C.

If these sediments are Permian in age they may be similar to those that form the Pedirka Basin which lies to west of Area C. Within the Permian the Purni Formation is a sequence of interbedded channel sands, organic rich overbank silts and shales and coals. This sequence, if present, underlying the magnetic anomaly region, may be a source for deep gas.

The Triassic Simpson Desert Basin has, to date, only been intersected in wells drilled within or marginal to the Poolowanna Trough. A redbed sequence of interbedded shales, siltstones and minor sandstones, the Walkandia Formation, was deposited at the initiation of the basin. This is overlain by the Peera Peera Formation which comprises fluvial lower flood plain to lacustrine sediments including shales, siltstones and sandstones.

At the base of the Eromanga Basin sequence, the Poolowanna Formation, of early to middle Jurassic age, consists of interbedded sandstones, siltstones, shales and minor coals. Massive coarse to medium grained sandstones deposited in a high energy braided stream environment are overlain by interbedded fine to medium grained sandstones, siltstones and coals deposited in a moderate energy meandering fluvial system. These lithogacies have been informally designated A and B.

The Algebuckina Formation consisting of shales and sandstones overlies the Poolowanna Formation. The massive Algebuckina Sandstone is seen on the basin margins while in the depocentres basal shales and coals are developed along with thick sand units topped by shale units with thin coals.

The Algebuckina Formation is overlain by the marginal marine Cadna-Owie Formation. A thick Early to Late Cretaceous section overlies the Cadna-Owie consisting of the marine shale of the Wallumbilla Formation or its equivalent, which constitutes a regional seal for the Jurassic-Early Cretaceous section. The Cadna-Owie Formation represents the onset of a basin-wide marine transgression which deposited an upwardly coarsening sequence.

8.4 Exploration Potential

8.4.1 Source

Black, organic rich shales are present in the upper part of the Peera Peera Formation in the Triassic Simpson Desert Basin. The Source potential of these sediments has been confirmed by the recovery of a light waxy oil from them in Walkandia - 1 and Poolowanna - 1 and numerous minor shows in other wells drilled on the margins of the Poolowanna Trough.

The Poolowanna Formation at the base of the Eromanga basin also has proven source potential. Dispersed organic matter is present throughout the Formation and carbonaceous shales and coals are believed to be the source for Poolowanna oil. Numerous wells have recorded good oil shows in the Poolowanna Formation but the most significant was in Poolowanna - 1 which flowed oil to the surface at a rate equivalent to 96 barrels per day.

Fluorescence has been reported in the basal sand and shale units of the Algebuckina Formation suggesting possible source potential in the shales and coals.

Maturation modelling indicates that, in synclines in the of the area of interest, sediments of the Triassic Peera Peera Formation and the Jurassic Poolowanna and Basal Algebuckina Formations have been mature for oil generation.

8.4.2 Reservoir

Several reservoir sands of varying quality are present in the Simpson Desert and Eromanga Basin sequences.

Lithofacies A of the Poolowanna Formation is a massive sandstone providing thick reservoirs with porosities towards the edges of the basin averaging 14% and indications of good permeability. The overlying lithofacies B also contains reservoir sands, however, clean sands are less common and permeability isprobably poor. Thicker sands may have developed in lithfacies B within the depocentre due to the coalescence of channels, these would have a linear geometry and may form stratigraphic traps.

Silica and carbonate cementation affects the prosity and permeability of the sandstones in the deeper parts of the Poolowanna Trough but this effect decreases towards the margins.

The tops of the sand in the Algebuckina Formation basal units form good quality reservoirs and the topmost sands of the Formation also have good reservoir characteristics. Artesian ground water flow through these sands further reduces their potential as trapping reservoirs.

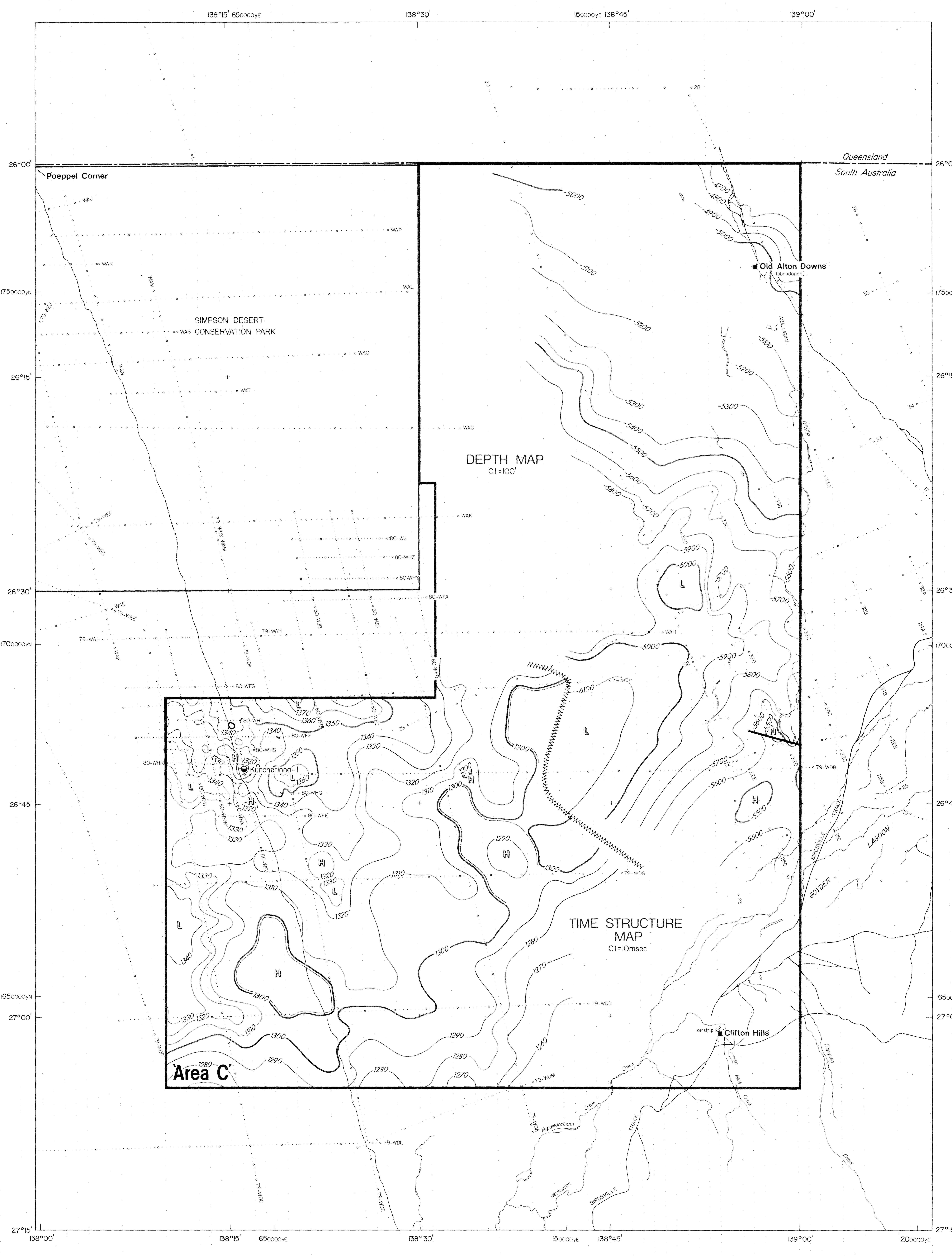
8.4.3 Prospects and Leads in the Application Area

One structure, Kunchinerinna - 1 has been drilled. A number of structural leads labelled L83-6B, 6C, etc .. have also been delineated from the 1979 Peera Peera Seismic survey. There are 12 such structural leads (enclosure 2) of varying sizes. All would need further seismic before drilling.

The 1962 Clifton Hills seismic survey also found some strctural leads. There are 6 of these. (A to F on enclosure 2).

Inspection of the 1979 seismic survey indicates that the degree of structural complexity appears to increase from south to north. Seismic Line WDD near the southern part of Area C shows very little structural deformation. It is hoped that reprocessing of the Clifton Hills seismic will be possible so that good use can be made of this data.

RB:3593C



Well with oil show

Main road

Track

River or creek

Water hole

Closure

Fault

GREAT SANDY OIL N.L.

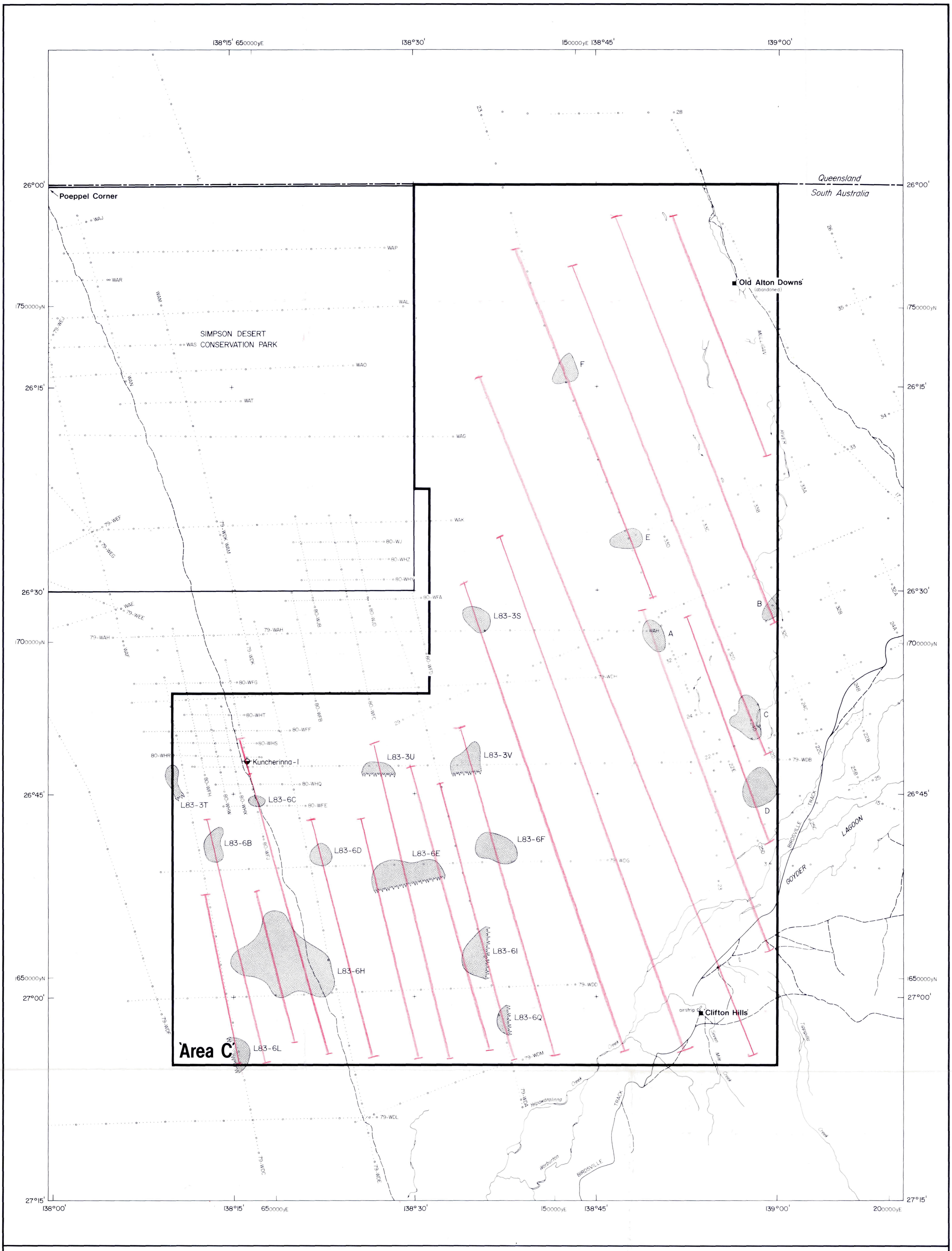
'Area C'
Simpson Desert Joint Venture

'C' HORIZON TIME STRUCTURE
AND DEPTH MAPS

0 1:250000 25km

Compiled by: J.R. Conolly	Date: September 1989
Drawn by: L. Underhill	Drawing No.: 1

8080-1



GREAT SANDY OIL N.L.

'Area C'
Simpson Desert Joint Venture

STRUCTURAL LEADS FROM SEISMIC

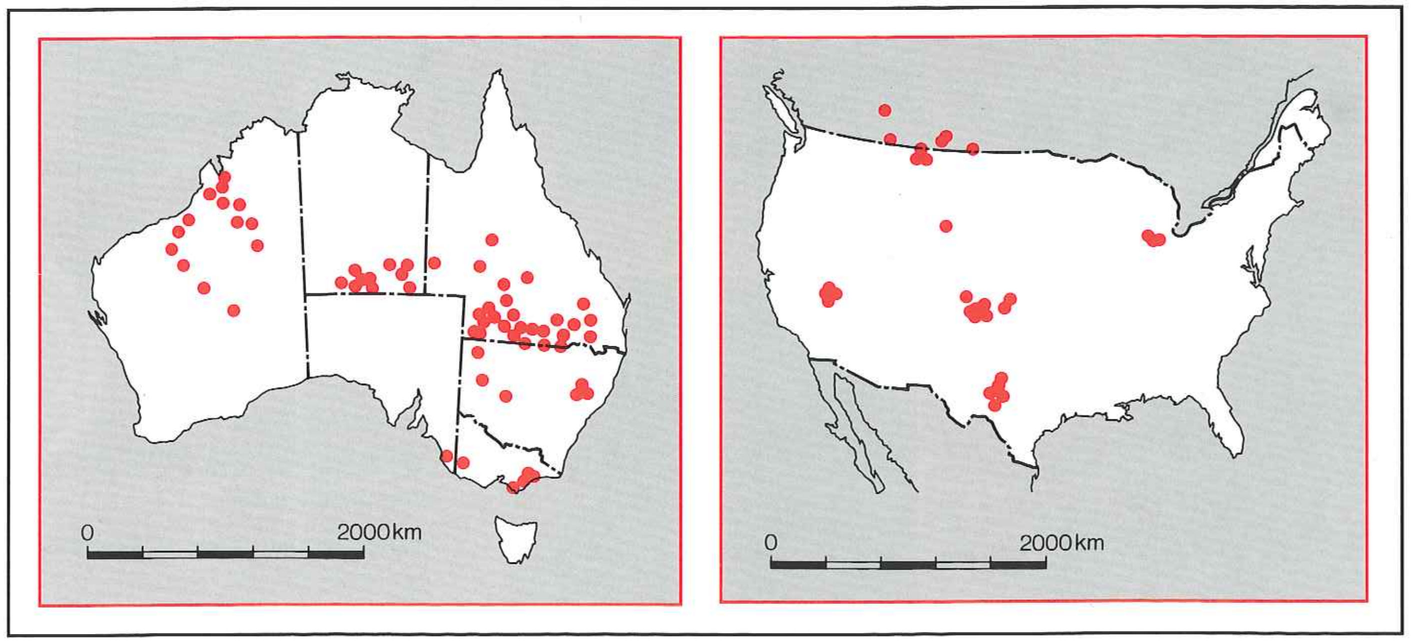
1 : 250 000

0 — 25km

Compiled by: J.R. Conolly	Date: September 1989
Drawn by: L. Underhill	Drawing No.: 2

8080-2

000029



Areas surveyed by Petrofocus

Research
the key to the future

Petrofocus, in conjunction with the Commonwealth Scientific and Industrial Research Organisation (CSIRO), has been granted funds by the National Energy Research, Development and Demonstration Council of Australia (NERDDC) to carry out research into the application of isotopic analysis of soil gas samples to exploration. The study is designed to test the hypothesis that there are unique isotopic "signatures" in the light alkanes that can be collected at the surface, that these "signatures" relate to the source of the microseepage at depth and finally to extend the methods developed to enable differentiation between soil gas hydrocarbons sourced from actual petroleum accumulations and those that have extraneous sources, such as shallow gas or coal measures. Environmental factors influencing the amount of gas in the soil will also be studied as an adjunct to the main project. The result of these investigations will be to improve the definition of hydrocarbon accumulations at depth by means of Geochemistry and to better estimate their composition using soil gas techniques.

Petrofocus Clients

Listed below are some of the companies that hold interests in exploration permits over which Petrofocus has conducted surveys.

Ampol Exploration Ltd.
Australian Consolidated Minerals Ltd.
Australian Petroleum Fund
Banner Petroleum Corp.
Barrack Energy Ltd.
Bligh Oil & Minerals N.L.
Bridge Oil Ltd.
Brisbane Petroleum N.L.
Chevron Canada
Chevron Nuigini
Claremont Petroleum N.L.
Cluff Resources Pacific Ltd.
Command Group of Companies
Conex Australia N.L.
CPC Petroleum Corp. N.L.
Coronet Resources N.L.
Crusader Limited
Total Minetone (Australia) Corp.
Cultus Resources N.L.
Drillsearch N.L.
Eagle Corp. Ltd.
Eromanga Hydrocarbons N.L.
First Australian Resources
Giant Resources Ltd.
Golden West Hydrocarbons N.L.
Home Energy Company Ltd.
Hudbay Oil
Kufpec Australia Pty. Ltd.
Kundu Petroleum Ltd.
Lakes Oil Ltd.
Lasmo Energy Australia Ltd.
Laurel Bay Petroleum Ltd.
Leighton Mining N.L.
Lennard Oil N.L.
Meridian Oil N.L.
Metana Energy N.L.
Minora Resources N.L.
Moage Limited
Mosaic Oil N.L.
Muswellbrook Petroleum Ltd.
National Venture Corp. N.L.
New Zealand Oil & Gas Ltd.
Northgate Exploration
Ocean Resources N.L.
Oilmet Investments Ltd.
Omega Oil Ltd.
Orca Petroleum N.L.
Pan Continental Petroleum Ltd.
Pan Pacific Petroleum N.L.
Peko Oil Ltd.
Pelsart Resources N.L.
Petroleum Securities Australia Ltd.
Petroz N.L.
Phoenix Oil & Gas N.L.
Placer Pacific Ltd.
Placer-Cego Petroleum
Plymouth Recourses N.L.
Poseidon Ltd.
Royal Resources Exploration Inc.
Seahawk Oil International Inc.
Shell Company of Australia Ltd.
Southern Goldfields
Strata Oil N.L.
TCPL Resources Ltd.
Texaco Producing Inc.
TMOC Resources Ltd.
Ultramar Australia Ltd.
United Petroleum Ltd.
Vamgas Ltd.
Victoria Exploration N.L.
Wainoco Australia Ltd.
Western Mining Corp. Ltd.

Petrofocus Pty Ltd
Suite 304, 3rd Floor
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AUSTRALIA 2000

Tel. (02) 290 3500
Fax. (02) 262 1110

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CANADA T2P 2R9

Tel. (403) 265 9656
Fax. (403) 237 7444

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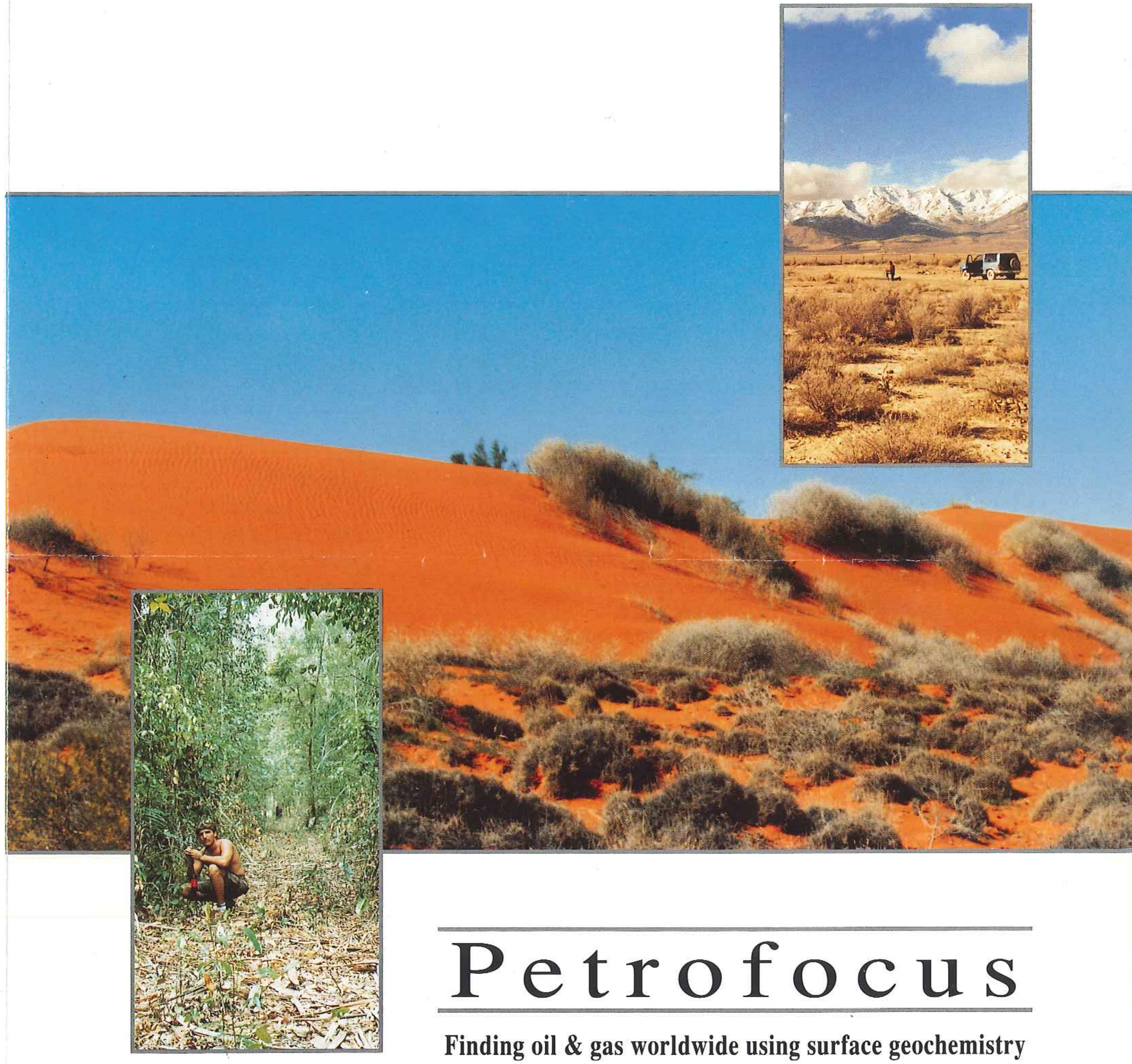
140 East 19th Avenue
DENVER, COLORADO
USA 80295

Tel. (303) 831 1820
Fax. (303) 831 1829

ADDENDUM

000027



Petrofocus

Finding oil & gas worldwide using surface geochemistry

Petrofocus

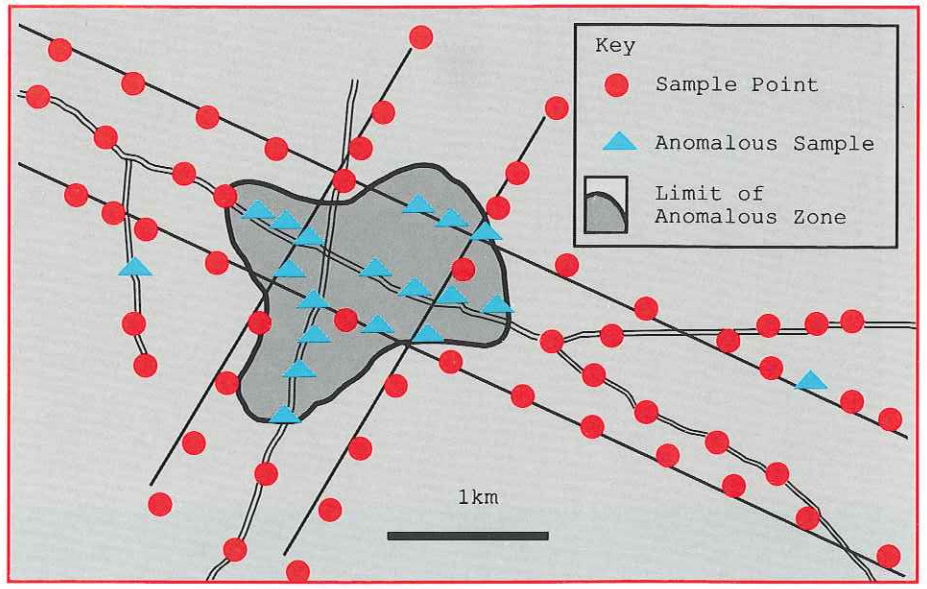
specialising in soil gas surveys worldwide.

Petrofocus provides the petroleum exploration industry with surface geochemical techniques for finding hydrocarbons.

Petrofocus offers an integrated service – it will plan and execute surveys and interpret results.

Petrofocus has experience in Australia, the United States, Canada, Papua New Guinea and New Zealand and continues to refine and improve the techniques it has developed. It will run orientation surveys over known fields and carry out research.

Petrofocus has run over 90 surveys in Australia, analysing over 15,000 samples in the past eight years . In the United States and Canada over 15,000 samples have been collected and analysed from different sedimentary basins, from Texas in the south to Saskatchewan in the north.



Typical survey layout using roads and existing seismic lines showing re-sampling at closer spacing to confirm anomalous zones

Planning

the key to successful surveys

Our survey leaders are petroleum exploration graduates and their knowledge of geology and geophysics enables close liason with the exploration personnel of the client company. Discussion of the objectives of surveys enables advice to be given on the most effective survey format.

Surveys

fast & reliable

Surface geochemical surveys can be carried out along existing roads, tracks and fencelines. No line cutting is needed. Large areas can be covered in a matter of days in the case of reconnaissance surveys and detailed survey areas can be re-sampled several times in a short period improving the statistical interpretation of the results.

Reproducible results.

Samples are analysed the same day they are collected allowing areas of interest to be followed up immediately with re-sampling or extension of the survey to delineate boundaries or edges of anomalies.

Portable equipment

The briefcase sized gas chromatograph is easily set up in any kind of field base from motel room to bush camp. The soil gas sampling equipment is very portable and sampling can be carried out from most vehicles including helicopters and motorcycles. In particularly rugged terrain samples can be collected along walking traverses.

Environmentally sound

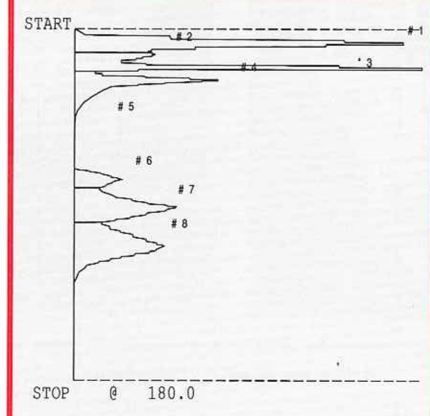
Standard **Petrofocus** surveys are carried out from a four wheel drive vehicle by two operators. The sampling technique involves the insertion of a probe having a diameter of a little over 1cm. Environmental disruption is minimal.

Shothole and Rock Chip Sampling

Petrofocus has developed methods to identify hydrocarbons in shothole cuttings and soil and rock chip samples. Results can be integrated with the soil gas surveys. Samples may be collected by the client's personnel and sent for analysis to a central point where the portable **Petrofocus** laboratory can be set up thus reducing the cost per sample point. These methods have proved most effective in Papua New Guinea.

Economical

Speed of execution and simplicity of operation mean that **Petrofocus** surveys can be run on a limited budget or as a low cost element of a larger project.



SAMPLE RUN NOV 7 1988 16:1
ANALYSIS # 252
TEMPERATURE 32
GAIN 200

COMPOUND NAME	PEAK	R.T.	AREA	PPM
METHANE	1	8.5	31.99	PPM
ETHANE	2	15.9	0.656	PPM
UNKNOWN	3	27.9	9.3	US
PROPANE	4	38.8	0.209	PPM
UNKNOWN	6	79.1	681.8	US
ISO-BUTANE	7	91.3	0.090	PPM
N-BUTANE	8	107.2	0.097	PPM

A typical soil gas analysis

Interpretation

the key to success

In the forty or so years that surface geochemical methods have been used a limitation to successful application has been the interpretation of results.

Petrofocus has experience in surface geochemical methodology and interpretation.

In the field experienced **Petrofocus** operators are able to provide "quick look" assessments of the results of the survey in progress, enabling modification of the survey by the client if required.

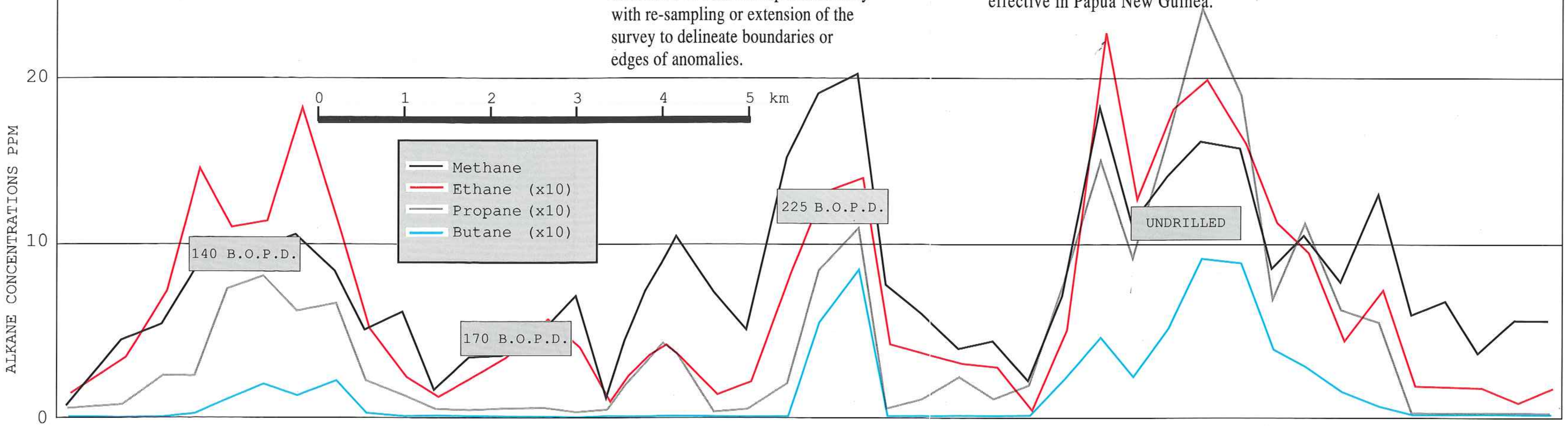
When all the data has been collected the final interpretation consists of three major steps:

1. Threshold values for each of the components tested are determined using simple statistical methods and ratios of the component values are calculated to provide an indication of the composition of the source of the anomalous levels of hydrocarbons in the soil gas sample.

2. Samples containing concentrations significantly greater than observed background levels are plotted onto maps and clusters of them are identified. Profiles of the concentrations of all the tested components are prepared along selected traverses and, if the sample grid is sufficiently closely spaced, contour maps for each of the components are drawn.

3. All data displays are then integrated with the available geological and geophysical information to arrive at the final interpretation.

Petrofocus is able to carry out all of these steps in-house.



Example of a profile showing concentrations of light alkanes in samples taken over producing fields

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P

PETROLEUM ACT, 1940

PETROLEUM EXPLORATION LICENCE NO. 43

I, JOHN HEINZ CORNELIS KLUNDER, Minister of Mines and Energy in the State of South Australia pursuant to the provisions of the Petroleum Act, 1940, HEREBY GRANT to:

> Nobjade Pty Limited (Nobjade), the registered office of which is situated at c/- A R Conolly & Co, 1st floor, 44 Margaret Street, Sydney, NSW, 2000 (hereinafter referred to as the "Licensee"), a Petroleum Exploration Licence in respect of the area set out below, to have effect for a period of five years and to expire on 21 MARCH 1996 but carrying rights of renewal conferred by the Petroleum Act, 1940.

COMMISSIONER OF STAMPS
S.A. STAMP DUTY
ORIGINAL DULY STAMPED
28/02/91 12:34

Description of Area

The land comprised in this licence is that part of the State of South Australia described in the Schedule hereto.

Conditions

1. The Licensee shall at all times comply with:

   (a) the provisions of the Petroleum Act, 1940 and of any regulations for the time being and from time to time in force under the Act; and

   (b) all directions given to it under the Act or the Regulations for the time being and from time to time in force under that Act.

2. During the term of the licence, the Licensee shall carry out or cause to be carried out, exploratory operations on the area comprised in the licence in accordance with such work programmes as are approved by the Minister from time to time. These exploratory operations shall include but not necessarily be limited to:

   (a) in the first year of the term of the licence the review of geological and geophysical data and the acquisition processing and interpretation of 750 kilometres of geochemical soil sampling at a total estimated cost of $125,000 (one hundred and twenty five thousand dollars);

F02458

(b) in the second year of the term of the licence the acquisition processing and interpretation of 100 line kilometres of seismic surveying at an estimated total cost of $375,000 (three hundred and seventy five thousand dollars);

(c) in the third year of the term of the licence the drilling of one exploration well to economic basement at an estimated total cost of $800,000 (eight hundred thousand dollars);

(d) in the fourth year of the term of the licence the acquisition processing and interpretation of an undesignated amount of seismic and geochemical surveying at an estimated total cost of $300,000 (three hundred thousand dollars);

(e) in the fifth year of the term of the licence the drilling of one exploration well to economic basement at an estimated total cost of $800,000 (eight hundred thousand dollars).

3. Within sixty days after the end of each year (being the period of twelve calendar months ending on the anniversary of the date upon which this licence comes into force), the Licensees shall submit to the Minister a full and complete written statement of expenditures actually made or caused to be made by the Licensees during that year upon approved exploratory operations. This statement of expenditures shall be accompanied by a written opinion on the veracity of the statement from an auditor whose qualifications and independence from the Licensees are acceptable to the Minister.

4. In the event that the Licensees during any year of the term of this licence (a year being the period of twelve calendar months ending on the anniversary of the date upon which this licence comes into force) fail to comply with the exploratory operations requirements of this licence, it is an express term of this licence that the Minister then may at his discretion either cancel this licence or authorise such variation to these requirements as the Minister thinks fit.

5. (a) Not less than thirty days before the commencement of each year (being the period of twelve calendar months ending on the anniversary of the date upon which this licence comes into force), the Licensees must arrange to meet in person with the Director-General or his representative to review the progress of the programme of exploration for the current licence year, and to present a proposal for the programme of exploration for the forthcoming year;

(b) if at any time the work being carried out or intended to be carried out by, or at the cause of, the Licensees is in the opinion of the Director-General not in accordance with the sound principles and practices of petroleum exploration, he may give the Licensees written directions as to the work being carried out or intended to be carried out, and the Licensees shall comply with those directions.

6. In addition to the quarterly reports specified in the Petroleum Regulations 1970, the Licensees shall promptly prepare and submit to the Director-General in a form acceptable to him, detailed reports on all exploratory operations done or caused to be done by or on behalf of the Licensees within and in relation to the licence area.

7. An application to drill a well within the area comprised in the licence shall include written proposals of the Licensees in relation to the bringing under control of the well, in the event that effective control of the well is lost, and to the clean-up of oil spills, including financial proposals such as well control insurance or other means to cover the costs involved in such operations.

SIGNED SEALED AND DELIVERED
by the said MINISTER OF MINES
AND ENERGY at ADELAIDE this

...22............day of March.......19........

MINISTER OF MINES AND ENERGY

MINISTER OF MINES AND ENERGY ADELAIDE

SIGNED SEALED AND DELIVERED
by the said LICENSEES at

..........Sydney.......... this

..............19th........ day of ....February.... 1991.

<u>THE COMMON SEAL of NOBJADE PTY LIMITED</u>
was hereto affixed in the presence of:-

NOBJADE PTY. LIMITED A.C.N. 003 411 149 Common Seal

.... (Director)

.... (Secretary)

PEL 43

The Schedule

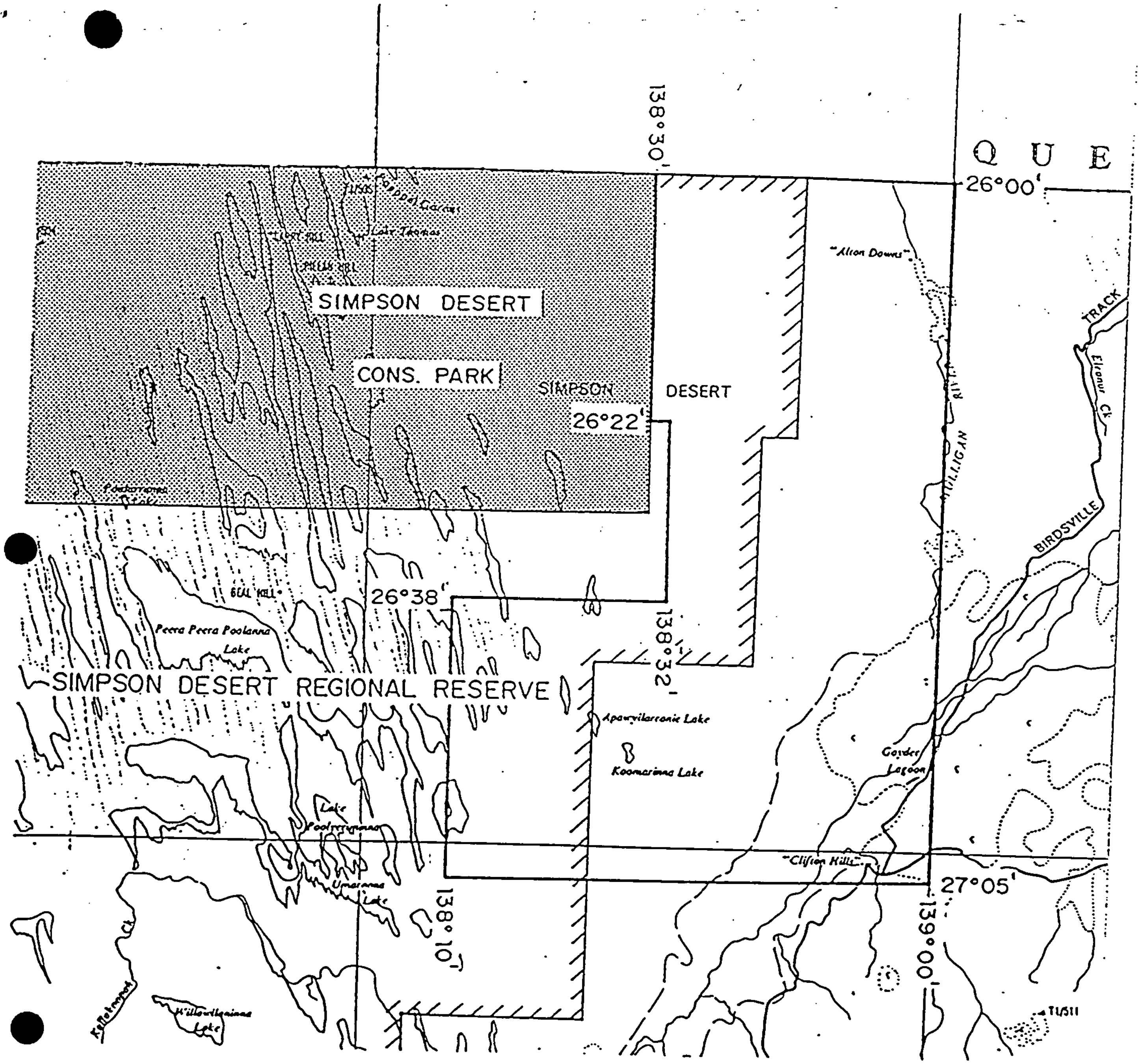
DESCRIPTION OF AREA

All that part of the State of South Australia, bounded as follows:

> *Commencing at a point being the intersection of the northern border of the State of South Australia and longitude 138°30′ east, thence east along the said border to longitude 139°00′ east, south to latitude 27°05′ south, west to longitude 138°10′ east, north to latitude 26°38′ south, east to longitude 138°32′ east, north to latitude 26°22′ south, west to longitude 138°30′ east and north to the point of commencement.*

All the within latitudes and longitudes are geodetic and expressed in terms of the Australian Geodetic Datum as defined on p.4984 of Commonwealth Gazette number 84 dated October 6, 1966.

AREA: 7,453 square kilometres approximately



SCALE 1:1000000

0 20 40 60 80 100 KILOMETRES

NOTE : There is no warranty that the boundary of this Licence is correct in relation to other features on the map. The boundary is to be ascertained by reference to the Australian Geodetic Datum and the schedule.

THE PLAN HEREINBEFORE REFERRED TO

PETROLEUM EXPLORATION LICENCE NO. 43

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MEMORANDUM SR 27/2/91

PETROLEUM EXPLORATION LICENCE NO. 43

NOBJADE PTY LIMITED

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1. This licence granted on 22 March 1991 is hereby entered on the Petroleum Register.

2. A security in the sum of $4,000 bank guarantee has been lodged with respect to this licence.

3. Interests in the licence are:-

   . Nobjade Pty Limited - 100%

22/3/91

MINISTER OF MINES AND ENERGY ADELAIDE

JOHN KLUNDER
MINISTER OF MINES AND ENERGY

F02458

SR. 27/2/91

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NOBJADE PTY LIMITED

ACN 003 411 149

ROOM 101
1ST FOOR
44 MARGARET STREET
SYDNEY NSW 2000

TELEPHONE: 371 6667

FACSIMILE: 371 7193

6 June 1991

The Director General,
Department of Mines and Energy,
Post Office Box 151,
EASTWOOD. SOUTH AUSTRALIA 5063

<u>Attention:</u> Dr. R. Laws.

Dear Dr. Laws,

<u>Re: Petroleum Exploration Licence No. 43</u>

Nobjade Pty. Limited has contracted Exploration Services Inc. (GES Inc) of Dallas, Texas, to do surface geochemical work on PEL 43 in South Australia.

GES Inc. is currently working with us in Western Queensland where we are exploring the Eromanga Basin in ATP'S 416P and 469P.

We wish to move south into PEL 43 to do regional surface geochemistry surveys along roads and existing seismic lines.

The National Parks and Wild Life Services in Leigh Creek inform us that the Warburton River is still flowing into Lake Eyre, and it will be some time before we can get into PEL 43.

This is obviously delaying our programme. Even so, we are waiting to see if rivers dry up - not much of a chance in the next month or so. We are faced with the fact that our Dallas Contractors will have to return to Texas, and our next solution will be to try again in late September or October 1991, before the Summer Season.

I will keep you informed of our proposals as soon as the weather and/or Contractors will permit.

Sincerely yours,

John Conolly

Dr. J. R. Conolly

SR-27/2/91
Env. 8080

8080 RS

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NOBJADE PTY LIMITED

ACN 003 411 149

ROOM 101
1ST FOOR
44 MARGARET STREET
SYDNEY NSW 2000

TELEPHONE: 371 6667

FACSIMILE: 371 7193

16th October, 1991

The Director General,
Department of Mines and Energy,
Post Office Box 151,
EASTWOOD. SOUTH AUSTRALIA 5063

Attention: Dr. R. Laws

Dear Dr. Laws,

re: PEL 43 - SIMPSON DESERT

PROPOSED SURFACE SOIL/GAS SURVEY - DECLARATION OF ENVIRONMENTAL FACTORS

1. It is proposed to run a regional soil/gas survey in PEL 43.

2. This survey will have a crew of five (5) men with two (2) 4WD Toyota vehicles and a fly-tent camp.

3. A base camp will be set up at the Alton Downs Sheep Station (Manager - Mr. Peter Brown) where a Photovac - Gas Chromatograph will be used to measure C_1 to C_4 gases.

4. Samples will be taken using a steel probe at depths of approximately 1 metre.

5. Access will be by the 4WD vehicles along already existing seismic lines, or in the compacted red sands between dunes.

6. We do not envisage being near any aboriginal sites, historic relics, heritage items or geologic monuments, nor do we see any possible damage to the natural environment.

7. Dr. John Conolly of 6 Balfour Road, Rose Bay, N.S.W. 2029, will be in charge of the survey which should take 4-8 weeks, and will be run during the cooler months of the year.

Sincerely yours,

Dr. J. R. Conolly.

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NOBJADE PTY LIMITED

Room 101
1st Floor
44 Margaret Street
SYDNEY NSW 2000

Telephone 371 6667

Facsimile 371 7193

15 May 1992

Mr Bob Laws
Department of Mines and Energy
191 Greenhill Road
PARKSIDE SA 5063

Dear Bob

RE PEL43 EXPLORATION PROGRAM, SIMPSON DESERT

Please find enclosed a summary of Nobjade's exploration work on PEL43 during the first year of the permit (22 March 1991 to 21 March 1992).

The year has been marked by very wet weather which delayed our regional geochemical program from June to November and which subsequently left the soil profile so wet that it was impossible to obtain reliable soil-gas data.

Personnel from Geochemical Exploration Services Inc, Dallas, and I went to PEL43 twice during 1991 to run soil-gas surveys. The first (June) expedition was abandoned because the interdune areas were still flooded. 317 soil gas samples were taken during the second expedition in November.

Only very low soil-gas values were obtained during this period, indicating that the soil profile was still too water saturated. This survey was abandoned in late November.

I visited the United States in February and March 1992 to have discussions with our potential partners in Texas and to further discuss the results of the November survey.

We are now in the second year of the permit without being able to achieve the first year's program. Because of this we have designed an alternate program which should still put us in a position to drill a well during the third year of the permit.

We now wish to run a 500 km ground radiometric and geochemical survey. This survey should enable us to locate a structurally high area with associated radiometric and soil-gas anomalies. A 40 km grid of seismic could then be run over the most anomalous feature to define a target to drill within the third year of the permit.

The results of our first year's exploration effort and the rationale behind this proposed variation are discussed in detail in the attached report.

I hope you find this new program acceptable.

Yours sincerely

John Conolly
Director

→ RAF for response

M.A. MACDONALD & Co.
CERTIFIED PRACTISING ACCOUNTANTS

Doreen Lilian Macdonald
FCPA AFAIM

14th May 1992

PEL43
Statement of Expenditures during
1st year of permit
22nd March, 1991 to 21st March, 1992

(Includes all costs expended or caused to be expended on PEL43)

GEOLOGY (Includes data costs, satellite photography, preparation of base maps, regional geological compilation and lead evaluation).	$23,260
GEOCHEMICAL AND FIELD GEOLOGY SURVEYS (Includes costs of Geochemical Exploration Services Ink, Dallas Texas for two (2) field surveys plus collection of 317 soil gas samples)	$81,540
TRAVEL	$10,800
ADMINISTRATION & OVERLOADS	$ 7,250
TOTAL EXPENDITURE	$122,850

SIGNED M. A. Macdonald
M.A.MACDONALD & CO.

All Correspondence P.O. Box 239 Lane Cove NSW 2066
246 Longueville Road Lane Cove NSW 2066 Facsimile (02) 427 1236 Telephone (02) 427 3677 Toll Free (008) 25 2972
Bettington Street Merriwa NSW 2329 Facsimile (065) 48 2007 Telephone (065) 48 2226

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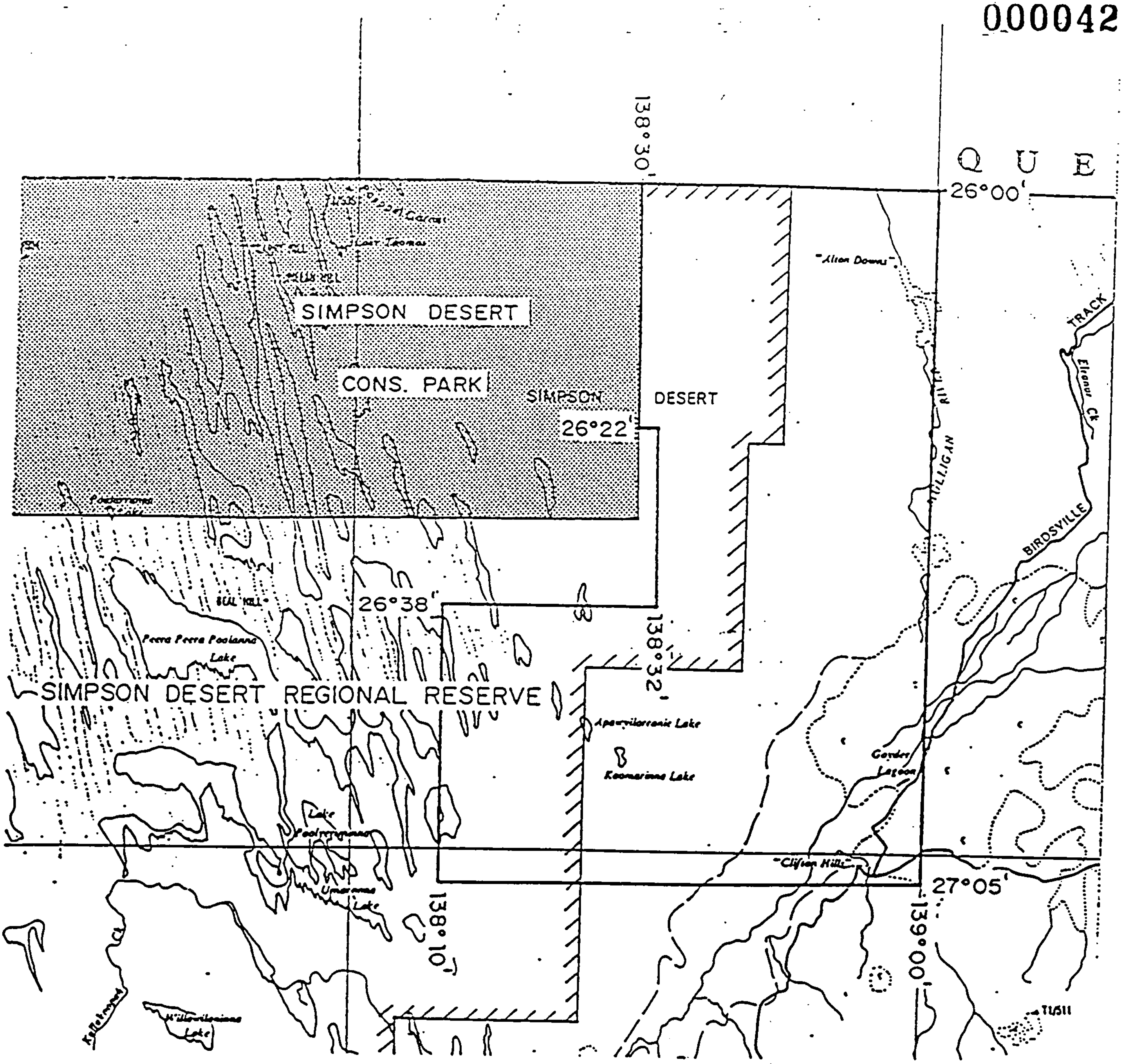
PEL43

Simpson Desert
South Australia

ANNUAL OPERATIONS REPORT

NOBJADE PTY LTD

44 Margaret Street
SYDNEY NSW 2000



NOTE : There is no warranty that the boundary of this Licence is correct in relation to other features on the map. The boundary is to be ascertained by reference to the Australian Geodetic Datum and the schedule.

THE PLAN HEREINBEFORE REFERRED TO

PETROLEUM EXPLORATION LICENCE NO. 43

DEPARTMENT OF MINES AND ENERGY - S.A.   SR 27/2/91   AREA 7453 km² (approx.)

TABLE OF CONTENTS

ATTACHMENTS

1. REPORT ON THE ACTIVITIES DURING THE FIRST EXPLORATION YEAR (22 March 1991 to 21 March 1991)

A. First Quarter: 22 March to 21 June 1991

During this month the Managing Director of Nobjade Pty Ltd, Dr John Conolly, visited the United States for six weeks (15 March to 20 April 1991). Meetings were held with Mr John Sandy of Geochemical Exploration Services Inc, Dallas, Texas, and plans were made for his company to run soil gas geochemical surveys in PEL43 in June and July 1991.

Preparations were made for Geochemical Services Inc, with a team of five people, to travel to Queensland where geochemical surveys were to be run in the Eromanga Basin, and then to travel further on to PEL43 where regional geochemical surveys were to be run in accordance with Nobjade's original plan.

The geochemical party arrived in Sydney on 7 May 1991 and after loading three 4-wheel drive trucks and two trailers with all the necessary camping and sampling equipment, proceeded to the Surat Basin and then on to the Eromanga Basin. Work finished in Queensland on 19 June and the sampling team then drove on to Birdsville, Queensland, where they arrived on 20 June.

B. Second Quarter: 21 June to 21 September 1991

The sampling party arrived at Alton Downs Station on 21 June. For the next two days attempts were made to access the PEL43, but all routes to the west were found to be blocked by large bodies of water that lay in the inter-dune areas. No sampling was attempted and the sampling crew returned to Sydney on 26 June and then back to Dallas, Texas.

During the remainder of this quarter Dr Conolly visited Canberra (4 and 5 July) where he spent two days inspecting satellite imagery over the PEL43 area.

Two satellite images were ordered to cover the entire PEL43 block. They were recent images that were selected on the basis that they would give an overall view of the permit. Copies at 1:250 000 and 1:100 000 scale were ordered from ACRES in Canberra.

C. Third Quarter: 22 September to 21 December 1991

Base maps were prepared from the 1:250 000 scale topographical maps by enlarging them to 1:100 000 scale. These were checked against the 1:100 000 scale satellite imagery. All major longitudinal dunes seen on the topographical maps could also be recognised on the satellite images, indicating that little or no major movement of these dunes had occurred since the topographical maps were made ten years ago. Plans were made to have the geochemical team from Dallas return to Australia as soon as possible.

A team of three men from Geochemical Services Inc, Dallas, arrived in Sydney on 17 November and at the Clifton Hills Station in PEL43 on 21 November. Sampling started on 22 November.

317 samples were taken up to 30 November. This survey was stopped at this point because the soil-gas readings were considered to be too low to be useful. It was concluded that the very heavy rains had caused a 'plug' of water to saturate the soil profile just beneath the open mud-cracked surface, inhibiting normal movement of the light alkane gases to the surface.

Only trace amounts (generally less than 1 ppm methane, and much less ethane, propane and iso- and n-butane) were sampled at most sample stations. "Normal" numbers (generally 5-10 ppm methane, 0.3 to 0.8 ppm ethane, 0.1 to 0.3 ppm propane, and 0.03 to 0.08 ppm iso and n-butane) did not occur.

During this survey, samples were run along the major tracks near and west of the Clifton Hills Station. The sampling crew used two 4-wheel drive Toyotas and electric drill probes powered by generators mounted on the rear of the vehicles. Most samples were taken from depths of 1 m or more. This sampling technique has been proven to be effective throughout the USA and has also been used in Africa and South America by Geochemical Exploration Services.

All aspects of this sampling procedure were thoroughly tested in the field during the sampling period and all proved to be operating efficiently. We can only conclude that the sampling conditions were as adverse as any that have been found over a ten-year period.

We believe that when the saturated water table conditions subside and return to normal, that better sampling can be achieved as has been done using similar techniques in the Simpson Desert by Petrofocus Pty Ltd during the 1980s.

The program was postponed until the 1992 field season.

D. Fourth Quarter: 21 December 1991 to 21 March 1992

Dr John Conolly visited the United States from 23 January to 8 March 1992. During this visit Dr Conolly gave a 3-day short course on oil exploration opportunities in Australia in Houston from 28 to 30 January 1992. He also visited with many oil companies in Houston, Dallas and Denver and discussed the Simpson Desert exploration program in PEL43 with most of these companies. A talk on the use of surface geochemical techniques in the search for oil in Australia was given to the Association of Petroleum Geochemical Explorationists in Dallas on 19 February 1992.

2. THE USE OF NATURAL RADIATION TO DETECT OIL AND GAS FIELDS

A. General Outline of Technique

Ground radiometric (gamma ray spectral) surveys are being used today to help detect oil and gas fields in the subsurface. The science behind this concept has evolved slowly over the past 30 years as more and more data is assimilated and numerous case histories accumulate, indicating the occurrence of natural gamma "lows" with haloed "highs" at the surface over oil and gas fields in the subsurface.

Nobjade's personnel have been involved in radiometric surveys during the 1980s in the mid-continent of the USA. Petrofocus USA Inc (based in Denver during 1986 to 1990) conducted radiometric surveys in the state line play over the Colorado/Kansas border, searching for Pennsylvanian Morrow channel sands. Several of the anomalous radiometric lows found during this work are now producing oil and gas fields.

Radiometric surveys have not been used in Australia in this manner mainly because geologists were concerned about the relatively easy way in which secondary uranium minerals formed in surface soils. It is just this process that is so important to the exploration model that is used to find oil and gas fields using natural surface gamma radiation.

Mr John Sandy who worked for Sun Oil Company during the 1970s was intimately involved in their use of surface radiometric surveys to locate oil and gas fields. Sun Oil Company's work over a 20-year period has been summarised in an article published in 1981 by the Southern Methodist University Press, Dallas, Texas, called "Unconventional Methods in Exploration for Petroleum and Natural Gas II - Exploration Radiometrics: Post Survey Drilling Results" by RC Weart and G Heimberg.

Sun's exploration model is illustrated by a simple 2-D diagram which shows low, continuous vertical microseepage of light alkane gases from oil and gas reservoirs to the surface. Soil alteration induced by the microseepage produces reduced secondary uranium minerals directly over the reservoirs. As time progresses, the continual microseepage of gases forms a "crust" of secondary carbonate minerals near the top of the water table. This crust in turn inhibits the microseepage flow which results in the re-oxidation of the uranium minerals and the formation of a relative radiometric low directly over the reservoir.

In addition, empirical data quite clearly shows that the edges of these radiometric lows are marked by anomalously high concentrations of uranium minerals which develop into a "halo" of high natural gamma radiation around the gamma low anomaly. Hence, it became increasingly obvious that radiometric surveys could be used to locate oil and gas fields on the surface, providing that a few important "rules" are carefully obeyed. These are:

1. Since the natural gamma measured comes from radioactive minerals present in the upper several centimetres of the soil, the best radiometric surveys are obtained in areas of undisturbed, uniform residual soils. Soil must be mapped as the surveys are run and variations normalised prior to interpretation.

2. Gamma radiation must be separated into its main component source elements which are uranium, thorium and potassium. This allows interpretation to be based on individual spectra. It is important to differentiate potassium-rich clay variations from uranium-rich sand variations, for example.

3. Interpretation should be based on pattern recognition developed by running multiple profiles and not just single line profiles. Profile-to-profile correlation of anomalous highs and lows is essential.

4. Radiometric surveys should be integrated with all other geological, geophysical and geochemical data.

We believe that the interdune silty claypans in the Simpson Desert portion of PEL43 could be a region where the radiometric survey method will work very well. The uniform surface virtually eliminates the need for normalising soil background variations and multiple parallel profiles are easily obtained by traversing parallel to the dunes.

The interdune claypan soils may be somewhat similar to the glacial till soils of the United States where Sun Oil Company ran many very successful radiometric surveys.

Although claypans and tills are both "transported", the thin veneer of uniform "soils" are ideal receptors for the hydrocarbon gas microseepage-induced alteration. The Albion-Scipio trend of oil fields in Michigan provided a classic example of radiometric response on glacial tills. Sun Oil Company published radiometric data on the Albion-Scipio trend showing an excellent haloed response. Interestingly, a second survey, five years after the first survey, revealed a dramatic decrease in the amplitude of the radiometric response, presumably due to depletion of the reservoir.

B. Appendix of Key Articles Describing how Radiometric Anomalies are Associated with Oil and Gas Fields

A series of important articles describing the radiometric technique, how it can be used, and a number of case histories, is enclosed as Appendix A.

Particular note should be made of the case histories.

C. PEL43 1992 Field Program - Radiometric and Soil Gas Surveys

A program for 500 km of reconnaissance radiometric surveys has been outlined on Plate 2. Most of the traverses cross regions of potential structural closure at the "C" seismic horizon. The remainder fill in areas where there is no regional seismic information (Plate 2). Soil gas samples will be taken at one kilometre intervals along each traverse.

This approach will be a "first" in Australia. If we can discover one or two leads where both attributes show strong anomalies, we should have a much better opportunity to attract a substantial joint venture partner to join us in the seismic/drilling phase of exploration.

3. REQUEST FOR VARIATION IN WORK PROGRAM

We request that our work program be varied as follows:

YEAR 1	300 km of soil gas survey (already completed).
YEAR 2	500 km of radiometric surveying. Soil gas samples will be taken over the most anomalous regions (estimated 400 samples). 40 km grid of seismic over the most prospective feature.
YEAR 3	Drill one well.

TABLE 1

SOIL GAS SAMPLES:
TABLE OF RESULTS 1991 PROGRAM

STATE South Australia PROJECT PEL 43

COUNTY Clifton Hills DATE 23 Nov 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	I-Butane	n-Butane	C_1-C_4	C_2-C_4	REMARKS
1	1.0	T		T		T	T*			Goyder Lagoon
2	T	T		T		T	T			Deeply mud-
3	1.0	T		T		T	T			cracked to 1.0
4	0.6	T		T		0.02	T			to 2.0 meters.
5	2.0	0.06		0.06		0.01	0.01			Aeration is
6	5.0	0.07		0.07		0.03	0.03			deep - dilution
7	2.0	0.01		0.02		0.01	0.01			of samples.
8	19.0	1.0		0.7		0.10	0.13			Water present
9	1.0	T		T		0.01	0.06			immediately below
10	1.5	T		T		0.01	T			deep cracks.
11	4.0	1.8		0.50		0.20	0.20			
12	1.0	T		T		0.03	0.02			Organic-rich,
13	1.0	T		T		0.03	0.02			dark grey to
14	0.4	T		T		0.01	0.05			black silts.
15	0.5	T		T		0.01	0.01			
16	0.6	T		T		0.03	0.02			Fierce snakes.
17	0.6	0.01		T		0.01	0.03			
18	1.0	0.20		0.10		0.04	0.04			
19	0.50	T		T		0.01	0.01			
20	1.0	T		T		0.01	0.03			
21	0.50	T		T		0.01	T			
22	0.60	T		T		0.01	0.01			
23	T	T		T		T	T			
24	1.0	T		T		0.01	0.02			*T = trace

STATE South Australia PROJECT PEL 43

~~COUNTY~~ Clifton Hills DATE 23/24 Nov. 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	I-Butane	n-Butane	$C_1 - C_4$	$C_2 - C_4$	REMARKS
25	1.0	T		T		T	T			
26	1.0	T		T		T	T			
27	1.0	T		T		0.01	0.01			
28	T	T		T		0.01	0.01			
29	0.5	0.3		0.20		0.02	0.04			
30	1.0	0.4		0.20		0.03	0.04			23 Nov.
31	1.0	T		T		0.80	0.07			24 Nov.
32	1.1	0.4		0.30		0.06	0.08			
33	7.0	T		T		0.03	0.04			
34	5.0	T		T		0.02	0.03			
35	2.0	T		0.20		0.10	0.20			
36	1.0	T		0.20		0.06	0.10			
37	3.0	T		0.40		0.02	0.04			
38	T	T		0.20		0.03	0.05			
39	3.0	0.7		0.10		0.06	0.06			
40	1.0	T		T		0.04	0.09			
41	1.0	0.1		0.40		0.04	0.04			
42	2.0	0.1		0.20		0.04	0.04			
43	5.0	T		0.20		0.05	0.07			
44	T	T		T		T	T			
45	1.0	T		T		0.04	0.09			
46	T	T		T		T	T			

000053

2

STATE South Australia PROJECT PEL 43

~~COUNTY~~ Clifton Hills DATE 25 Nov. 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	I-Butane	n-Butane	$C_1 - C_4$	$C_2 - C_4$	REMARKS
47	1.0	0.10		0.20		0.06	0.10			
48	T	T		T		T	T			
49	4.0	0.90		0.20		0.06	0.10			
50	1.0	T		T		T	T			
51	4.0	T		T		0.01	0.05			
52	23.0	T		T		0.04	0.09			
53	36.0	T		T		0.02	0.04			
54	3.0	T		T		T	0.03			
55	5.0	0.70		0.06		0.10	0.50			
56	4.0	T		T		0.01	0.05			
57	1.0	T		T		T	0.02			
58	15.0	T		T		0.02	0.07			
59	14.0	T		T		0.01	0.03			
60	2.0	T		T		0.02	0.05			
61	1.0	T		T		0.02	0.30			
62	6.0	T		T		0.02	0.04			
63	13.0	T		T		0.10	0.30			
64	7.0	T		T		0.06	0.20			
65	3.0	T		T		0.06	0.20			
66	T	T		T		T	T			
67	1.0	T		T		0.03	0.03			
68	T	T		T		T	T			
69	5.0	T		T		0.02	T			
70	2.0	T		T		0.02	T			

3

STATE South Australia PROJECT PEL 43

~~COUNTY~~ Clifton Hills DATE 25 Nov. 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	I-Butane	n-Butane	C_1-C_4	C_2-C_4	REMARKS
71	1.0	T		T		T	0.20			
72	2.0	0.10		0.10		0.20	0.04			W of Mooloowurdoo
73	2.0	0.30		0.40		0.05	0.05			waterhole
74	1.5	0.10		T		T	T			
75	1.0	0.10		T		0.01	0.01			
76	2.7	0.05		T		0.02	0.02			
77	7.1	0.50		T		T	0.02			
78	1.0	T		T		T	0.02			
79	1.0	0.10		T		T	T			
80	1.0	T		T		T	0.01			
81	T	T		T		T	T			
82	0.5	T		T		T	0.01			
83	T	T		T		T	T			
84	T	T		T		T	0.01			
85	1.0	T		T		T	0.01			
86	1.1	T		T		T	T			
87	T	T		T		T	0.01			
88	T	T		T		T	0.01			
89	1.0	T		T		T	T			
90	0.5	T		T		T	T			
91	T	T		T		T	T			
92	27.0	0.5		T		T	0.01			
93	73.0	1.1		T		T	0.01			

000055

4

STATE South Australia PROJECT PEL 43

~~COUNTY~~ Clifton Hills DATE 26 Nov. 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	I-Butane	n-Butane	$C_1 - C_4$	$C_2 - C_4$	REMARKS
94	1.0	T		0.20	0.09	T				
95	T	T		T	0.10	T				
96	T	T		T	0.50	T				
97	0.5	0.40		0.20	0.60	T				
98	0.7	T		0.20	0.60	T				
99	2.0	0.20		0.40	0.70	T				
100	1.0	0.50		0.50	0.40	T				
101	T	T		T	0.20	T				
102	T	T		T	0.20	T				Goyder Lagoon Rd
103	1.0	T		T	0.30	T				
104	T	T		T	0.30	T				
105	T	T		T	0.20	T				Mudcracked ground
106	T	T		T	0.10	T				to 1 meter
107	T	T		T	0.10	T				
108	T	T		T	0.20	T				Air penetrates
109	0.6	T		T	0.20	T				– deep.
110	T	T		T	0.10	T				
111	0.5	T		T	0.20	T				
112	0.5	T		T	0.20	T				
113	1.0	T		0.10	0.10	T				
114	0.5	T		T	0.07	T				
115	T	T		T	0.06	T				

000056

STATE South Australia PROJECT PEL 43

~~COUNTY~~ Clifton Hills DATE 27/28 Nov. 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	I-Butane	n-Butane	C_1 - C_4	C_2 - C_4	REMARKS
116	T	T		T		T	T			
117	T	T		T		0.10	T			
118	T	T		T		0.10	T			
119	T	T		T		0.10	T			
120	T	T		T		0.15	T			
121	T	T		T		0.10	T			
122	0.5	T		T		0.10	T			
123	T	T		T		0.40	T			
124	T	T		T		T	T			
125	T	T		T		0.20	T			
126	T	T		T		0.10	T			
127	T	T		T		0.10	T			
128	T	T		T		0.10	T			
129	T	T		T		0.20	T			
130	T	T		T		0.20	T			
131	T	T		T		0.20	T			
132	T	T		T		0.40	T			27 Nov.
133	T	T		T		0.08	0.20			28 Nov.
134	T	T		T		T	T			Traverse → N
135	2.0	0.20		0.80		0.06	0.30			on rig road
136	1.0	T		0.05		0.10	0.01			to Kunch. well
137	1.0	T		T		T	T			Sampling
										between dunes
										only.

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STATE South Australia PROJECT PEL 43

~~COUNTY~~ Clifton Hills DATE 29 Nov. 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	I-Butane	n-Butane	$C_1 - C_4$	$C_2 - C_4$	REMARKS
140	3.0	T		0.20		T	T			
141	2.0	T		T		T	T			
142	2.0	T		T		T	T			Uniform,
143	1.0	T		0.10		T	T			inter-dunal
144	4.0	T		0.20		T	0.08			silts and sands.
145	2.0	T		0.10		T	T			
146	3.5	T		0.20		T	0.10			Stn. 144 –
147	2.0	T		0.10		T	0.10			Murdamarroo
148	4.0	T		0.20		T	0.08			waterhole
149	T	T		0.20		T	0.10			
150	T	T		T		T	T			
151	T	T		T		T	T			
152	0.5	T		0.10		T	0.10			
153	1.0	T		0.10		T	T			
154	1.0	T		0.20		T	T			
155	2.0	T		0.10		T	0.20			
156	3.0	0.50		0.04		0.08	0.03			
157	2.0	T		T		T	T			
158	2.5	T		T		T	T			
159	1.0	T		T		T	T			
160	2.5	0.50		0.04		0.10	0.03			
161	1.0	T		0.05		T	T			
162	2.0	T		T		T	T			
163	2.0	T		T		T	T			

000059

STATE South Australia PROJECT PEL 43

~~COUNTY~~ Clifton Hills DATE 29 Nov. 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	I-Butane	n-Butane	$C_1 - C_4$	$C_2 - C_4$	REMARKS
164	2.0	0.10		0.04		0.04	0.01			Murda Hill
165	3.0	T		T		T	T			
166	2.5	T		T		T	T			
167	2.0	T		T		T	T			
168	2.0	0.50		0.08		0.08	T			
169	2.0	T		T		T	T			
170	2.0	0.30		0.02		T	T			Traverse along
171	1.0	T		T		T	T			rig road N
172	1.0	T		T		T	T			to Kuncherinna
173	1.5	T		T		0.20	T			well.
174	2.0	T		0.02		0.20	0.05			
175	1.0	T		T		0.20	T			
176	2.0	T		T		T	T			
177	1.5	T		T		0.30	T			
178	2.0	0.60		0.40		0.40	T			
179	1.5	0.60		T		T	T			
180	1.5	T		T		T	T			
181	2.0	T		T		T	T			
182	2.0	T		0.10		0.60	T			
183	2.0	T		T		0.10	T			
184	2.5	T		T		0.10	T			
185	2.0	T		T		0.10	T			
186	0.5	T		T		0.20	T			
187	2.0	T		T		T	T			

000060

STATE South Australia PROJECT PEL 43

~~COUNTY~~ Clifton Hills DATE 29 Nov. 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	i-Butane	n-Butane	C_1 - C_4	C_2 - C_4	REMARKS
188	2.0	0.40		0.30		0.10	T			
189	2.0	T		T		T	T			
190	1.0	T		0.02		0.10	T			
191	2.0	T		T		T	0.01			
192	2.0	T		T		0.40	T			← Kunch. well
193	2.0	0.20		0.30		0.10	T			
194	2.0	T		T		T	T			Traverse to
195	1.0	T		T		T	T			Kuncherring
196	5.0	T		T		T	T			
197	2.0	T		T		0.60	T			Sandhills &
198	3.0	0.30		0.30		0.80	T			clay pan - damp.
199	2.0	0.10		0.10		0.04	0.04			End line to N.
200	1.0	0.10		T		T	T			
201	T	T		T		0.40	T			
202	T	T		T		0.30	T			
203	0.5	T		T		0.08	T			
204	T	T		T		0.08	T			
205	0.5	T		T		T	T			
206	T	T		T		T	T			
207	1.0	0.20		0.20		0.10	0.10			
208	T	T		T		0.10	T			
209	T	T		T		0.20	T			
210	12.0	T		T		0.10	T			
211	30.0	T		T		0.10	T			

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STATE South Australia PROJECT PEL 43

~~COUNTY~~ Clifton Hills DATE 28/29 Nov. 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	I-Butane	n-Butane	C_1-C_4	C_2-C_4	REMARKS
212	T	T		T		T	T			
213	5.0	0.10		T		0.06	T			
214	2.0	0.20		0.20		0.10	T			
215	3.0	0.50		1.00		0.10	T			
216	T	T		T		T	T			
217	T	T		T		T	T			
218	1.0	T		T		0.10	T			
219	8.0	T		T		0.08	0.08			
220	1.0	T		T		0.08	T			
221	T	T		T		0.20	T			On Birdsville Tr.
222	T	T		T		0.40	T			near Clifton
223	T	T		T		T	T			Hills Station.
224	4.0	T		T		0.20	T			
225	1.0	T		T		T	T			
226	1.0	T		T		T	T			
227	1.0	T		T		0.05	T			
228	0.5	T		T		T	T			
229	0.6	T		T		0.09	T			
230	6.0	T		T		0.05	0.04			
231	1.0	T		T		0.03	T			
232	T	T		T		T	T			
233	1.0	T		T		0.10	T			
234	T	T		T		0.02	T			
235	T	T		T		T	T			

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STATE South Australia PROJECT PEL 43
~~COUNTY~~ Clifton Hills DATE 29 Nov. 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	I-Butane	n-Butane	C_1 - C_4	C_2 - C_4	REMARKS
236	T	T		T		T	T			
237	T	T		T		0.05	T			Road along
238	T	T		T		T	T			dunes, hard-
239	1.0	0.10		0.20		0.01	T			packed silts.
240	T	T		T		T	T			
241	T	T		T		0.20	T			
242	0.5	T		0.10		0.05	T			
243	T	T		T		T	T			
244	0.5	T		T		0.50	T			
245	0.5	0.50		0.30		0.40	0.30			West of
246	1.0	T		T		0.20	T			Clifton Hills
247	T	0.30		0.30		0.50	T			
248	T	T		0.20		0.20	T			
249	T	T		T		0.60	T			
250	T	T		T		0.10	0.01			
251	0.5	T		T		0.30	T			
252	0.5	T		T		0.10	T			Heavy rains - Feb
253	T	T		T		0.10	T			may have caused
254	0.5	T		T		T	T			a plug of water
255	T	T		T		T	T			to keep gas from
256	0.5	T		T		0.02	T			rising?
257	0.5	T		T		T	T			
258	T	T		0.20		0.20	T			
259	T	T		T		T	T			

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STATE South Australia PROJECT PEL 43

~~COUNTY~~ Clifton Hills DATE 29/30 Nov. 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	i-Butane	n-Butane	$C_1 - C_4$	$C_2 - C_4$	REMARKS
260	T	T		T		0.60	T			
261	T	T		T		0.40	T			
262	T	T		T		0.40	T			
263	T	T		T		0.25	T			
264	T	T		T		0.30	T			29 Nov.
265	T	T		T		T	T			30 Nov.
266	T	T		T		0.05	T			Rig Road.
267	T	T		T		T	T			N →
268	T	T		T		0.05	T			
269	T	T		0.02		0.04	0.05			
270	T	T		T		T	T			
271	T	T		T		0.05	T			
272	0.5	T		T		0.04	T			
273	T	T		T		T	T			
274	T	T		T		0.06	0.02			
275	T	T		T		0.03	T			
276	T	0.10		0.10		0.10	0.05			
277	0.5	T		T		0.01	T			
278	T	T		T		T	T			
279	0.05	T		0.10		0.08	T			
280	T	T		T		0.04	T			
281	T	T		T		T	T			Track along W
282	T	T		T		T	T			side of Goyder
283	T	T		T		T	T			Lagoon

STATE South Australia PROJECT PEL 43

~~COUNTY~~ Clifton Hills DATE 30 Nov. 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	I-Butane	n-Butane	C_1-C_4	C_2-C_4	REMARKS
284	T	T		T		T	T			Rig Road
285	T	T		T		T	T			
286	0.5	T		T		0.02	T			
287	T	T		T		0.02	T			Packed silts
288	T	T		T		T	T			along edge
289	T	T		T		T	T			of dunes.
290	0.5	T		T		T	T			
291	T	T		T		T	T			W of Clifton Hills
292	T	T		T		0.04	T			
293	0.5	T		T		T	T			
294	T	T		T		T	T			
295	T	T		T		0.02	T			
296	T	T		T		T	T			
297	T	T		T		T	T			
298	0.5	T		T		T	T			
299	T	T		T		T	T			
300	T	T		T		0.04	0.01			
301	T	T		T		0.06	T			SW of Clifton Hills
302	T	T		T		T	T			
303	T	T		T		T	T			
304	T	T		T		T	T			
305	T	T		T		0.04	T			Seismic Line
306	T	T		T		T	T			
307	T	T		T		0.20	T			

000064

STATE South Australia PROJECT PEL 43

~~COUNTY~~ Clifton Hills DATE 30 Nov. 1991

INTERSTITIAL SOIL GAS SURVEY DATA

Concentration in PPM (Volume)

SAMPLE #	Methane	Ethane	~~Ethylene~~	Propane	~~Propylene~~	I-Butane	n-Butane	$C_1 - C_4$	$C_2 - C_4$	REMARKS
308	T	T		T		0.20	T			
309	T	T		T		0.05	0.01			
310	T	T		T		0.01	T			
311	T	T		T		0.07	T			
312	T	T		T		T	T			
313	T	T		T		T	T			
314	T	T		T		T	T			
315	T	T		T		T	T			
316	0.5	T		T		T	T			
317	T	T		T		0.05	T			

APPENDIX A

SELECTED LITERATURE

GROUND RADIOMETRIC (GAMMA-RAY SPECTRAL) SURVEY

Ground gamma-ray surveys are a rapid, cost-efficient approach to hydrocarbon exploration. Regional surveys, along roads or cross-country, can provide hydrocarbon anomaly leads that can be followed up by detailed surveys.

Modern, computerized gamma-ray surveying requires a sophisticated system and methodology which includes:

- Multi-channel, gamma-ray spectrometer
- Large volume, lead-shielded crystal detector
- All data digitally recorded on computer disc for spectral ratioing and printout
- All data normalized for soil background changes and low energy level radon daughter product radiation

HOW IT WORKS

Light hydrocarbon and associated gases migrate vertically to the surface from oil and gas reservoirs regardless of depth or type of caprock. Ascending primarily along fractures, the gases cause chemical alteration in the overlying soils which is detectable as changes in the normal soil radiation level. Typically, this alteration results in gamma radiation "lows" that occur directly above hydrocarbon reservoirs. The alteration is caused by chemical reduction and microbiological-induced changes in the soil and subsoil. Since background levels in natural gamma-ray intensity change as different soils are traversed, every soil change must be normalized to eliminate "non-seepage" related anomalies.

MODELS

In regional exploration, modeling gamma-ray response patterns that overlie target production is very useful. Recent discoveries are best since the radiometric signature changes as microseepage decreases with reservoir depletion. An example of an actual profile over a producing Austin Chalk reservoir is shown overleaf. The very strong "haloed low" is an excellent model for gamma-ray exploration for the Austin Chalk in this area.

Austin Chalk Trend - Texas

The Austin Chalk trend of South Texas is an ideal place to delineate hydrocarbon microseepage alteration using radiometrics. Spectral gamma surveys, normalized for changes in background due to soil changes, outline areas of surface alteration that lie along the trend of the fracture zones that contain hydrocarbons.

The fractured reservoirs of the Austin Chalk trend are zones of essentially-vertical, multiple fractures. Their surface manifestation can be delineated by mapping hydrocarbon microseepage-induced alteration in the soils above the fracture zones. The reservoir seepage along the fracture zones result in elongated surface anomalies that usually match the surface trace of NE-SW trending fractures (see overleaf) that can be readily seen on aerial photographs.

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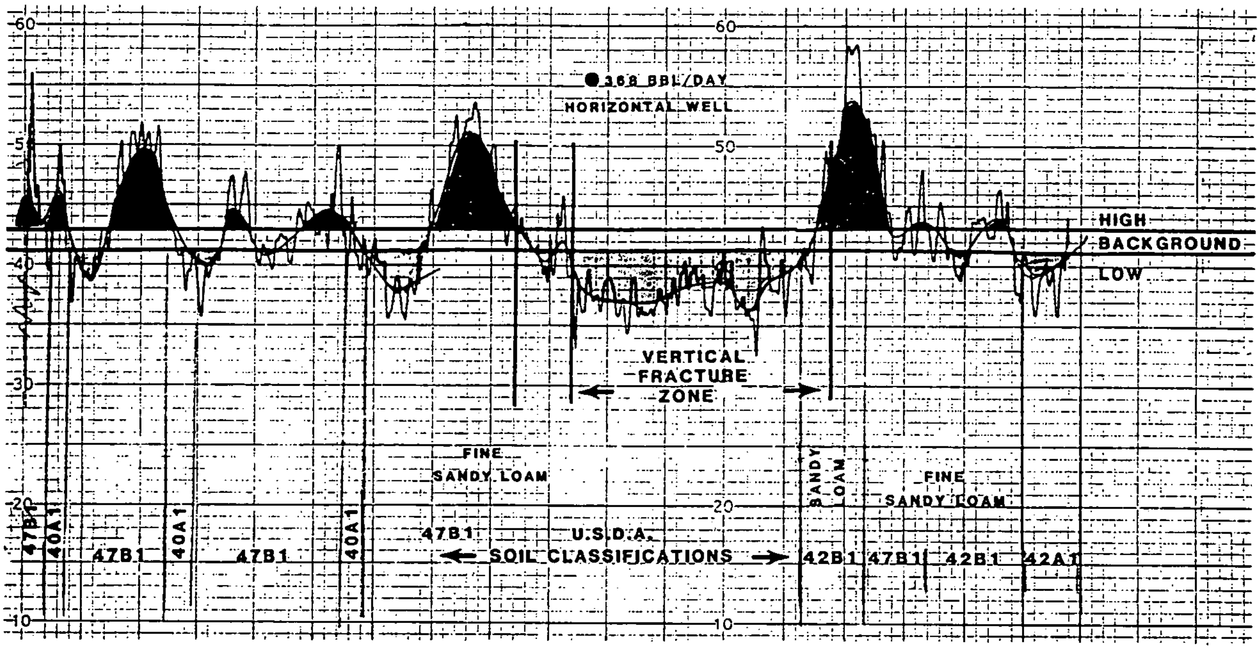
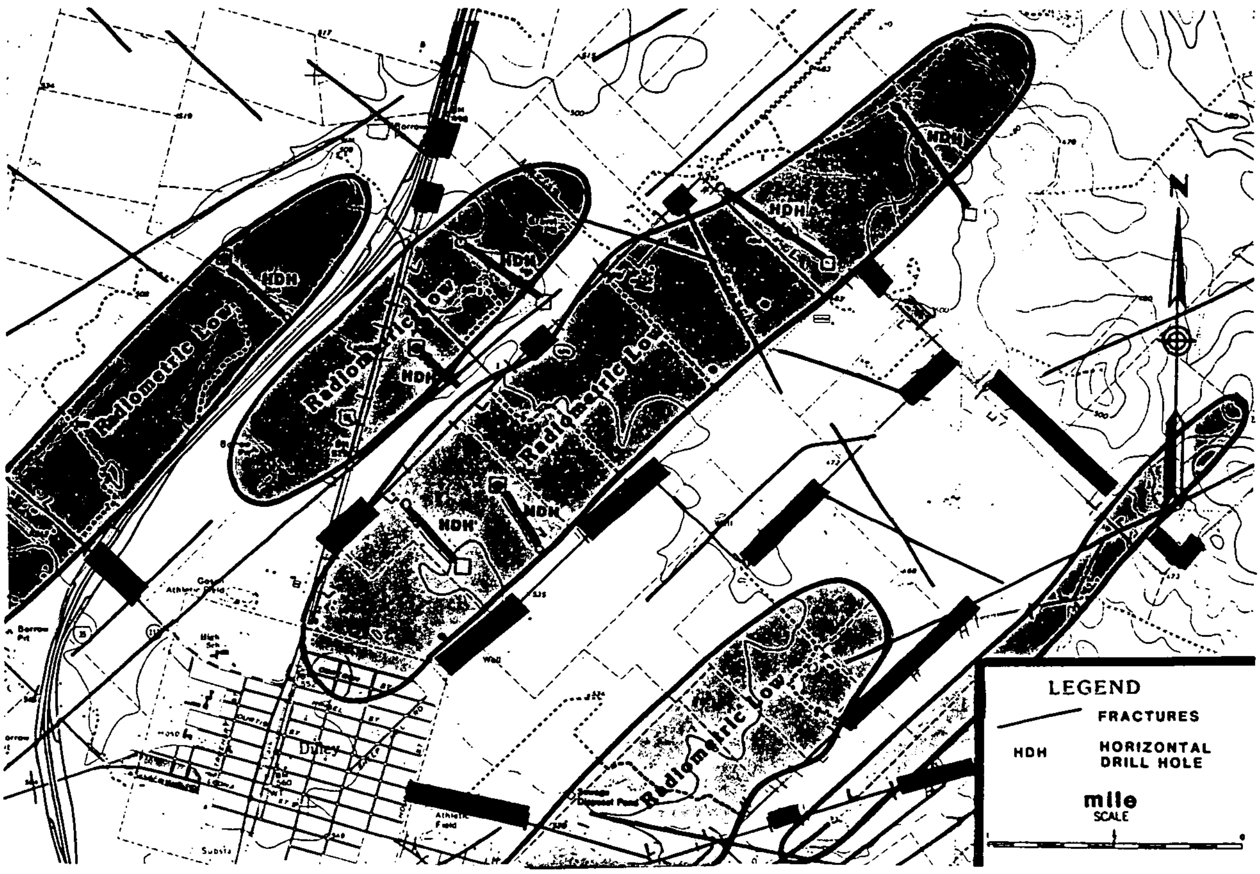
AUSTIN CHALK, RADIOMETRIC PROFILE
LA SALLE COUNTY, TEXAS



RADIOMETRIC LOW, PRODUCING FRACTURE ZONE
DILLEY, FRIO COUNTY, TEXAS



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EXPLORATION RADIOMETRICS: POSTSURVEY DRILLING RESULTS

Richard C. Weart and George Heimberg

SUNMARK EXPLORATION COMPANY

Sunmark Exploration Company initiated a program in 1977 to investigate hydrocarbon exploration techniques. This study was prompted by the desire to evaluate various exploration methods for possible application in frontier areas where the geological and physical conditions have impeded the successful utilization of conventional tools, and to lower front-end petroleum exploration costs. Radiometrics was one of the methods chosen for evaluation, based primarily on the plausibility of the theoretical considerations supporting the method, and the very low field survey costs.

Radiometric surveying, first used in the 1920s for hydrocarbon exploration, is considered to be a direct oil and gas finding method. With the exception of the drill bit, all direct hydrocarbon exploration methods are categorized as unconventional by the majority of geoscientists and accepted as viable by only a few. The primary reason for this lack of acceptance is failure of the explorationist to conceptualize and accept as valid the vertical migration process. This process, which most unconventional techniques depend upon, is predicated on the principle that formation fluids and gases do ascend vertically, or nearly so, through the sedimentary section, and that as a result of this migration surface manifestations of anomalous conditions at depth, such as hydrocarbon accumulations, are measurable and mappable. Geoscientists have largely been conditioned to think in terms of impermeable barriers in connection with trapping mechanisms, and of lateral rather than vertical migration with respect to porous and permeable aquifers. Many investigators, however, are marshaling a large amount of evidence which is providing compelling arguments for vertical migration and theoretical support for the empirical approach of case histories.

Assuming that vertical migration of formation fluids is an active, nearly continuous, and universal mechanism in sedimentary areas, it is also the necessary agent for the transport toward, and to, the earth's surface of all kinds of matter in solution. This includes the radioactive, soluble deterioration products of the igneous basement and the overlying sediments. The capability of hydrocarbons to adsorb radioactive materials, as well as the shielding effect that subsurface hydrocarbon accumulations have to vertical fluid migration, creates a low radiation anomaly above such an accumulation—the well-known chimney effect (Figure 1).*

The high radiation halo associated with such an anomaly usually approximates the outline of a probable oil and gas accumulation of unknown magnitude and indeterminate depth. Hydrodynamic conditions, fracture patterns, coning effects from diffusion, and other geologic conditions can often distort and shift the halo pattern. The halo of high radiation values is probably due to an increase in the vertical flow volume of formation fluids diverted around, and also expelled from, the hydrocarbon trap, as indicated by the arrows. The water expelled from the trap as it is replaced by hydrocarbons is most likely to contain greater amounts of radioactive material in solution than normal formation waters because of its proximity to increased concentration of radioactive elements normally found in association with hydrocarbons.

As the formation fluids with their dissolved components rise vertically through the overlying sedimentary burden, exposure to changing chemical and physical environments promotes the precipitation of various elements formerly

*See atlas for Fig. 1 and Figs. 4-14.

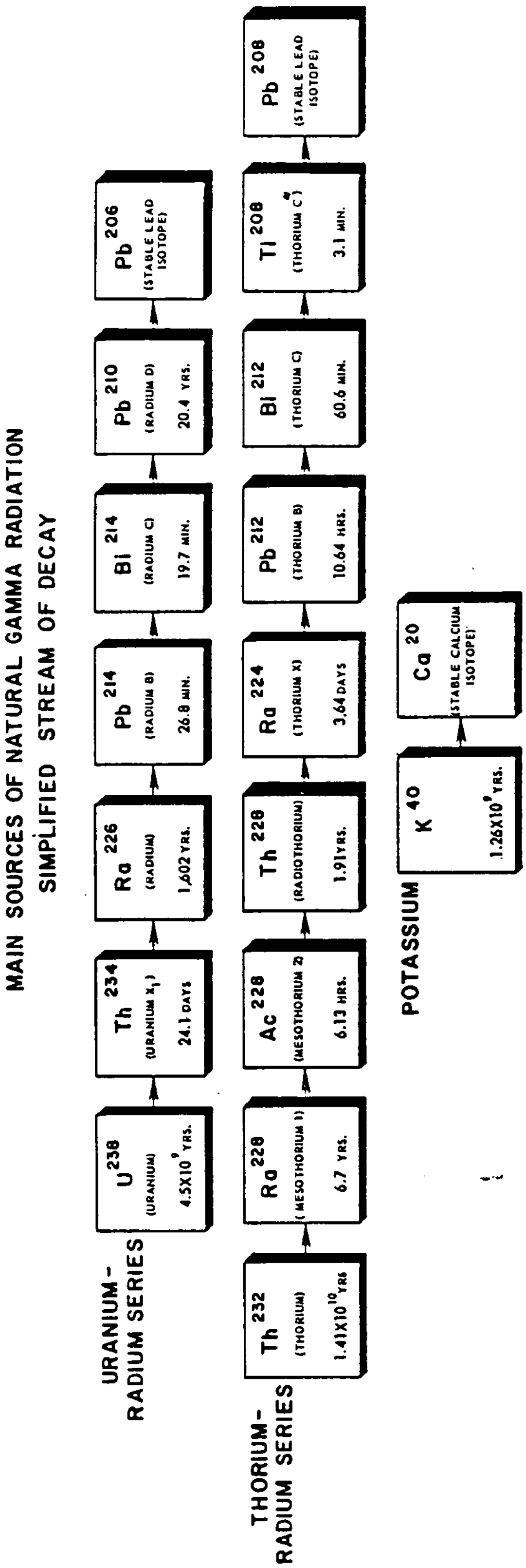

Fig. 2.

held in solution. Included among these elements are the gamma ray emitters uranium, thorium, and potassium-40. Each of these elements has a long half-life and tends to provide a permanent gamma ray source in the near-surface soils and rocks where it has been emplaced. Major members of the uranium and thorium decay series, several of which are high gamma contributors, are indicated in Figure 2. Uranium is by far the most soluble in water compared to thorium and potassium-40. It and its daughter products are, for this reason among others, the greatest contributors to the total gamma radiation intensity in most areas.

Total gamma radiation was measured in all field surveys. It is recognized that cosmic radiation and other sources contribute to the total measured intensity, which is in turn influenced by a number of different variables, such as stratigraphic-pedological changes, variations in moisture, temperature, and pressure, topography, faulting, and others. False anomalies can usually be detected by close observation of the terrain, response of the instruments, and size, shape, and character of the anomaly. Experience and knowledge of the geology in the survey area is very helpful if not necessary in this regard. Diurnal variations in radiation intensity occur and can be detected by instrument drift. The diurnal changes occur rather slowly and can be largely discounted because of the short line segments usually surveyed and the resetting of the recorder to a standard base line position at the end of each segment.

All of our surveys were conducted on a contract basis. A vehicle-mounted 5½-foot-long, 5,000 cu in ionization chamber was used to measure total gamma radiation. The direct current generated by the chamber was preamplified and then continuously recorded with a Hewlett-Packard 7028-A gas chromatograph recorder synchronized with the odometer of the vehicle. The recorded traces were manually and/or computer reduced to ten averaged radiometric values per survey mile, transferred to a base map, and used for contouring the radiometric signature of the surveyed area. Sites inaccessible to four-wheel-drive vehicles were surveyed with a 1,000 cu in ionization chamber that is portable by two men.

CLASSIFICATION OF RADIOMETRIC ANOMALIES

CLASS	SURVEY GRID	SIZE AND SHAPE.	INTERNAL VALUES	EDGE CONTRAST	HALO	REMARKS
I	GOOD DETAIL	FAVORABLE	CONSISTENTLY LOW	MOSTLY 10 UNITS OR MORE	WELL DEFINED	FULLY ACCEPTABLE
II	SEMI DETAIL	FAVORABLE	CONSISTENTLY LOW WITH FEW EXCEPTIONS	MOSTLY 10 UNITS OR MORE	EVIDENT ALONG MOST SURVEY LINES	SHOULD MOVE UP TO CLASS I WITH ADDITIONAL CONTROL
III	SPARSE	APPARENTLY FAVORABLE	VARIABLE	NORMALLY SLIGHTLY BELOW 10 UNITS	VAGUELY DEFINED	FURNISHES LEADS FOR ADDITIONAL WORK
IV	NORMALLY INSUFFICIENT BUT MAY VARY	NORMALLY UNFAVORABLE BUT MAY VARY	OFTEN HIGHLY VARIABLE	NORMALLY VERY LOW BUT MAY VARY	POOR OR ABSENT	NOT USABLE. ONE OR MORE UNACCEPTABLE PARAMETERS PRESENT

Fig. 3.

Reconnaissance and semidetail surveys were usually conducted utilizing a grid density of one mile or larger depending on the estimated areal extent of the objective. Interesting anomalies were then detailed with a finer grid. Independent interpretations were made by the contractor and Sunmark personnel.

The size, shape, and definition of radiometric anomalies are often a function of survey grid density as well as of interference by geological, meteorological, and cultural parameters, some of which have been mentioned previously. All of these can and do have a bearing on the significance of a given anomaly, and thus on its usefulness in exploration. In order to rank the mapped anomalies according to their significance, a classification system has been developed based on a critical analysis of the radiometric values, interpretation, and tightness of the grid survey. The fourfold classification (Figure 3), while obviously subjective, appears to be quite effective.

The four classes are based on the quality of five parameters. Tightness of the survey grid is important and should be dependent on the size of the objective expected in a particular area. Size, shape, and orientation of an anomaly are often the factors which, in conjunction with other geologic information, determine the economic viability and the validity of the prospect or lead. The lower and more consistent the radioactive values are within the halo, the more attractive the anomaly. The larger and sharper the difference in radioactive values between the halo, normal background, and the area within the halo, the greater the significance or validity of the anomaly, although it cannot yet be claimed that radiometric exploration is a quantitative or depth delineation tool. Finally, the more continuous the halo, in terms of areal definition, the more significant the anomaly.

Sunmark currently has in excess of seventy radiometric surveys on file. Distribution is as indicated in Figure 4 in the contiguous Lower-48 states. In some cases, one dot represents more than one survey. Well over 50% of the surveys were conducted by or for Sunmark. Sites were chosen with various objectives in mind in order to determine and compare radiometric response to oil, gas, and gas-oil reservoirs, shallow, intermediate, and deep hydrocarbon accumulations, and such other factors as soil, moisture, terrain, coal beds, and lithology.

Surveys were tied into known production where possible in order to determine radioactive response to a local field as compared to normal background. An attempt was made to coordinate surveys with future drilling, wildcat or development, by Sunmark or others in the industry in order to "call the shots" as much as possible.

As in most unconventional methods, repeatability of data is much desired and needed for authenticity purposes. The data of portions of many of these survey sites have been repeated with good results. Data from sites revisited, even after a few years' hiatus, have shown a high degree of repeatability.

Figure 5a shows the track of one of the radiometric survey lines run in 1973 across the approximately one-mile-wide Albion-Scipio Field in southern Michigan, shown in yellow, and rerun in 1978. Both the 1973 and 1978 recorder traces show the field anomaly and the somewhat unimpressive halos in a similar manner (Figure 5b). In Figure 5c the 1978 trace is superimposed on the 1973 trace. The good congruence is obvious. Notice that the *only* radiometric anomaly along this line segment occurs over Albion-Scipio Field.

WEST FELDA FIELD, FLORIDA

In 1971, when it was technically very difficult or even impossible to carry out seismic exploration in southern Florida, Sun Oil Company became interested in the idea of conducting a radiometric reconnaissance survey covering the updip portion of the Sunniland producing trend. Such a survey appeared even more feasible because of the then ongoing "100-year" drought which had lowered water levels by some ten feet. By that time, only the southeastern portion of West Felda Field had been developed, and radiometrics, it was hoped, would provide clues concerning the ultimate size and shape of the field.

Prior to final approval of the survey, a field check of the "halo" or "chimney" concept was suggested based on the proposition that a "chimney" should be recognizable at any given subsurface level above the oil body. Since Sun's wells in the West Felda Field had been drilled and completed in an identical manner and logged with the very same logging tools, and since the Lower Cretaceous strata in this vicinity consist of chemically precipitated carbonates and evaporites on a tectonically quiescent shelf, exceptional uniformity from well to well could be anticipated and conditions for such a check appeared very favorable.

The gamma ray curves from eight wells along a line running roughly north-south across the east end of the West Felda Field were used for this purpose (Figure 6a). Seventeen individual gamma curve points between the top of the Lower Cretaceous at 6,000 ft and the Middle Sunniland pay at 11,500 ft were found to be correlatable in all eight wells. The intensities of these points were measured in API units and plotted on a section (Figure 6b). Their combined averages of all seventeen points are shown diagrammatically on the profile.

A definite radiometric deficiency, shown in yellow, is evident above the field, although well 28-3 registers somewhat higher for an unknown reason. A halo, shown in red, is also indicated. The pay thickness in these wells is shown in green at the bottom of the diagram. Although one may want to construe a quantitative relationship between pay thickness and radiometric values, no such conclusion can or should be drawn at this time.

Postsurvey drilling results (Figure 7) are indicated by the large dots in West Felda Field and its immediate vicinity. Green dots are producers. The pink dots are dry holes. The pink line indicates the position of the previously discussed radiometric profile.

In the color scheme, yellow shows radiometrically deficient areas, while red means higher than background values. Thus, fields and radiometric prospects should appear in yellow, halos and other unfavorable anomalies in red. Small dots indicate presurvey wells, while large dots mark those wells that were drilled after the completion of the radiometric survey. No classification or ranking of radiometric anomalies, with one exception, is shown in this and the following illustrations.

Figure 7 shows only a portion of the survey. Felda Field on the right, developed prior to the survey, is radiometrically well defined with a halo indicated along most of the periphery. The larger West Felda anomaly on the left shows an even better developed, more continuous halo. Postsurvey drilling at West Felda agrees well with the radiometric data.

The dry hole on the large anomaly in T46S, R27E is the Sun 14-4 Turner, which had oil and gas shows in cores and tested a very small amount of free oil. Northwest of Felda Field, Tribal drilled two wells on Sun farmout on a small radiometric anomaly. Both wells had good shows in cores and recovered free oil, up to 120 ft on drill stem test. The wells were plugged as noncommercial based on 1971 prices. This is a good case in point showing that radometrics can only indicate the presence or absence, but not the quantity of hydrocarbons in a reservoir. All dry holes should be checked for bona fide shows in a statistical evaluation for radiometric data.

The somewhat limited statistical base of forty-eight postsurvey wells indicates that 81% of the wells completed as producers fall on a radiometrically favorable anomaly, while two-thirds of the dry holes were predictable. The combined percentage shows that seven out of ten wells were predicted correctly. Ambiguous wells and wells over a mile from an actual radiometric survey line are excluded from the statistics.

LITTLE CREEK FIELD, MISSISSIPPI

Sun's earliest association with radiometric surveying occurred in 1959 in conjunction with a survey conducted for independents Willie Hughes and John Noble. The discovery well for McComb Field was drilled on a Sun farmout solely on the strength of this survey. Details are given in an article by George Miller published in the February 13, 1961, issue of the *Oil and Gas Journal*. At the time of the survey there were no wells in the county. Figures 8a and 8b are fashioned after an illustration in Miller's articles. Figure 8a shows the postsurvey drilling results in the Pike County portion of the Little Creek Field as of 1961, the year of publication. The congruence is obvious. The published illustration shows a radiometric prospect west of the field, presumably separated by a narrow unproductive area.

In Figure 8b the large dots show all the wells drilled *after* 1961 at Little Creek. Obviously, the radiometric prospect held up well. The statistical results, based on 345 postsurvey control wells, show the radiometric predictions to be 82% correct for the entire survey area, which includes McComb Field to the southwest.

SOUTHWEST HINTON AREA, OKLAHOMA

Beginning in 1977 Sunmark became progressively more involved with radiometric surveying. One of the earlier surveys was conducted in Caddo County, Oklahoma (Figure 9), while Sun was in the process of developing Lower Pennsylvanian Marchand stratigraphic sand production in Northwest Sickles Field. Some wells had been completed, others were making hole, and some were locations. The nature, trend, and relationships of the various sand bodies were not very clear.

Radiometrics indicated several northwesterly oriented, weakly connected prospective trends. Subsequent drilling results generally agree with this. The three nonproducers aligned west-east near the south end of the Northwest Sickles Field within the radiometric anomaly in T11N, R13W encountered 7, 1, and 4 ft of pay, respectively. Lengthy completion attempts were made in two of them before abandonment. Wildcat and development drilling is currently taking place a short distance south of, and on trend with, the untested interesting radiometric anomalies in the southwest corner of the map.

Because of the rather small number of control wells available, both presurvey and postsurvey wells are included in the statistics. The percentage of agreement with radiometric data is very high, approaching 85%.

SHANNON TREND, CAMPBELL COUNTY, WYOMING

Several radiometric projects were carried out by Sunmark in 1977 along the Cretaceous Shannon, Ferguson, and Muddy trends in Wyoming's Powder River Basin. The only trend with statistically sufficient postsurvey drilling is the stratigraphic Shannon sand trend (Figure 10) in Campbell County and its continuation into northern Converse County, where it mingles with the oil and gas production from Cretaceous Dakota sands in Powell Field.

Hartzog Draw Field, which had been discovered a short time prior to the survey, had seen some drilling essentially as far southeast as T45N. Drilling in the remainder of the map area was fairly sparse and scattered at the time. Since the survey, 141 wells have been added in the area.

Interestingly—but possibly a matter of coincidence—the pattern of the radiometric anomalies in T41-42N agrees with the deterioration of the Shannon sand condition in this vicinity.

Statistics, based on the 141 postsurvey wells, again show about 80% correct calls for the radiometric survey.

BEECHER ISLAND AREA, LAS ANIMAS ARCH

The Beecher Island area is one of nine areas in eastern Colorado and adjacent parts of Kansas and Nebraska that were radiometrically surveyed as part of an experimental unconventional exploration project carried out by Sun in 1978. Figure 11 shows the actual appearance of one of our radiometric maps after evaluation and ranking of the anomalies. Class I through IV anomalies are color coded as in Figure 3.

The Beecher Island Field anomaly is in the center. It is the largest Niobrara gas field in the area and demonstrates a classic radiometric anomaly. Most Niobrara production in the area is structurally controlled. The several undrilled east-west oriented anomalies north of Beecher Island should be interpreted as one single prospect, since the high radiometric values within this prospect are probably caused by major faulting.

The significant regional Goodland fault lineament runs diagonally SE-NW through the area. It follows essentially a zone of unfavorable radiometric values that separates the Beecher Island area anomalies from a belt of similar class I anomalies southeast of the lineament. The cluster of green dots near the center of the west edge of the map are postsurvey wells in Mildred Field. Mildred Field was not surveyed and thus does not appear as a defined anomaly.

The large anomalies in the southeast corner of the map were recommended as good prospects. Subsequently, Murfin drilled a Niobrara gas discovery, shown by the green dot, in December, 1978. Since then, additional oil and gas offset wells have been completed north of the discovery.

The radiometric survey was 68% correct based on 28 post-survey wells (large dots in Figure 11), and of 197 presurvey wells 71% are correctly called by the survey. The difference in accuracy between presurvey and postsurvey drilling is slight.

PACHUTA CREEK AREA, MISSISSIPPI

A semidetailed survey in the Pachuta Creek area, Clarke County, Mississippi (Figure 12), shown here by permission of Rush Oil Company, was made in 1966 prior to any production in Clarke County. The high incidence of discoveries to radiometric anomalies that were made in the eight years subsequent to the survey in the Pachuta Creek area is striking.

The radiometric anomalies of the Nancy trend agree quite well with fault blocks at the Smackover level. The nearly undrilled north half of the Pachuta Creek anomaly lies in a large east-west trending graben.

The results from 147 wells drilled postsurvey indicate that about 73% were called correctly by radiometrics.

COYOTE CREEK AND MEDICINE POLE HILLS FIELDS, NORTH DAKOTA

A 1971 radiometric survey in Bowman County, North Dakota (Figure 13), within the Williston Basin, was made for two independents, Youngblood and Wilhite. The three wells that are circled had been drilled. The survey was made to help determine whether the two discoveries would develop into a single field or would remain separated. Radiometrics apparently predicted correctly the separation between Coyote Creek Field in the north and Medicine Pole Hills Field in the south.

The thirty postsurvey wells show a statistical average of 66%, two out of three correct.

WEST MORK LAKE AREA, NORTH DAKOTA

A final example (Figure 14) is a survey in the West Mork Lake area, Ward County, North Dakota, made by an independent contractor for Youngblood and Wilhite in 1971. The Mississippian sand reservoir is linear and stratigraphic in nature. Good halo development is evident. The large dots designate the locations of the discovery wells for the two fields drilled prior to the survey. Radiometrics indicate a nonproductive zone or barrier between the two fields.

The statistical figures for this particular case include both presurvey and postsurvey wells. The correct call rate of 86% is exceptionally high.

STATISTICAL SUMMARY

Figure 15 tabulates the statistical results of the examples previously shown, with the exception of the Clarke County, Mississippi, area. In order to broaden the data base, however, the Las Animas Arch statistics include the postsurvey wells of *all* nine areas of Sunmark's 1978 experimental project.

The yellow bars indicate the percentage of producers drilled in radiometrically favorable areas, the red bars the dry holes drilled in radiometrically unfavorable areas, and the green bars the combination of the two. The appropriate percentage figures are given in the last column.

As is shown, the radiometric results are consistently over 50% correct and are often in the 70% or better range. The same holds true for almost all other areas that we have approached statistically. It does not seem to matter whether only postsurvey wells or all wells are included.

The three bars on the bottom line give the total tally which says that, on the average, the radiometric method may be correct three out of four times. This figure closely agrees with domestic drilling statistics, compiled by various sources, which indicate approximately 75%

to 80% of all wells drilled result in producers.

A large number of radiometric surveys completed and in Sunmark's file are of recent vintage. Postsurvey drilling statistics are not yet available. Our experience to date strongly implies that the proper utilization of this type survey in an integrated exploration program can be effective in the reconnaissance phase for developing leads and prospects, and can provide supplementary evidence in localizing and evaluating prospects. Its place in hydrocarbon exploration as a cost-effective front-end tool and a risk-reducer, as well as a potential substitute for conventional exploration methods under certain geological conditions, should be seriously considered by the explorationist.

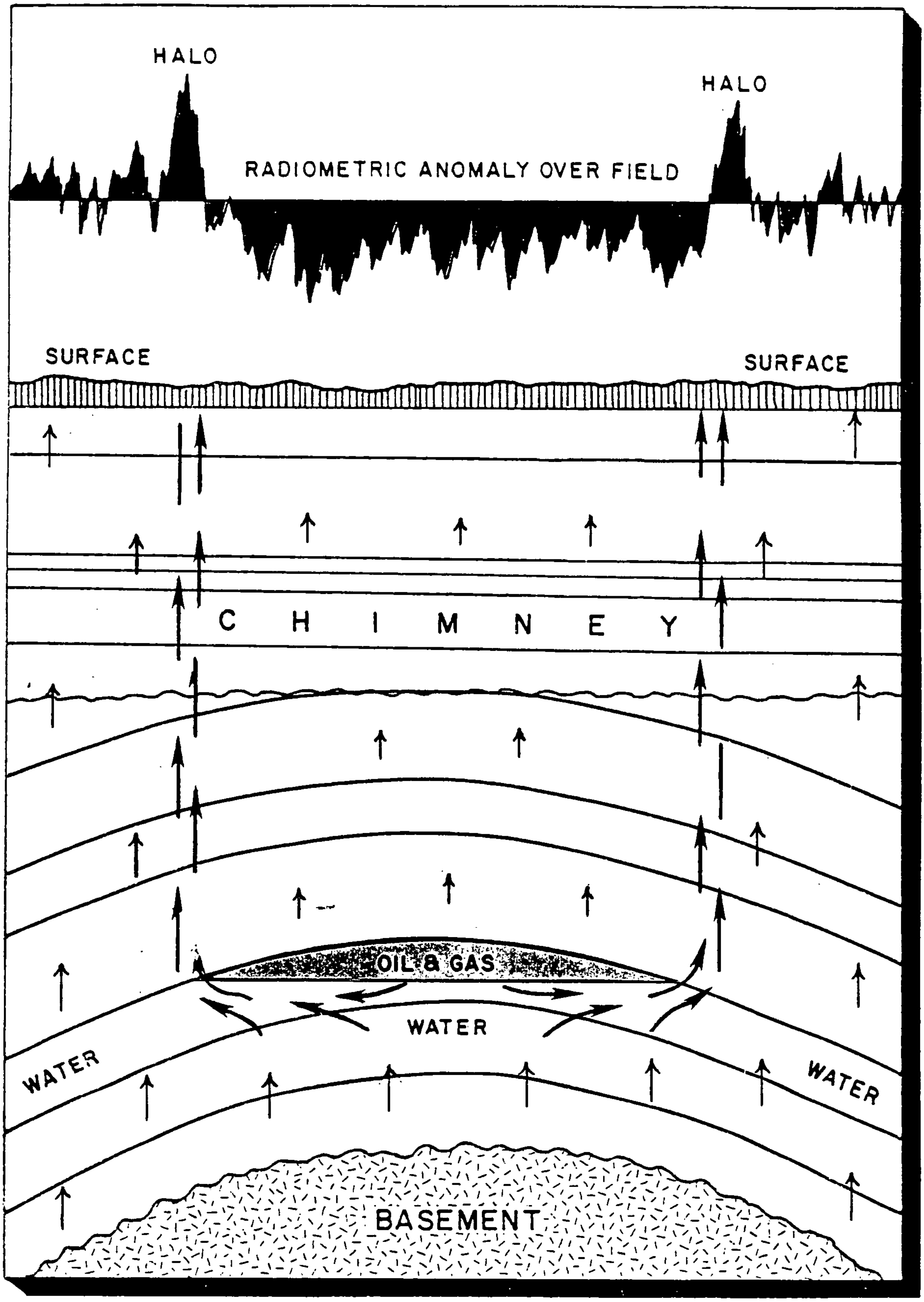

Fig. 1. Idealized radiation halo anomaly pattern. Size of arrows indicates relative volumes of water movement and radionuclide saturation.

SURVEY YEAR	AREA , STATE	CONTROL WELLS	PREDICTION	STATISTICAL RESULTS %
1958	LITTLE CREEK - MC COMB MISSISSIPPI	345	●	88.6
			⌖	61.0
			ALL	82.0
1971	SUNNILAND TREND FLORIDA	48	●	81.0
			⌖	66.7
			ALL	72.9
1971	RHAME AREA NORTH DAKOTA	30	●	69.6
			⌖	57.1
			ALL	66.7
1971	WEST MORK LAKE AREA NORTH DAKOTA	* 63	●	82.6
			⌖	87.5
			ALL	85.7
1977	SHANNON TREND WYOMING	141	●	88.0
			⌖	63.3
			ALL	79.4
1977	SOUTHWEST HINTON AREA OKLAHOMA	* 39	●	88.5
			⌖	76.9
			ALL	84.6
1978	LAS ANIMAS ARCH COLORADO, KANSAS, NEBRASKA	58	●	70.0
			⌖	71.4
			ALL	70.7
	AVERAGE	724	●	85.7
			⌖	68.1
			ALL	79.7

* INCLUDES PRE-SURVEY DATA

Fig. 15. Statistical drilling results for seven radiometrically surveyed areas.

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Fig. 12. Pachuta Creek area, Clarke County, Mississippi. Pay is from the Jurassic Smackover limestone (oil) an Norphlet at 13,500 to 17,500 ft. Postradiometric survey drilling results illustrate an extremely high discovery incidenc to radiometric lows for this particular area, and based on 147 control wells, a 73.5 percent correct prediction record

* SUN EXPLORATION & PRODUCTION

EFFECTS OF HYDROCARBON LEAKAGE ON EARTH SURFACE MATERIALS

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ABSTRACT

The detection of hydrocarbon seepage was one of the most successful of the early exploration techniques. Hydrocarbon seepage has been shown to cause a variety of late stage diagenetic effects. Early diagenetic effects, however, may also be caused by hydrocarbon maturation and migration. These early diagenetic effects may be recognizable by remote sensing and geophysical techniques.

The maturation path of kerogen, summarized by the van Krevelin diagram, indicates that oxygen-rich compounds, such as carbon dioxide and organic acids, are produced prior to peak hydrocarbon generation. These acids are responsible for the creation of secondary porosity in reservoir sands by the solution of carbonates and unstable silicates such as feldspar. The continued migration of these fluids results in the precipitation of these materials as cements farther along the migration pathway. The concentration of these early cements along the preferential hydrocarbon migration pathway can be linked to the reported relationship of high seismic velocities, concentration of iron/manganese/clay minerals and carbonates, hard drilling, and topographic relief to reservoired hydrocarbons.

INTRODUCTION

Near-surface diagenetic changes reported to be related to reservoired hydrocarbons are generally assumed to be caused by recent hydrocarbon leakage. These changes, however, may also occur early in the diagenetic history of the rocks, prior to the accumulation of significant quantities of petroleum. In fact, diagenetic changes potentially occur along the entire hydrocarbon migration path from the source rock to the reservoir and up to the surface. These changes differ along the migration pathway as the fluids interact with the changing chemical/biologic systems of the rocks, and they change with time as the composition of the products produced from maturing kerogen changes. The diagenetic changes associated with migration of early maturation products creates a prepared ground situation that is in many ways similar to the prepared ground concept in ore deposits, complete with the potential for subtle alteration patterns further along the migration path from accumulations. This paper will review a model of the interaction of early kerogen maturation and its effects on reservoir diagenesis, and suggest that many of these diagenetic processes may be recognizable over accumulations as early events rather than late. The consequences of this model will then be compared to the available information on diagenetic patterns related to petroleum accumulations.

SEEPAGE AND MINERALIZATION

Many of the early explorationists reported associations of productive areas to seeps, topographic highs, saline waters, and surface mineralization. Sawtelle (1936) reports that these features were instrumental in the discovery of 70% of the Gulf Coast salt dome fields. Although many of these observations appear to be largely unsupported by critical scrutiny, it should be remembered that many of these early explorationists were not only astute observers but also successful explorationists. There are many instances where an operational rule of thumb appears to be unfounded but upon careful and thorough study reveals new well-founded principles.

A causal relationship of near-surface hydrocarbon seepage to reservoired petroleum, while not universally accepted, is the best understood of the near-surface relationships and is a necessary building block for the others. The migration routes of macroseepage from petroleum accumulations and source rocks has been summarized by Link (1952). The extension of this relationship to microseepage is, however, less straightforward. The establishment of a spatial correlation is much more difficult because of the smaller signal-to-noise ratio, the high spatial variability caused by the presence of fractures and other permeable pathways, and sampling limitations The simplifying assumption that microseep anomalies occur vertically over the hydrocarbon accumulations limits the acceptance of microseep data. A sounder but more difficult approach is to extend the surface seepage information downward into the subsurface with geological and geophysical information, as Jones and Drozd (1983) recommend and Link (1952) did with macroseeps. The compositional correlation of microseepage with the type of underlying production (gas, condensate, oil) (Jones and Drozd, 1983) is, however, convincing evidence that a causal relationship does exist between microseepage and reservoired petroleum.

Accepting the seepage of reservoired hydrocarbons to the surface, as well as directly from source rocks, let us review the relationship of these migrating hydrocarbons with the mineral phases through which they pass. The correlation of mineralogic changes to hydrocarbon seepage has been recognized since the early days of exploration. Thompson (1933) points out that sulfur and pyrite are commonly associated with oil accumulations. He also points out that in the presence of hydrocarbon gases, gypsum and possibly anhydrite are replaced by limestone in salt dome cap rocks and in the Persian Gulf-Iraq oil belt. These limestones generally form resistant topographic highs in these areas. Indeed, one of the early rules of thumb was to look for the high ground when locating a well. McDermott (1940) reports the coincidence of secondary mineralization, such as caliche, with microseepage in the vicinity of some Texas oil fields. Rosaire (1940) expands the association of secondary mineralization with hydrocarbon seepage to include silicates.

Three factors inhibited the acceptance of a relationship between diagenesis and reservoired petroleum: the lack of a theoretical basis for the relationship between diagenetic and reservoired petroleum, nonhydrocarbon related diagenetic effects, and the newly developed seismic techniques. In Russia, however, research on surface evidence of hydrocarbon seepage continued. These results, coupled with the efforts of a few American workers, have led to a resurgence of interest in surface techniques, and in some cases to a scientific basis for a causal relationship to petroleum concentrations. Feely and Kulp (1957) demonstrated that the sulfur present in the cap rocks of Gulf Coast salt domes originated by bacterial action on the anhydrite, and that calcite replaced the anhydrite as a result of bacterial oxidation of petroleum. Kirkland and Evans (1976) used this theory to explain the topographically distinct limestone buttes in the Castile formation of the Delaware Basin. They suggested that the replacement limestones were initiated by seepage of hydrocarbons upward into the anhydrite along fractures and then extended outward parallel to bedding. The recent work of Donovan (1974), Ferguson (1975), and Donovan et al. (1979) demonstrates that the presence of hydrocarbons reduces the mineral phases present. Thus, magnetite and pyrite are produced from the reduction of ferric oxides and reddish units are bleached to a lighter color. These effects are often associated with calcite cementation produced by the oxidation of hydrocarbons.

KEROGEN MATURATION

The general changes in the composition of maturing kerogen are summarized in the van Krevelin (1961) diagram shown in Figure 1. These reaction paths require that the early maturation products be dominated by oxygen-rich compounds and that later compounds be hydrogen rich. The early products are generally characterized as mixtures of carbon dioxide, water, and methane. These are idealized end members. The actual products probably include organic acids such as acetic (Carothers and Kharaka, 1978) and oxalic (Surdam et al., 1984), which subsequently break down to these components. These end member compositions in combination with the reaction paths of the van Krevelin diagram predict a range of product yields. Reported estimates of carbon dioxide are 1%–15% (Bjorlykke, 1984), 22% (Franks and Forester, 1984), and 25% with 3% water (Laplante, 1974).

The produced organic acids and carbon dioxide (hereafter referred to as early products) are more soluble than the later produced hydrocarbons and should really migrate out of the source rock with the formation waters. The compounds are very reactive and, given sufficient flux, are capable of mobilizing and later precipitating a variety of mineral phases.

MODEL OF DIAGENESIS

Cementation in sedimentary rocks has been observed in thin sections for a considerable period of time. The recent recognition of the importance and widespread occurrence of secondary porosity in sandstone reservoirs has spurred research in this area. The importance of secondary reservoir porosity to hydrocarbon accumulation has caused conceptual models of these diagenetic processes to emphasize the creation of porosity. We will turn these observations and models around and address the question: What happens to the mineral matter that is removed from the reservoir rock?

A generalized sequence of diagenetic changes in sandstone reservoirs is diagrammatically represented in Figure 2 (summarized from Loucks et al., 1984; Schmidt and McDonald, 1979; Milliken et al., 1981; Land, 1984; Franks and Forester, 1984; and Moncure et al., 1984), using a generalization of Hunt's (1979) conception of the generation of gases from kerogen as a reference. The following explanation of the reactions and mass transport of materials represented by this sequence is based on the work of the above authors with the addition of Siebert et al. (1984), Graustein et al. (1977), and Hayes (1979). Many diagenetic events occur which are not shown in Figure 2. These will not be discussed because of their local nature.

The creation of secondary porosity requires fluid motion and a solution mechanism. The principal driving force for fluid transport is shale compaction. Clay dewatering and aquathermal expansion are generally unimportant, while hydrocarbon generation is locally important. The driving force for the diagenetic mineral reactions is the generation of early products from kerogen with a variety of undetermined mineral reactions in the shale, such as kaolinite altering to illite (Lee, 1984), being potentially important. The interaction of fluid motion and kerogen maturation causes a subsiding, compacting depositional sequence to evolve from an open system dominated regime to one dominated by closed system processes.

The open system is characterized by mass transport of kerogen maturation products and inorganic species to lower pressures (usually upward). Mass transport initiates in the region where kerogen forms early products and sufficient water flow exists to carry the products out of the shales. The solutions formed by this process continue along the migration path of the water, resulting in early cementation.

The closed system occurs under two circumstances: (1) in the region where kerogen can produce early products but is either not present in sufficient quantities and/or in a zone of reduced fluid flow as a result of bypassing; (2) below the region of production of early products from kerogen, where water drive is less and the only sources of acids are diminished production of such products from continued maturation of kerogen, unexpelled products, and those produced by mineral reactions in the shales.

The diagenetic sequence in the open system begins at a depth corresponding to the production of early products. These products react with the associated shales to dissolve as much of the carbonate as they can. Hower et al. (1976) indicates nannofossil carbonate is absent in many Gulf Coast wells below this depth. The organic acids also have the capability of complexing aluminum ions (Figure 3), thus enabling the solution of aluminosilicates (Surdam et al., 1984). Seibert et al. (1984) suggest that complexing is limited in the shale because the activity of aluminum is buffered to low values by the conversion of smectite to illite.

The waters, with their dissolved products, leave the shales and migrate toward lower pressured areas along the most permeable pathways available. As the waters enter sands, the clay mineral buffers are no longer present, and solution of the most soluble aluminosilicates (dominantly plagioclase) is enabled by the complexing of the organic acids. Carbonates may be either dissolved or precipitated in these sands, depending on the amount previously dissolved. Petroleum emplacement occurs shortly after the development of secondary porosity. Lee (1984) reports that the emplacement of gas arrested the precipitation of illite in the Rotliegendes sands of the North Sea. Continued migration of these fluids results in quartz precipitation and eventually in the precipitation of feldspar overgrowths, as well as other aluminosilicates in the lower temperature section, as the organic acids break down to carbon dioxide, water, and methane. This conversion to carbon dioxide and changes in pressure and temperature cause irregular precipitation and solution of carbonate along the migration path of the water. Complete pore blockage by carbonate cement in selected sands occurs over a zone of secondary porosity development in the Mobile-Texaco Citnalta 1-59 well on the Scotian Shelf (Figure 4, Schmidt and McDonald, 1979). These cements are early diagenetic events which predate early kerogen maturation in that section. As burial continues, the carbonate and feldspar previously precipitated may be redissolved as they pass downward into the region of active solution and are then recycled upward. If insufficient early products are available at that time, or if cementation is so complete that the flow path no longer goes through a particular sand, these cements will pass downward below the zone of production of organic acids and into the lower closed system regime.

This model suggests that most diagenetic calcite has been precipitated by the action of early products derived from the maturation of kerogen. If this is true, they should be isotopically depleted in carbon 13. While isotopic carbonate analysis data in Milliken et al. (1981) indicate that depleted compositions occur only in the zone of carbon dioxide production, relatively few measurements are reported above that zone. The few measurements above the zone of carbon dioxide production reported by Land (1984) show depletion. The recycling of carbonate by carbon dioxide from kerogen would be expected to deplete the carbonate successively each time it was recycled, resulting in very negative carbon 13 values. Insufficient data is available to test this hypothesis. The isotopic effects of the organic acids on the carbonate precipitated are presently unknown.

The zone of closed circulation located within and above the zone of early products generation is typified by closed system reactions. Small amounts of acids locally dissolve and precipitate carbonate species and some silicates. The general lack of organic acids will limit the feldspar and other aluminosilicate reactions. The carbonate reactions will proceed without significant interaction with organically derived carbon and thus will not be isotopically depleted.

The diagenetic sequence in the closed system below the zone of early product generation is characterized by in-place albitization of feldspars and precipitation of late calcite cements. These late calcite cements appear to be isotopically similar to marine carbonates, suggesting that they have not interacted with carbon dioxide from kerogen. This appears to argue against the hypothesis of transport of isotopically depleted carbonates down into this zone. The common explanation is that at the bottom of the zone of carbon dioxide production from kerogen, the carbon released is no longer depleted and thus the isotopic composition is reset and maintained in the closed system.

SPATIAL VARIABILITY OF DIAGENESIS RELATED TO MIGRATION

Seibert et al. (1984) indicate that secondary porosity in sands is essentially ubiquitious above the zone of early product generation from kerogen. He and Surdam et al. (1984) also point out that the zones of highest primary porosity generally have the greatest development of secondary porosity. This suggests a spatial mix of open and closed systems above the zone of kerogen early production generation. The detection of this spatial mix may be a clue to the subsurface pathway of hydrocarbon migration. The diagenetic model, developed to explain the creation of secondary porosity in sandstone reservoirs, suggests that there are two potential causes for spatial variability in the amount of both secondary porosity at the reservoir level and cementation farther along the migration pathway (open system versus upper closed system and degree of transport in the open system).

The upper closed system contains an average variability in porosity, compaction, and cementation. Depositional porosity is continually decreased by compaction. In situ recrystallization further decreases porosity in the sands aided by local mass transport from the shales to the sands.

In the open system (region of significant diagenetic mass transport) the reservoirs have well-developed secondary porosity. The materials removed from them are distributed farther along the migration path as local areas of increased cementation. Compared with the upper closed system, this section should have greater porosity variation with more porosity at the lower reservoir levels and less in the upper levels. An end member of the open system is the preferential migration pathway, a network of interconnecting high permeability channels between a high pressured region and a low pressured region (the path of least resistance and maximum flux). This pathway is composed of a network of high depositional and fracture permeability aided by the structuring of the depositional units which focuses flow (Roberts, 1980). Along this pathway the periodic upward recycling of carbonate and feldspar should be maximized. This section should exhibit the best secondary porosity development at the reservoir level. The shallower region of porosity reduction should be extensive and complete due to the extensive upward recycling.

The region of porosity reduction in the open system should differ from that in the upper closed system by:

1. Increased carbonate cementation.
2. Depletion of carbon 13 due to repeated interaction of the calcite with kerogen-derived carbon.
3. Increased occurrence of iron and manganese due to the complexing action of the organic acids.
4. Increased occurrence of diagenetic clay minerals (the composition of these clay minerals being homogenous in an area but variable between areas, composition being determined by the activity of the cations present).
5. Increased bulk density, caused by the precipitation of transported dissolved and complexed material.
6. Increased grain-to-grain contact area due to cementation.
7. High cohesion due to cementation.
8. High seismic velocity due to the increased bulk density and grain-to-grain contact areas.
9. Topographic relief due to increased mechanical and chemical stability.

The recognition of the areas of high cementation upward along the water migration path is based on the events in sandstones and hindered by our lack of knowledge of diagenesis in shales. It is possible that the majority of the cementation may occur in or just below the shales. If the cementation is distributed over a thick vertical sequence, it will be more subtle but perhaps more likely to be detected than if it is concentrated in one or more thin zones. In either case, different techniques of detection would be appropriate.

The recognition of these regions of high cementation is also complicated by the overlap in the degree of porosity reduction/cementation in the open system with that in the closed system. Although both systems may have regions of intense porosity reduction, the open system diagenetic pattern is expected to be more complete and spatially systematic than that of the closed system. Further complications occur during uplift. At this time, late diagenetic processes may overprint these early patterns, in some cases reinforcing them and in other cases obliterating the older patterns and developing new ones.

COMPARISON OF THE MODEL WITH PUBLISHED DATA

The existence of large regions displaying lateral variability in secondary porosity caused by the migration of early maturation products is reported by Loucks et al. (1984) and Franks and Forester (1984) in the central Texas Gulf Coast Wilcox and Frio sections. The sands in this approximately 150-mi-wide strip have higher permeabilities (Figure 5) and secondary porosity than those to the northeast and southwest. This area also contains higher concentrations of carbon dioxide in the reservoir gases and is undersaturated with respect to calcite (Figure 6). More than 50% of the secondary porosity is due to dissolution of calcite and feldspar. This dissolved material must have gone somewhere and should be further along the migration path.

Carbonate diagenesis has been related to reservoired hydrocarbons and their leakage by many workers (Thompson, 1933; McDermott, 1940; Rosaire, 1940; Donovan, 1974; and others). The early workers noted the relationship while the later workers suggested it was related to surface bacterial action (Feely and Kulp, 1957). The recent work in reservoir sands suggests that although surface processes may be involved, they may represent a remobilization of an earlier relationship, or in some cases the earlier relationship itself. Isotopically depleted carbon in carbonates is dominantly reported in caliche, but Land (1984) reports its subsurface occurrence in Frio sands. Increased iron and manganese have been reported by many workers (Donovan, 1974; Ferguson, 1975; Donovan and Dalziel, 1977). These concentrations may be due either to late near-surface effects or to earlier migration events that have only recently been exposed. Few studies have attempted to relate clay mineral occurrence at shallow depths to deeper reservoired hydrocarbons, as suggested by Rosaire (1940). Collins (1980) interpreted an anomalously high clay and iron spectroscopic signature over the Wyoming Patrick Draw and Table Rock fields, using an airborn spectroradiometer. Paylor (1983) studied the surface formations at Table Rock and found an increase in clay content over the field (Figure 7) as well as increased iron mineralization (hematite and pyrite). The increased clay concentration was accompanied by an alteration of illite to smectite (Figure 8). This zone is not currently seeping significant quantities of light hydrocarbons like that at nearby Patrick Draw. There are, however, light hydrocarbons in the surface material which are released by mechanical and thermal disaggregation (Matthews et al., 1984). This suggests that alteration at Table Rock may have been a deeper, earlier diagenetic event, and alteration at Patrick Draw may be recent.

High cohesion over subsurface productive structure indicated by a decrease in the rate of drilling (Figure 9) was recognized by many early drillers (Rosaire, 1938). This was often related to silicification in the units above production. This phenomenon is usually not recognized today because of modern drilling techniques. This high cohesion and chemical stability is also responsible for the topographic highs related to fields in some areas.

Locating prospects from seismic reflection profiles commonly utilizes the simplifying assumption that lateral changes in velocity either do not exist or are unimportant. The fact that this assumption is not always correct can be affirmed by many explorationists who have drilled time highs only to find themselves dry and lower on the structure than they predicted. Rosaire (1938) reports several instances where high interval velocities exist over structural accumulations but not off them. High seismic velocity in the Mesozoic-Tertiary sediments of the Spitsbergen basin have been related to porosity reduction due to cementation (Elverhoi and Gronlie, 1981).

CONCLUSIONS

Published conceptual models of reservoir diagenesis state that the early generation products of kerogen breakdown (carbon dioxide and organic acids) are responsible for the creation of secondary porosity in sandstones. These same models suggest that the leached material is precipitated as early cements in overlying sands. It is suggested that this zone of early cementation is concentrated along the preferential migration pathway from the reservoir to the surface (Figure 10). This theoretical zone of cementation explains the high velocity zones, concentration of iron/manganese/clay minerals and carbonates, hard drilling, and topographic relief (Figure 11) that have been reported to occur over fields. This zone of cementation should also complicate the distribution of surface hydrocarbon seepage. The detection of these early diagenetic zones offers the potential to recognize a part of the preferential migration pathway, formed by early kerogen maturation products, that was later utilized by the migrating hydrocarbons.

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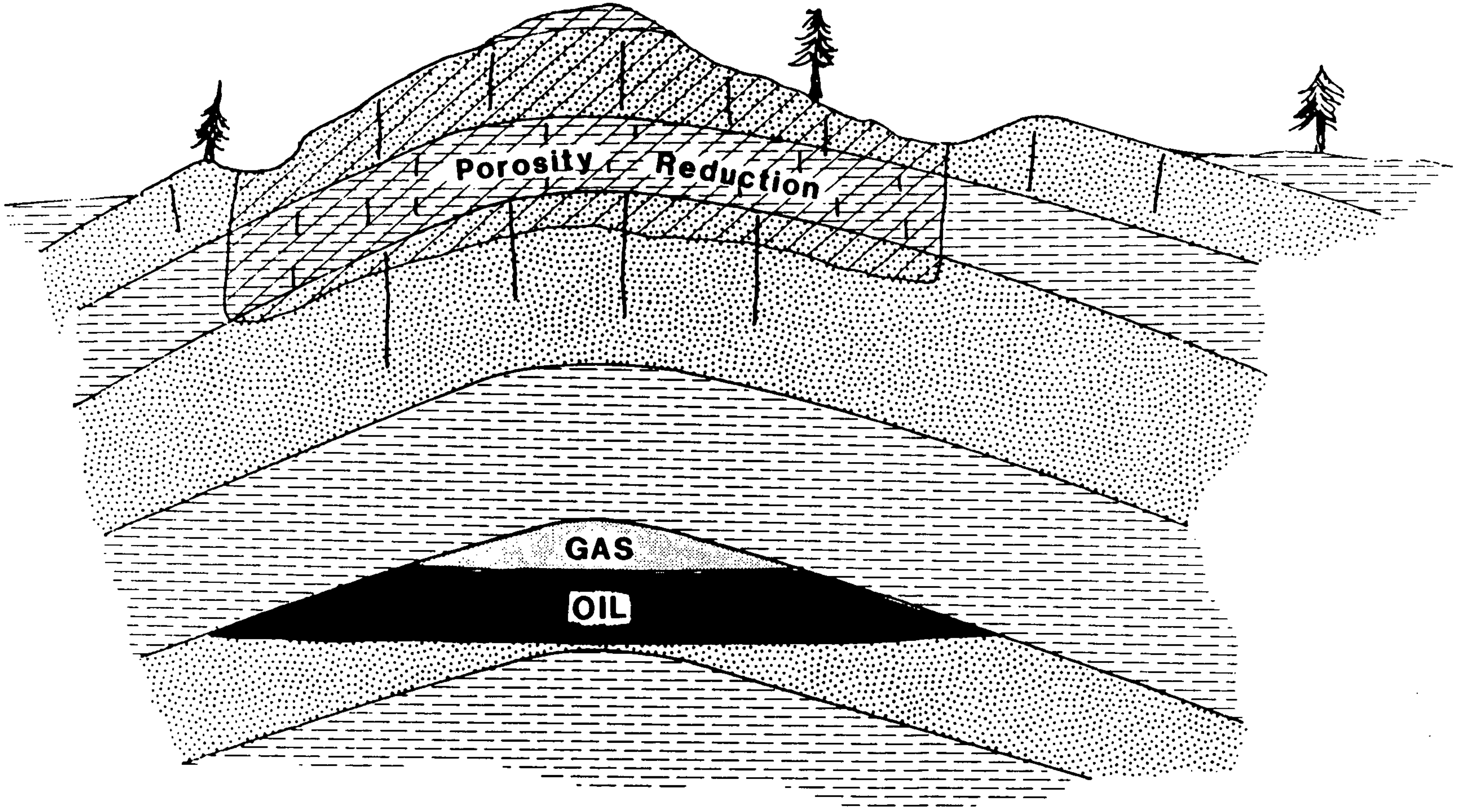


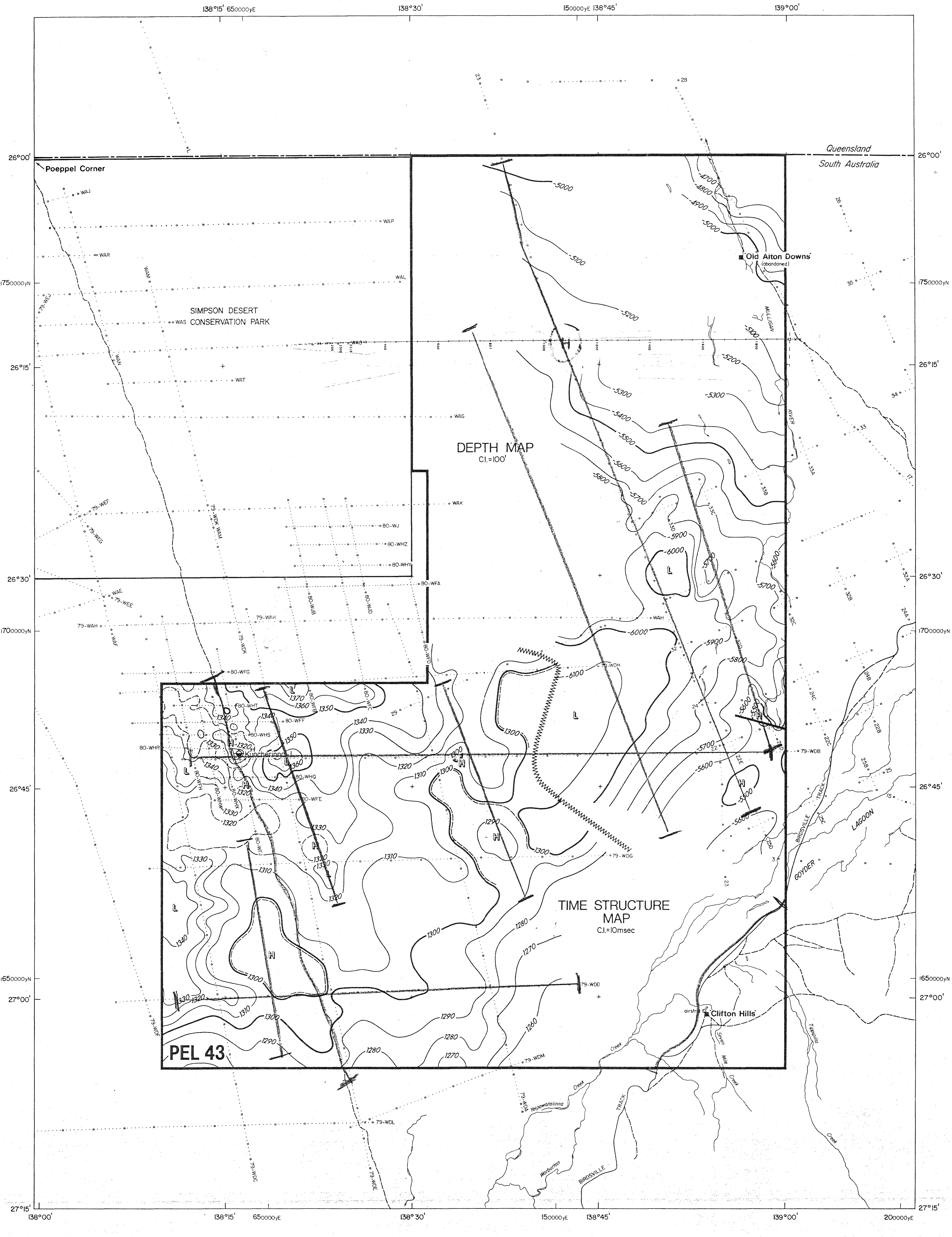
Fig. 11. Exposure of an earlier cementation event (as formed in Figure 10), due to erosion.

SOIL GAS ALKANE SURVEY

NOBJADE PTY LTD

PEL 43

PLATE 1 MAP SHOWING 317 SOIL GAS SAMPLE LOCATIONS



Well with oil show

Closure

Main road

Fault

Track

River or creek

Water hole

RADIOMETRIC AND SOIL GAS PROGRAM

1992 Field Season

500 Line Km

NOBJADE PTY LTD

PEL 43
Simpson Desert Joint Venture

'C' HORIZON TIME STRUCTURE AND DEPTH MAPS

0 1:250000 25km

1992 RADIOMETRIC PROGRAMME PROPOSAL

8080-4

PLATE 2

8080 R7

000088

MEMORANDUM

PETROLEUM EXPLORATION LICENCE NO 43

A Variation of Licence Conditions to take effect from 29/6/1992 is hereby entered upon the Petroleum Register.

ADELAIDE

JOHN KLUNDER
MINISTER OF MINES AND ENERGY

SR 27/2/91

F04394.RAF

PETROLEUM ACT, 1940

I, JOHN HEINZ CORNELIS KLUNDER, Minister of Mines and Energy in the State of South Australia pursuant to the provisions of the Petroleum Act, 1940, HEREBY VARY THE CONDITIONS of Petroleum Exploration Licence No 43 of which the licensee is:

- Nobjade Pty Limited, C/- AR Conolly and Co, 1st Floor, 44 Margaret Street, Sydney, NSW, 2000.

VARIED CONDITIONS

The Licensee shall comply with all the conditions specified in Petroleum Exploration Licence No 43 dated 22/3/91, except that in accordance with Section 17(3) of the Petroleum Act, 1940, Condition 2(a)(b) is hereby cancelled and replaced by:

a) in the first year of the term of the licence 317 kilometres of soil geochemical surveying at a total estimated cost of $122,000 (one hundred and twenty two thousand dollars)

b) in the second year of the term of the licence 500 kilometres of ground radiometric and geochemical soil surveying and 40 kilometres of seismic surveying at a total estimated cost of $300,000 (three hundred thousand dollars).

SIGNED, SEALED AND DELIVERED
BY THE SAID MINISTER OF
MINES AND ENERGY AT ADELAIDE
THIS 29th DAY OF June 1992

ADELAIDE

JOHN KLUNDER
MINISTER OF MINES AND ENERGY

8080 R8

000090

file PEL 43

27/2/0941

NOBJADE PTY LIMITED

ACN 003 411 149

ROOM 101
1ST FOOR
44 MARGARET STREET
SYDNEY NSW 2000

TELEPHONE: 371 6667

FACSIMILE: 371 7193

→ Elinor can you use this = your prospect portfolio

Sep 8, 1992

~~6 June 1991~~

The Director General,
Department of Mines and Energy,
Post Office Box 151,
EASTWOOD. SOUTH AUSTRALIA 5063

RECEIVED
10 SEP 1992
DEPT. OF MINES AND ENERGY
OIL GAS & COAL DIVISION

Attention: Dr. R. Laws.

~~Dear Dr. Laws,~~

Dear BOB

Re: Petroleum Exploration Licence No. 43

Please excuse this rather hurried note but I am leaving for USA tomorrow & I would like you to include some leads in PEL 43 in your brochure.

It is obvious that the Kuncherinna prospect needs redrilling - we await our SOIL-GAS survey this year to tell us where to RUN seismic

Also, there is an excellent "horst-like" lead at "Mulligans" on line 85-WPN with a potential flat spot in the ? Triassic.

I hope you can get someone to do something with this material

Sincerely

John Conolly

KUNCHERINNA # I

SUMMARY

Mature potential source rocks occur in the Poolowanna Beds, the Peera Peera Formation and the upper part of the unnamed Triassic redbeds. In addition, marginally mature potential source rocks with fair to moderate TOC may be present in the lower half of the Wallumbilla Formation.

The Algebuckina Sandstone, the basal parts of the unnamed Triassic redbeds, and the older, pre-Triassic rocks have negligible source potential.

The source-rock study conducted by AMDEL does not include kerogen typing, therefore no firm comments on the oil vs gas productivity of the sequence can be made. Thus, a rock may have a very high TOC, and be mature for oil generation, but generate only gas due to the type of organic matter present in the rock. Plots of HC/EOM and HC/TOC give anomalous results which can be explained if the Poolowanna Beds and Peera-Peera Formation are gas-prone source rocks.

The results presented above are consistent with those from Walkandi I and Erabena 1. The pattern of source rock types and maturities thus appears to have a degree of consistency over the Simpson Desert area. However, minor changes are:

(a) the Poolowanna Beds are not quite as rich in TOC at Kuncherinna 1 as at Walkandi 1

(b) the Peera Peera Formation and upper part of the unnamed "redbeds" are richer source rocks at Kuncherinna 1 than elsewhere.

While this report confirms the presence of mature source rocks in the Poolowanna Beds and Peera-Peera Formation, the following additional studies should be conducted:

(a) close-spread sampling of the Poolowanna Beds and Peera-Peera Formation, to gain a better understanding of the type and distribution of the source rocks.

(b) Kerogen studies on the Poolowanna Beds and Peera-Peera Formation, in order to determine whether the source rocks are Type I, II or III kerogen, and thus whether the sediments are oil or gas prone.

1. INTRODUCTION

Twenty seven canned cuttings samples were submitted to AMDEL for full source rock analysis following the drilling of Kuncherinna No. 1. The results of the analyses, plus the chromatograms, are contained in Appendix I. This report summarises the data and comments on the significance of the results.

Kuncherinna No. 1 was an exploratory well designed to test the crest of the Kuncherinna Structure (Moore, 1981a). The well is located approximately 255 km northwest of Moomba, in the Simpson Desert. The nearest wells are Poolowanna No. 1 (65 km to the WNW), Walklandi No. 1 (80 km to the West), Thomas No. 1 (115 km to the NW), Poonarunna No. 1 (145 km to the SSW), Pandieburra No. 1 (160 km to the east) and Kalladeina No. 1 (160 km to the SE).

2. RESULTS OF DRILLING

The prime hydrocarbon targets in the well were the sands of the Upper and Lower Poolowanna Beds, and the Peera Peera Formation. The uppermost Algebuckina Sandstone represented a strong secondary target, whereas the Toolebuc Formation and upper Cadna-owie Formation were considered as weak secondary targets (Moore, 1981a).

Only a trace amount of gas and no fluorescence was noted in the section above the Poolowanna Beds. The Upper Poolowanna Beds yielded traces of dull yellow fluorescence and very minor gas associated with coally stringers. However, fluorescence increased down the section and 10-15% bright yellow fluorescence was recorded from parts of the Lower Poolowanna Beds. DST 1 over the interval 8089'-8135' (Dr) yielded 90' of rat hole mud with a trace of oil. Log interpretation indicates that the Poolowanna Beds are of low porosity and are water saturated.

The Peera Peera Formation contained tight sandstones with up to 20% yellow fluorescence, yielding a weak, milky yellow crush cut. Fluorescence decreased downwards into the underlying Triassic red-beds.

Only one core was cut, this being an 11' pre-Triassic basement core.

The well was plugged and abandoned.

STRATIGRAPHY

The following sequence was encountered in Kuncherinna No. 1 (Richards, in press):

Table 1: Stratigraphy of Kuncherinna No. 1

Age	Formation	Depth	Elevation	Thickness
Recent to Early Cretaceous	Surficial/Eyre Fm/ Winton Fm/Mackunda Fm/ Allaru Mudstone	18'	51'	4170'
Early Cretaceous	Toolebuc	4188'	-4119'	136'
Early Cretaceous	Wallumbilla	4324'	-4255'	786'
Early Cretaceous	Cadna-owie	5110'	-5041'	123'
Mid Jurassic- Early Cretaceous	Algebuckina Sandstone	5233'	-5164'	2534'
Middle Jurassic	Upper Poolowanna Beds	7767'	-7698'	273'
Early Jurassic	Lower Poolowanna Beds	8040'	-7971'	362'
Late Triassic	Peera Peera	8402'	-8333'	542'
Early Triassic	Unnamed red-beds	8944'	-8875'	362'
Devonian	Pre-Triassic	9306'	-9237'	+ 99'
T.D.		9405'	-9336'	

The Winton Formation is non-marine and coal-bearing. The underlying MacKunda Formation is sandy and silty, and is probably paralic. The Allaru Mudstone and Wallumbilla Formation are grey, fossiliferous marine shales, generally assumed to be good source rocks when mature. The Toolebuc Formation is the lateral equivalent of the Julia Creek oil shale in Queensland, and is a dark grey, organic-rich mudstone.

Shales also occur in the lower part of the Cadna-owie Formation, but are essentially absent from the thick, braided fluvial Algebuckina Sandstone.

The Poolowanna Beds comprise interbedded shale, siltstone and sandstone, with very minor coal. The Upper Poolowanna Beds are less shaly and coaly than the Lower Poolowanna Beds in Kuncherinna No. 1.

The Peera Peera Formation is a fine-grained silty unit, of probable lacustrine and flood-plain origin. The upper portion however is very shaly, highly carbonaceous and has the visual appearance of an excellent source rock.

The unnamed Triassic redbeds are red and green siltstones, sandstones and shale and are assumed to be of poor potential as source rocks.

Samples for source-rock analyses were generally composited over 300' intervals from surface casing shoe to T.D. However, samples were not to cross formation boundaries as picked in the field (Moore 1981a). Prior to sealing each can, the cuttings were covered with fresh water and a biocide added.

The following sample spacing was obtained:

Table 2: Source rock sample listing, Kuncherinna No. 1

Sample No.	Sample Interval (ft. K.B.)	Relevant Formation Top	Relationship between Samples & Stratigraphy
1	2520 - 2820	? Mackunda Fm at 2693'	Winton (58%),Mackunda (42%)
2	2820 - 3120	Allaru Mudstone approx. 3000'	Mackunda (40%),Allaru (60%)
3	3120 - 3420		Allaru Mudstone (100%)
4	3420 - 3720		Allaru Mudstone (100%)
5	3720 - 4020		Allaru Mudstone (100%)
6	4020 - 4320	Toolebuc Fm at 4188'	Allaru (56%),Toolebuc (44%)
7	4320 - 4620	Wallumbilla Fm at 4324'	Wallumbilla (100%)
8	4620 - 4920		Wallumbilla (100%)
9	4920 - 5110	Cadna-owie Fm at 5110'	Wallumbilla (100%)
10	5110 - 5240	Algebuckina Sst at 5233'	Cadna-owie Fm (98%), Algebuckina (2%)
11	5240 - 5540		Algebuckina Sst (100%)
12	5540 - 5840		Algebuckina Sst (100%)
13	5840 - 6120		Algebuckina Sst (100%)
14	6120 - 6420		Algebuckina Sst (100%)
15	6420 - 6720		Algebuckina Sst (100%)
16	6720 - 7020		Algebuckina Sst (100%)
17	7020 - 7320		Algebuckina Sst (100%)
18	7320 - 7620		Algebuckina Sst (100%)
19	7620 - 7770	Upper Poolowanna Beds at 7767'	Algebuckina (98%), U.Pool(2
20	7770 - 8060	Lower Poolowanna Beds at 8040'	Upper Pool.(93%), Lower Pool. (7%)
21	8060 - 8340		Lower Poolowanna (100%)
22	8340 - 8410	Peera Peera Fm at 8402'	Lower Pool. (89%), Peera Peera (11%)
23	8410 - 8710		Peera Peera (100%)
24	8710 - 8930		Peera Peera (100%)
25	8930 - 9170	Unnamed redbeds at 8944'	Peera Peera (6%), Unnamed redbeds (94%)
26	9170 - 9320	Pre Triassic at 9306'	Unnamed redbeds (91%), Pre-Triassic (9%)
27	9320 - 9393		Pre-Triassic (100%)

Table 3: Total Organic Carbon, Kuncherinna No. 1

Sample No.	Depth (ft. K.B.)	Formation(s) Represented	T.O.C. (wt.%)	Source Potential at Maturity
1	2520 - 2820	Winton (58%), Mackunda (42%)	2.10	Very good
2	2820 - 3120	Mackunda (40%), Allaru (60%)	1.75	Good
3	3120 - 3420	Allaru (100%)	1.10	Poor
4	3420 - 3720	Allaru (100%)	1.10	Poor
5	3720 - 4020	Allaru (100%)	1.15	Poor
6	4020 - 4320	Allaru (56%), Toolebuc (44%)	2.10	Very good
7	4320 - 4620	Wallumbilla (100%)	1.60	Moderate
8	4620 - 4920	Wallumbilla (100%)	1.10	Poor
9	4920 - 5110	Wallumbilla (100%)	1.25	Poor
10	5110 - 5240	Cadna-owie (98%), Alge (2%)	1.05	Poor
11	5240 - 5540	Algebuckina (100%)	0.15	Negligible
12	5540 - 5840	Algebuckina (100%)	0.25	Negligible
13	5840 - 6120	Algebuckina (100%)	0.05	Negligible
14	6120 - 6420	Algebuckina (100%)	0.65	Very poor
15	6420 - 6720	Algebuckina (100%)	0.20	Negligible
16	6720 - 7020	Algebuckina (100%)	0.05	Negligible
17	7020 - 7320	Algebuckina (100%)	0.15	Negligible
18	7320 - 7620	Algebuckina (100%)	0.10	Negligible
19	7620 - 7770	Algebuckina (98%), U.Pool.(2%)	6.75	Excellent
20	7770 - 8060	U.Pool. (93%), L. Pool. (7%)	1.15	Poor
21	8060 - 8340	Lower Poolowanna (100%)	1.25	Poor
22	8340 - 8410	L.Pool.(89%), Peera Peera (11%)	0.70	Very poor
23	8410 - 8710	Peera Peera (100%)	3.40	Very good
24	8710 - 8930	Peera Peera (100%)	2.45	Very good
25	8930 - 9170	P.Peera (6%), Redbeds (94%)	2.15	Very good
26	9170 - 9320	Redbeds (91%), Pre-Triassic (9%)	0.30	Negligible
27	9320 - 9393	Pre-Triassic (100%)	0.20	Negligible.

6.1.2 **Results**

Results are contained in Table 3 and Figure 2. The middle to upper portions of the Winton Formation were shown to be coally and rich in TOC in Walkandi No. 1 (Moore, 1982a, Fig. 2). This upper section was not sampled in Kuncherinna No. 1. The rest of the Cretaceous sequence has poor to moderate source potential.

As expected the high-energy, braided fluvial Algebuckinna Sandstone has negligible source-rock potential. A sample at the base of the sandstone sequence yielded excellent potential (6.75% TOC), however this sample contained some shale from the uppermost Poolowanna Beds.

In contrast to Walkandi 1 and Erabena 1, the Upper and Lower Poolowanna Beds contain only moderate amounts of TOC, and have poor potential.

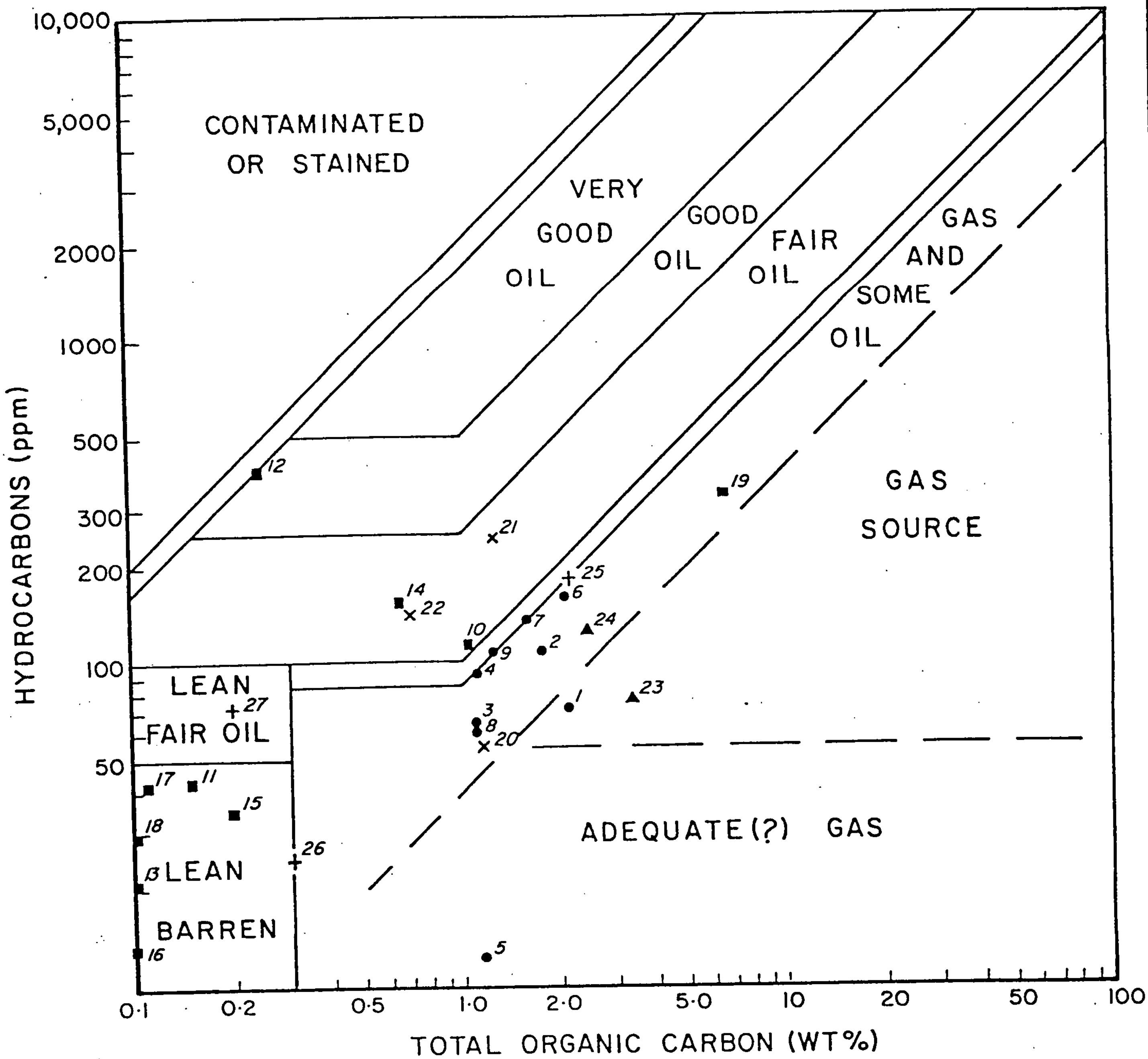
The Peera Peera Formation has very good potential, particularly in the upper part. TOC content decreases downwards, with the Triassic redbeds and the underlying basement rocks generally displaying negligible potential.

000096

DELHI PETROLEUM PTY. LTD.

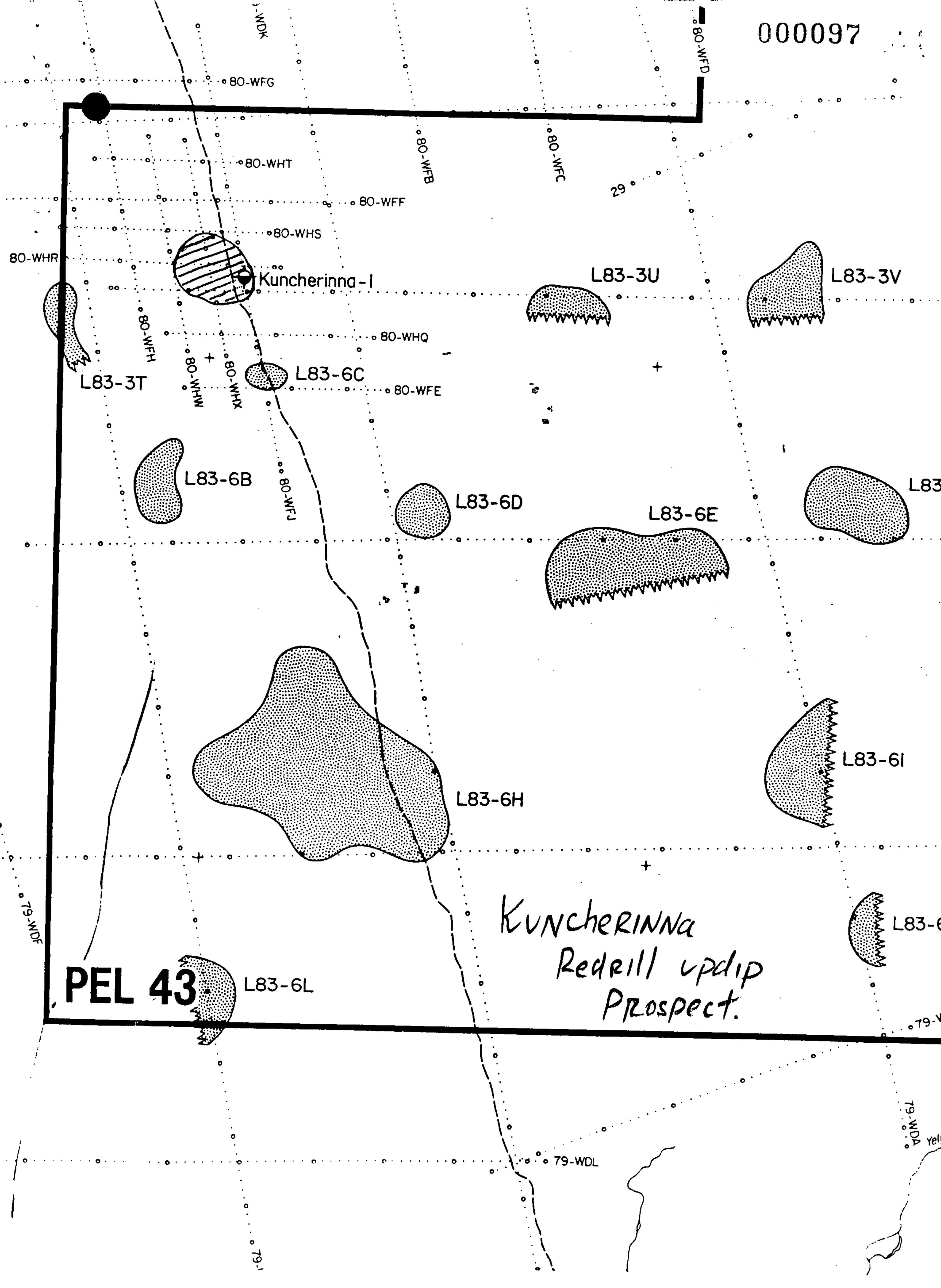
KUNCHERINNA-1

SOURCE ROCK RICHNESS



EXPLANATION OF SYMBOLS	
●5 SAMPLE NUMBER	× POOLOWANNA BEDS
● SURFACE TO 'C' HORIZON SAMPLES	▲ PEERA PEERA FORMATION
■ CADNA-OWIE FM. AND ALGEBUCKINA SST.	+ UNNAMED REDBEDS AND BASEMENT

000097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80-WHT
80-WFB
80-WFC
29
80-WFF
80-WHS
80-WHR
Kuncherinna-1
L83-3U
L83-3V
80-WFH
80-WHQ
80-WHW
80-WHX
L83-3T
L83-6C
80-WFE
L83-6B
80-WFJ
L83-6D
L83-6E
L83-6I
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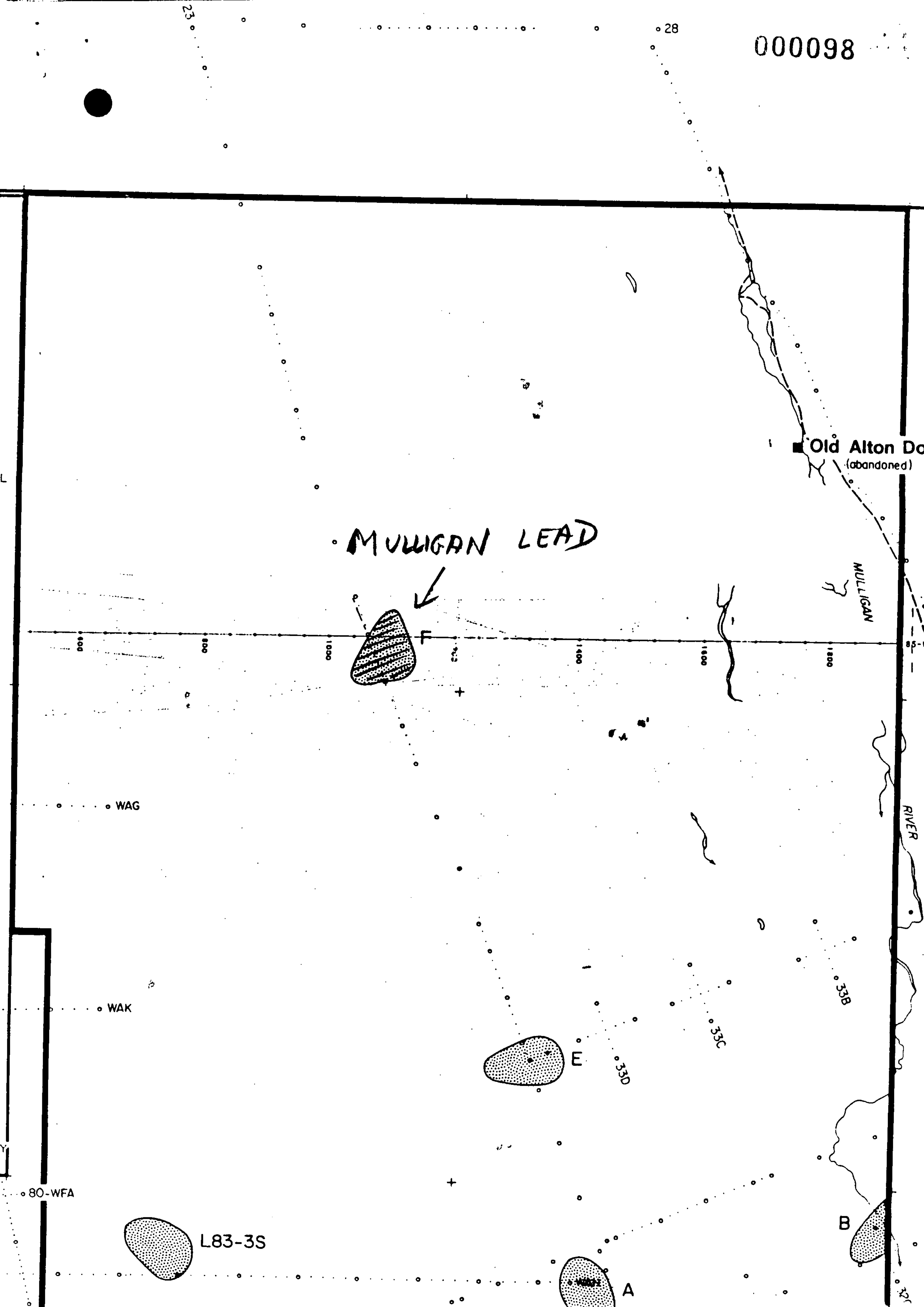
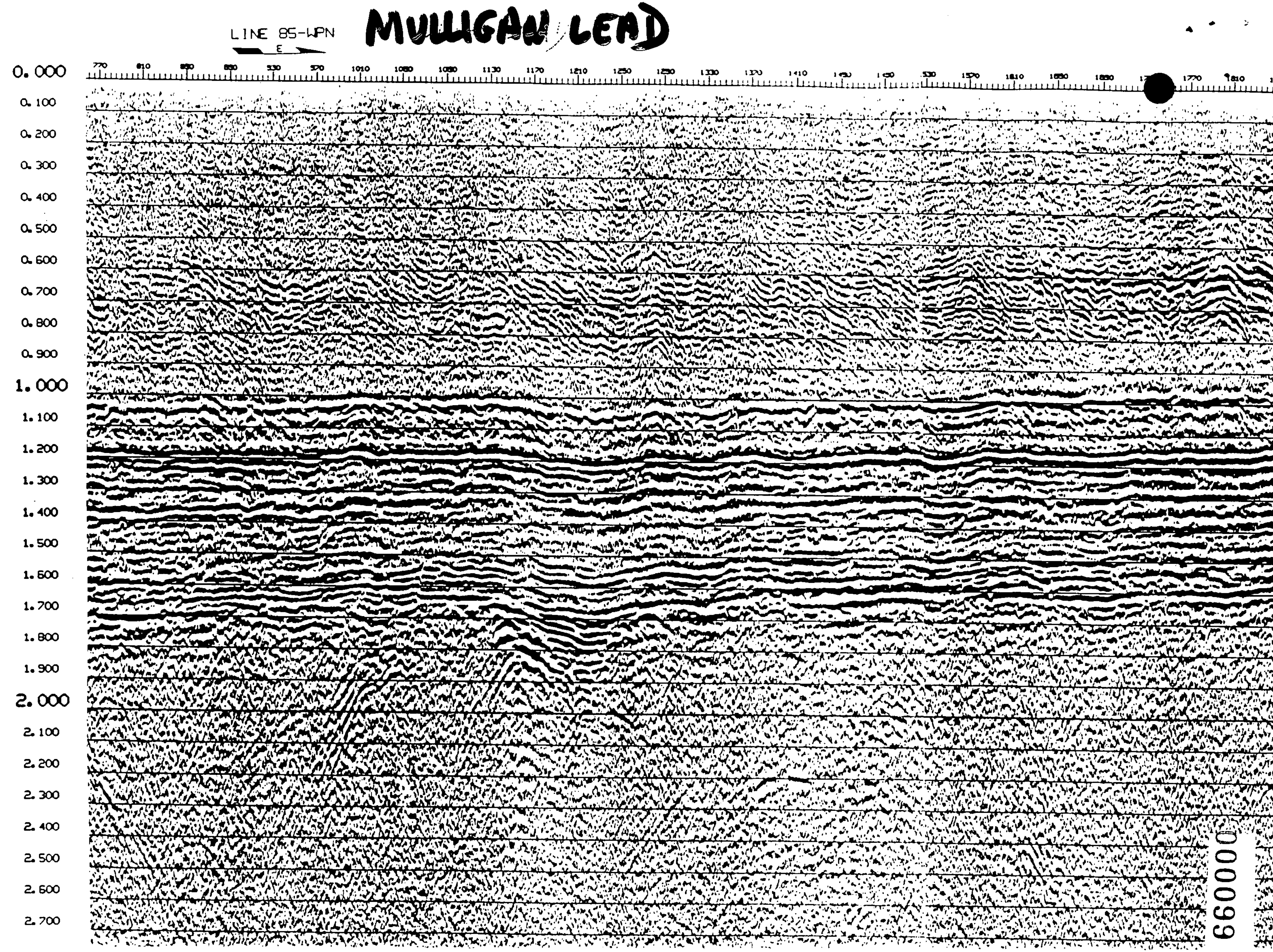
Kuncherinna
Redrill updip
Prospect.
PEL 43
L83-6L
79-WDL
79-WDA


23
28
Old Alton Do
(abandoned)
MULLIGAN LEAD
F
MULLIGAN
RIVER
WAG
WAK
80-WFA
L83-3S
E
33D
33C
33B
A
B
1000
1400
1600
1800



MULLIGAN LEAD
LINE 85-WPN
E
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0.300
0.400
0.500
0.600
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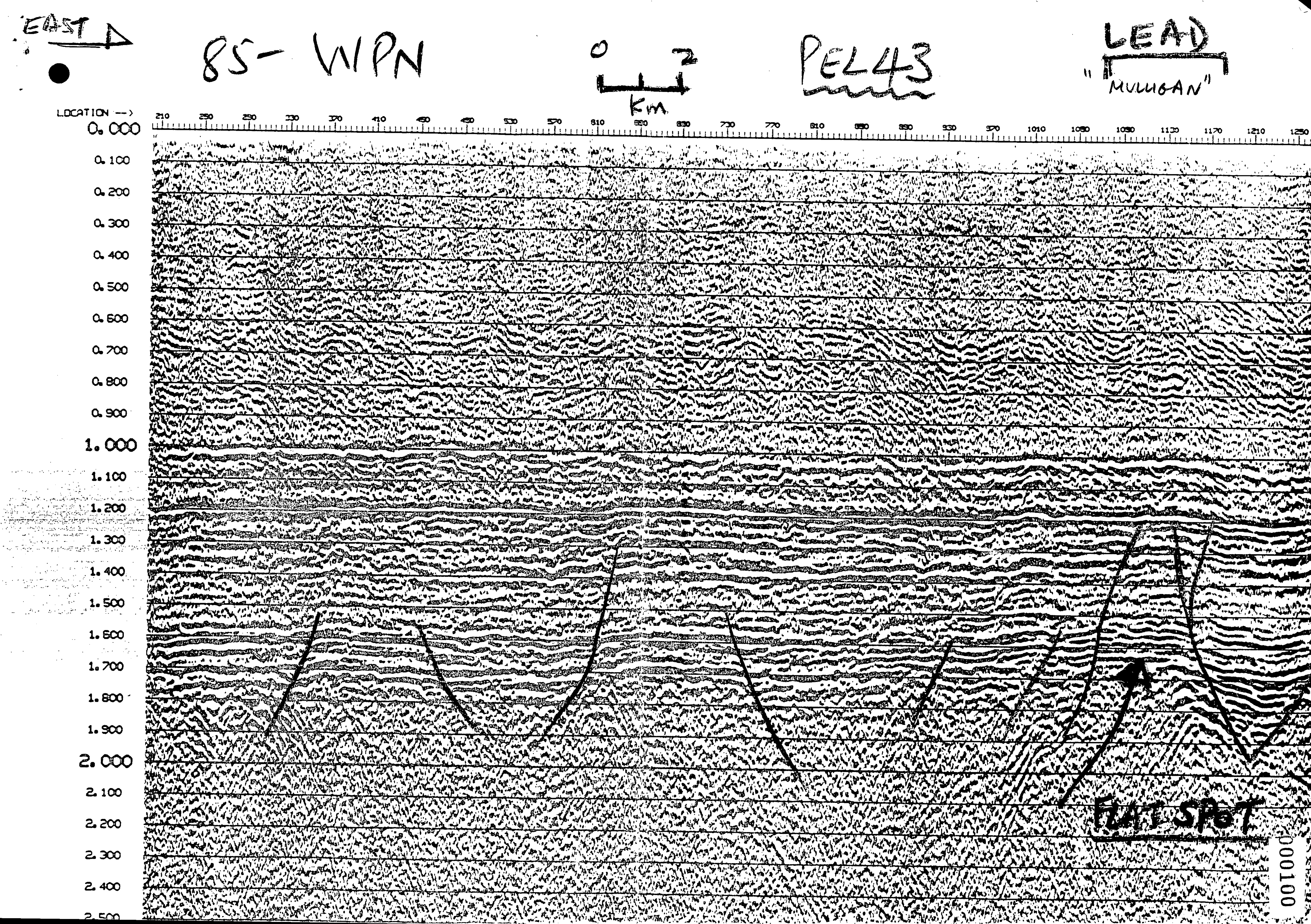
000099


EAST
85- WPN
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Km
PEL43
LEAD
"MULLIGAN"
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1.900
2.000
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2.400
FLAT SPOT
000100

8080 R9

000101

NOBJADE PTY. LIMITED

ACN 003 411 149

LEVEL 21
1 CASTLEREAGH STREET
SYDNEY NSW 2000

TELEPHONE: 337 4705

FACSIMILE: 337 3332

10 February 1993

The Director General
South Australian
Department of Mines and Energy
191 Greenhill Road Parkside
P O Box 151
EASTWOOD SOUTH AUSTRALIA 5063

Attention: Bob Laws

Dear Bob

Nobjade Pty Limited is hereby giving notice that they wish to relinquish PEL 43 in the Simpson Desert.

Three seperate trips were made to the USA last year to seek farm-in partners. Unfortunately large, remote, sparsely explored areas such as PEL 43 are difficult to explore.

Regardless of our best efforts, we are forced, in this ecomonic climate, to relinquish this permit.

We do wish to continue to explore in South Australia, but will have to wait for another opportunity.

Sincerely

NOBJADE PTY. LIMITED A.C.N. 003 411 149 Common Seal

Alan Conolly - Director
KR\519

8080 R10

000102

SR 27/2/91

MEMORANDUM

Surrender of PEL 43

This memorandum will confirm that on 15 MARCH 1993 I gave my consent to the surrender of the above licence.

My consent is effective at the end of licence year 3 ending 21 March 1993.

FRANK BLEVINS MP
MINISTER OF MINERAL RESOURCES

15/3/93

F05329.mc