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PEL 50

EROMANGA BASIN

FARM-OUT BROCHURE AND SUPPORTING DATA

Submitted by

Felstea Pty Ltd
1991

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Enquiries: Customer Services
Ground Floor
101 Grenfell Street, Adelaide 5000

Telephone: (08) 8463 3000
Facsimile: (08) 8204 1880

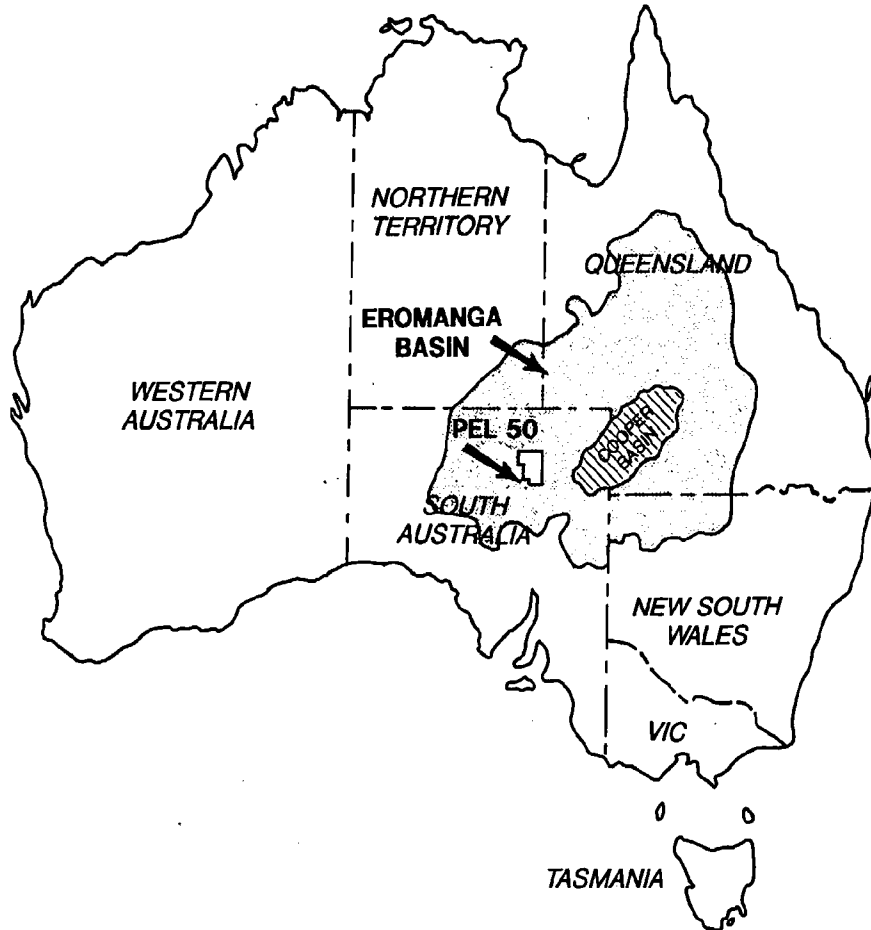


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PEL 50

SW EROMANGA BASIN

SOUTH AUSTRALIA



PROSPECTS AND GEOLOGICAL SUMMARY

Offered by:

FELSTEAL PTY. LTD.
1801 Broadway, Suite 1550
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EXECUTIVE SUMMARY

PEL 50

EROMANGA BASIN, AUSTRALIA

Petroleum Exploration license No. 50 (PEL 50) was granted to Felstea Pty. Ltd. on 1 July 1991 for an initial term of 5 years. The license covers an area of 10,075 km² (about 2,500,000 acres). PEL 50 is located in east-central Australia's Eromanga Basin (Figure 1), in which over 400 million barrels of oil in place have been discovered since 1977. To date, only three exploratory wells have been drilled in PEL 50. Although these tests failed to establish production, they have clearly demonstrated the presence of hydrocarbon shows, reservoirs, seals and mature source rocks. Over 2,300 km of mostly recent vintage seismic data have been acquired, which define three drillable prospects, three strong leads, and 24 other leads showing rollover on one or two seismic lines. In addition, significant potential exists for stratigraphic traps on the flanks of the seismically defined structures. The existing structural prospects and leads in PEL 50 have been conservatively estimated by Santos Ltd to contain over 200 million barrels of potential recoverable oil.

Exploration targets in PEL 50 are primarily Jurassic fluvial sandstone reservoirs sourced by underlying Jurassic lacustrine shales and by adjacent Permo-Triassic source beds. Regional seal is provided by an Early Cretaceous marine transgressive shale. Structuring occurred principally in the Early Tertiary, prior to oil generation and migration. To the east, near the center of the Eromanga Basin, comparable anticlinal structures, with reservoirs of similar age and depositional environment, have produced at rates up to 4,600 BOPD and have individual field reserves of up to 42 MMBO recoverable.

Depth to economic basement is less than 1,525 meters (5,000 ft) on structural highs. Dry hole cost is expected to be about US\$500,000 (A\$650,000); to drill and complete is expected to cost about US\$900,000 (A\$1,200,000). The primary target (Late Jurassic Namur Sandstone) is anticipated at a depth of about 1,100 meters (3,600 feet) on structure. With over 20% porosity and good to excellent permeability, the Namur is a high quality reservoir. Within PEL 50, cored source rocks (Birkhead Fm) yielded up to 15.2% TOC values, and are mature for oil generation.

The first of the drillable prospects is the Lake Promise Prospect. This structure covers 15,320 acres of closure and recoverable reserves are conservatively estimated at 46 million barrels of oil. The target for Lake Promise is the Namur Sandstone which is anticipated at a depth of 3,720 ft. The second drillable prospect is the Lake Kool Prospect. This structure covers 4,200 acres and has estimated recoverable reserves of 13 million barrels of oil. The target is the Namur Sandstone at a depth of 3,750 ft. The third prospect is the Lakeside Prospect. This structure encompasses an area of 15,400 acres at the lowest closing contour. The targets for Lakeside are the Namur at a depth of 3,520 ft. and the Hutton at a depth of 4,895 ft. Reserves are conservatively estimated at 46 million barrels.

PEL 50

EROMANGA BASIN, AUSTRALIA.

INTRODUCTION

On 1 July 1991, Felstea Pty. Ltd. was granted Petroleum Exploration License No. 50 (PEL 50) for an initial term of five years (See work program at Appendix 1). Located in east-central Australia's Eromanga Basin (Figure 1), PEL 50 covers an area of 10,075 km² (3,890 square miles or 2,488,525 acres).

Previous Activity

PEL 50 was originally part of the much larger Pedirka Sector of PELs 5 & 6, acquired by Santos Ltd. in 1956 and renewed in 1976. The area which now comprises PEL 50 was retained through the first 25% relinquishment, which took place in February, 1984. It was relinquished by Santos in February 1989 in the second 25% round. PEL 50 represents the northeastern, most prospective portion of a larger area known by Santos Ltd as the Lake Eyre Block.

Two dry exploratory wells were recently drilled in PEL 50 on separate structures, which confirmed the presence of excellent reservoirs, seals and mature source rocks. A stratigraphic test drilled in 1964 was intentionally located off structure, and demonstrated the presence of excellent source rock within the block. Two of the three wells had shows. Since 1964, over 2,300 km of seismic data (Figure 2 and Plate 5) have been acquired over PEL 50, representing an investment of about \$5 million (Australian)(Appendix 2). Three key seismic interpretive maps by Santos (1988) are available as Plates 1 through 4 (in pocket). In addition, gravity and aeromagnetic surveys are available over the block (Appendix 3). At the time of relinquishment, Santos recognized two seismically defined drillable prospects, four strong leads, and 24 other leads based on rollovers on one or two seismic lines (Figure 2). Although Santos identified Lakeside as a strong lead, Felstea Pty deems it a drillable prospect since a large closure is already shot out. Additionally, seismic is expected to confirm an even larger closure than currently mapped.

The southwestern portion of the Eromanga Basin is sparsely drilled. Figure 3 shows key well control in the vicinity of PEL 50.

Exploration Access

Lake Eyre National Park lies in the southern half of PEL 50. When this park was designated in 1984, the proclamation specified continued rights of access for exploration and production. The conditions under which exploration can be undertaken are detailed in Appendix 4, and are considered to be very favorable.

Morphologically, PEL 50 is dominated by the lake itself. Lake Eyre is normally a large, dry salina, but is subject to occasional flooding since it is the catchment area for an immense interior drainage basin. In fact, Lake Eyre occupies the lowest point on the Australian continent, and is slightly below sea level. The land surface around Lake Eyre consists essentially of flat, monotonous plains broken by shallow creek beds, numerous saline playas and predominantly north-south trending low seif dunes. The area is normally very arid, and is characterized by sparse vegetation (Santos, 1988).

EROMANGA BASIN

The Eromanga Basin is a broad intracratonic downwarp, covering over 1.7 million square kilometers in east-central Australia (Figure 1). The basin contains up to 3 km of sediment of Early Jurassic to Late Cretaceous age, known as the Eromanga Basin sequence. The Jurassic sediments represent predominantly fluvial/lacustrine environments, whereas the Cretaceous consists of transgressive marine shale, grading upwards into marginal marine and non-marine coarser clastics. The deepest, central portion of the Eromanga Basin overlies the Cooper Basin, containing glacial, fluvial and lacustrine sediments of Permian and Triassic age. The Poolowanna Trough (Figures 6 and 7) represents a large, deep downwarp in the western portion of the Eromanga Basin, in the vicinity of PEL 50.

Production History

The high rate of success enjoyed during the last 15 years of exploration has resulted in the Eromanga Basin now being Australia's most active area for onshore oil and gas exploration and development. The initial oil discoveries from the Eromanga Basin sequence resulted from exploration and development of the deeper Cooper Basin gas reservoirs. Although Permian-Triassic Cooper Basin production was established in 1963, the first economic gas discovery from the Jurassic-Cretaceous Eromanga Basin sequence was not made until 1976, while drilling for a deeper target. The following year, oil was recovered from the Jurassic in the Poolowanna 1 well, located about 125 km north of PEL 50. In 1978, a well in Strzelecki Field flowed 2,400 BOPD from the Jurassic, firmly establishing the oil potential of the Eromanga Basin sequence in the vicinity of Cooper Basin gas fields. In 1981, Jackson Field was discovered; with recoverable reserves of 42 million barrels, it is the largest oilfield found to date in the Eromanga Basin (Lavering et al., 1986). More recently, Cretaceous production has been established in the deeper portions of the Eromanga Basin. Original oil-in-place reserves of about 400 million barrels have been discovered in the Eromanga sequence (Tupper and Burckhardt, 1990) since the initial Poolowanna 1 discovery in 1977, with the majority of fields falling in the 1 to 8 million barrel range (see Figure 4 and Tables 1 and 2) (Lavering et al., 1986). Vertical stacking of pay zones is characteristic of the fields. Eromanga-sourced oil is usually light (40 - 51 deg API) and paraffinic, with low gas content (Wecker, 1989).

Source Rock Maturity

While adequate structures, reservoirs and source rocks are readily demonstrable in PEL 50, the issue of maturity requires more careful analysis. As discussed in more detail later in this report, the lacustrine Birkhead Formation is considered to be the principal source rock underlying PEL 50. Birkhead samples from the three wells in PEL 50 have indicated vitrinite reflectance values from 0.63 to 0.7, equal to or higher than values associated with production elsewhere in the basin (Figure 5).

Recent work on Eromanga non-marine oils and condensates has led to a revision of the conventional thresholds for onset of hydrocarbon generation from terrestrial (land-plant dominated) organic matter. According to McKirdy and Willink (1988), the conventional threshold is at a vitrinite reflectance level of 0.6% at the top of the gas window and 0.7% at the top of the oil window. However, they concluded that "in certain circumstances, Cretaceous and Jurassic organic-rich sediments have generated and expelled economically significant amounts of oil at maturation levels as low as $VR = 0.5 - 0.6\%$." In fact, at some localities such as Tintaburra Field east of the Cooper Basin, the Jurassic and Cretaceous sourced oil at vitrinite reflectance equivalents as low as 0.5 - 0.54 and 0.42 - 0.48, respectively (Newton, 1986). Similarly, the Early Cretaceous Murta Member sourced oil in three western Cooper Basin fields at maturation levels of $VR = 0.5 - 0.6\%$ (Powell et al., 1989). They attribute the earlier maturation to the presence of bacterial organic matter. Also, Powell et al. state that "it appears that bacterial reworking of primary terrestrial organic matter during sedimentation and early diagenesis imparts the ability to generate hydrocarbons at an earlier stage of maturation ($VR < 0.7\%$) than otherwise would be the case."

McKirdy and Willink (1988) concluded that "three groups of oils, each generated with a different maturity window, can now be recognized in the Eromanga/Cooper Basin:

Source	VR calc (%)*
Cretaceous (Murta)	0.50-0.60
Jurassic (Birkhead, Basal Jurassic)	0.55-0.80
Permian - oil	0.70-0.95
- condensate	0.95-1.50

* Based on recalibrated methylphenanthrene index"

Structure

As shown in Figure 6, PEL 50 is situated on the south margin of the Poolowanna Trough, which attains about the same depth to the C seismic horizon (Early Cretaceous Cadna-owie Formation) as the Cooper Basin. Figure 7 shows the major structural trends recognized in the Cooper-

Eromanga Basin. Figure 8 is a time structure map by Santos (in Teakle, 1990A) on the C horizon which demonstrates the structural grain of PEL 50. In general, the block is centered over the southern arm of the Poolowanna Trough, which shallows gently towards the southwestern margin of the Eromanga Basin. Two principal north/northeast structural trends (Figure 8) are present in PEL 50: 1) the Warrandinna-Lake Promise Trend, with sediments draped over pronounced basement topographic highs, and 2) the Lakeside-Tirari-Warburton Trend, along which reverse faulting is responsible for many of the structures. Both of these structural trends parallel the prominent Birdsville Track Ridge, located some 70 km east of the license (Figure 7).

The prospects and leads identified in PEL 50 result from a combination of onlap and drape of Jurassic non-marine sediments over basement highs, followed in some areas by Tertiary reactivation or enhancement of structures by folding and/or faulting. According to Santos, 1988, "the Lake Eyre Block experienced two principal phases of structuring - the first prior to Eromanga Basin sedimentation (Ordovician) and the second during the (early-mid) Tertiary Period. The Ordovician orogeny produced severe structural and metamorphic deformation of Warburton Basin sediments (basement), developing a structural framework of varying competency which would be exploited during subsequent tectonic and/or erosional events. The (early-mid) Tertiary orogeny was a predominantly compressional event in the eastern Lake Eyre Block (and Mulka Block) which produced the observed structures via flexure and faulting, often involving reactivation of elements of [the Ordovician orogeny] induced structural framework."

HYDROCARBON POTENTIAL

Reservoirs and Seals

The Jurassic portion of the Eromanga Basin sequence contains the principal targets for hydrocarbon exploration in PEL 50. A generalized stratigraphic column is shown in Figure 9. The Namur Sandstone Member (Mooga Formation) of Late Jurassic age is the primary target, and blankets the block as a thick fluvial sandstone sequence with excellent reservoir properties. The Middle Jurassic Hutton Sandstone constitutes an extremely attractive target where present, although it is interpreted to be absent in several areas of PEL 50 due to non-deposition over some basement highs. Along basement low trends, Hutton fluvial channels represent an attractive, untested stratigraphic target. The Middle Jurassic Birkhead Formation, where present, provides both an excellent source rock and seal. The Early Jurassic Poolowanna Formation is oil bearing in the nearby Poolowanna Trough, and oil may have migrated south from it into PEL 50. The Early Cretaceous Cadna-owie Formation and overlying Bulldog Shale provide effective regional seals as well as exhibiting excellent source rock potential.

"Basement" Potential

Economic basement for PEL 50 is considered by Santos (1988) to be Ordovician-Cambrian (?) metasediments of the Warburton Basin (Figure 10). The potential for production from the Cambro-Ordovician section underlying PEL 50 is difficult to assess because of the very limited penetration and the acquisition and/or processing of the seismic data emphasizing shallower targets. The Cambro-Ordovician sequence is believed to have undergone significant structural deformation, including thrusting, during the Delamerian Orogeny (Late Ordovician?) (Roberts et al., 1990). In the three wells drilled to date, a maximum of 226' of "basement" has been penetrated, and it was variable in both lithology and structure. Poonarunna 1 encountered quartzites dipping 60 - 90 degrees (possibly overturned); Lake View 1 encountered metasiltstones dipping 10 degrees; and Tirari West 1 also encountered metasiltstones (structure unknown). The weathered contact between "basement" and the overlying Eromanga sequence generally produces a strong reflection known as the "Z" horizon, and seismic resolution of the underlying structure is hindered by the reflectivity of this event.

Oil shows were reported in a core of a "bituminous layer" in Poonarunna 1 one foot above "basement" (Stobie, 1986), suggesting possible migration from a deeper source. Hydrocarbon shows have been reported from Cambro-Ordovician rocks from several widely spaced localities in central Australia. Live oil was recovered from Cambrian carbonates on the east side of the Flinders Range, southeast of PEL 50, as well as in the eastern Officer Basin, west of the license (Gaughan and Warren, 1990). To the northwest, hydrocarbon shows and source rocks are described from Cambrian to Ordovician rocks in the Georgina Basin (Lodwick and Lindsay, 1990). To the east of PEL 50, in the eastern Cooper Basin, Early Cambrian to Early Ordovician sediments of the Kalladeina Fm had shows (oil stain with fluorescence and cut) in vuggy fractured dolomites that flowed up to 5,200 BWPD at Gidgealpa Field (Roberts et al., 1990). Alexander and Hough (1990) suggest that the Dullingari Group (the metasediments penetrated to date) may form a regional seal in the vicinity of PEL 50 for any older reservoir units.

Basement Influence on Sedimentation

In PEL 50, the Eromanga sequence was deposited directly on "basement" of Cambro-Ordovician age. According to Santos (1988), "Basement topography effected significant control on Jurassic lithology and facies distribution.... This influence on sedimentation declined as palaeotopography progressively diminished through burial and onlap by sediment. Basement topography impacted significantly on Hutton Sandstone lithology and lateral extent whilst the Namur (Algebuckina) experienced minor basement control."

Peera Peera and Poolowanna Formations

To the north of PEL 50, a thick section of fluvial and flood plain sediments (Peera Peera and Poolowanna Formations; Figure 9) was deposited in the Poolowanna Trough. The Poolowanna yielded oil on DST at a rate of 96 BOPD (Baily, 1989) in Poolowanna 1 (about 125 km north of PEL 50), and significant oil shows in Poolowanna 2 and 3, Walkandi 1 (about 150 km north),

and Kuncherinna 1 (about 130 km NNE) (Alexander and Hough, 1990). Poolowanna source rocks may underlie the northern part of PEL 50, or oil generated in the trough may have migrated southward into the block. Seismic interpretation suggests localized depocenters for the Poolowanna on the northeastern margin of the license (Santos, 1988). The Poolowanna contains source rocks with TOC up to 15%, and vitrinite reflectance levels of 0.88 - 0.97%, within the oil generation window for woody-herbaceous Type III kerogen (McKirdy and Willink, 1988).

The Peera Peera Formation had a show of 42 gravity condensate in Poolowanna 1, and yielded vitrinite reflectance values of 1.00 - 1.09% (McKirdy and Willink, 1988). Oil shows were also noted in the Peera Peera in Poolowanna 2 and 3, Walkandi 1 and Miandana 1 (Alexander and Hough, 1990). According to McKirdy and Willink (1988), the Poolowanna 1 crude oils from both the Poolowanna and Peera Peera Formations experienced long distance migration, enhancing the possibility of migration from the Poolowanna Trough into PEL 50.

Hutton Sandstone

The Middle Jurassic Hutton Sandstone represents fluvial sands initially deposited in basement lows, and which progressively overlapped and buried basement topography. The Hutton was deposited in paludal to braided fluvial environments, with a general increase in fluvial regime upsection which produced increasing lateral continuity and vertical thickness of individual sediment packages. Basinwide, the average porosity in the upper part of the Hutton ranges between 15 - 30%, and average permeabilities are in the 3 - 5 darcy range (Wecker, 1990). Consequently, flow rates can be high, with a maximum recorded flow rate in excess of 3,700 BOPD. The Hutton is one of the principal producing horizons in the Eromanga sequence in the Cooper Basin region to the east. For example, it is expected to produce 39 MMBO at Jackson and 22 MMBO at Strzelecki Field (Table 1).

In PEL 50, the formation is possibly up to 200 feet thick. According to an interpretation by Santos (1988), the Hutton is absent over a large part of PEL 50. However, examination of the seismic lines suggests it may be more widespread. The Hutton was not encountered in the three, structurally high tests drilled to date in PEL 50. The nearest penetration of the Hutton is about 95 km east, in Mulapula 1, where porosities over 20% were encountered. In Poolowanna 3, 160 km north, the Hutton equivalent (lower Algebuckina) had numerous sample shows of fluorescence and cut, but this section lacks the Birkhead seal of PEL 50. Exploration for Hutton channel sands along basement low trends, on lower relief basement features, and on the flanks of larger structures, represents an extremely attractive stratigraphic play which deserves much more attention in PEL 50.

Birkhead Formation

The lacustro-deltaic Birkhead Fm (Middle Jurassic) is considered the principal source rock for PEL 50. The maximum thickness penetrated in the block is 256' at Tirari West 1, but seismic suggests it thickens considerably off structure, and generally thickens to the north. A sidewall core from Tirari West 1 was interpreted to have an VR equivalent of 0.65 to 0.7 derived from

spore color (Nugent, 1989). In the same well, green fluorescing oil droplets were reported from two Birkhead sidewall cores (Kerraville Konsultants, 1989). Almost 200 feet of Birkhead was encountered in Poonarunna 1, where it displays excellent source rock characteristics. It contains oil and gas-prone Type II-III kerogen with Rock-Eval hydrogen indices of $HI = 402 - 561$ (McKirdy and Willink, 1988). TOC values in core range from 2% to 15%, and vitrinite reflectance values of 0.63 - 0.65 were observed.

Both the thickness and organic content of the Birkhead are expected to increase into a depocenter to the north and northeast (Santos, 1988), with a corresponding increase in the maturity up to $VR = 0.8 - 1.0$ (Figure 11). Also, the formation is buried more than 700 feet deeper adjacent to the mapped structural trends, and its maturity values should be locally enhanced (Nugent, 1989).

The Birkhead is absent over some of the basement structures in PEL 50 (Plate II), as shown by well control and seismic. For example, it was absent at Lake View 1, and is projected on Santos' (1988) interpretation to be missing at Lake Promise and Lake Kool prospects, and present at Lakeside prospect. It is emphasized that Santos' interpretation should be viewed with caution, since at Tirari West 1 they predicted 108', but drilled 256' (Nugent, 1989).

Namur Sandstone (Mooga Formation)

The Late Jurassic Namur Sandstone (Mooga Formation) is the primary target in PEL 50. The Namur progressively overlapped and buried the last vestiges of basement topography. It blankets the block with thick, braided fluvial sandstone with good to excellent reservoir characteristics. The Namur consists of fine to coarse grained sandstone, with interbeds of siltstone, and minor amounts of coal and shale (Figure 12). In the three wells drilled to date, it ranges in thickness from 800 - 1,200'. In Tirari West 1, the Namur was 1,196' thick, and displayed an average porosity of about 20% in the upper 400'; the porosity averaged 12 - 15% in the lower part (Nugent, 1989). Good permeabilities are anticipated throughout PEL 50 based on drill stem and flow tests in the three wells drilled to date. For example, in Lake View 1, good permeability is confirmed by a test of the upper Namur which flowed water at a rate of 1,150 barrels per day.

A non-economic amount of oil was recovered from the Namur at Mulapula 1, 95 km southeast of PEL 50. The Namur is oil and gas productive in numerous fields in the Cooper sector of the Eromanga Basin (Tables 1 and 2). For example, the Namur has reserves of about 9 million barrels of oil in place in both Strzelecki and Dullingari fields, and in place reserves of 43 BCF and 17 BCF at Namur and Marabooka fields, respectively. Flow rates of 2,000 BOPD were reported from the Namur at Dullingari.

Although the Birkhead may be absent over some of the structures in PEL 50, the overlying Namur Sandstone constitutes such an excellent reservoir that migration from nearby Birkhead source rocks should not pose a problem. In fact, "Evidence from Mulapula 1.... suggests migration of oil some considerable distance from Birkhead depocenters. Oil recovered from a test of the top of the Namur gave an equivalent source maturity of $VR_{calc} = 0.82$ which was

considerably greater than any VR values from the Eromanga section intersected in the well" (Nugent, 1989).

Cretaceous Sedimentation

A major change in depositional style took place in the Cretaceous, which is dominated by marine and marginal marine to continental sediments that attain a maximum thickness of about 2,000 m in the basin center. Rapid subsidence and deposition of this thick sequence enabled generation of hydrocarbons from the Jurassic sequence, beginning in the latest Cretaceous and continuing today (Moore and Pitt, 1984). Much of the Cretaceous sequence in the Eromanga Basin is immature for hydrocarbon generation in traditional terms, yet hydrocarbon shows occur sporadically throughout. As mentioned in the source rock maturity section of this report, early bacterial action modified the kerogen so that it generates oil at lower vitrinite reflectance values than conventionally recognized. For example, at Tintaburra Field, Early Cretaceous oils have a maturity indicating $VR = 0.42 - 0.48$ (Newton, 1986). Several excellent source rock units occur in the Cretaceous, and the associated reservoirs would be highly prospective in areas of higher heat flow or in deeper basins.

In contrast to the underlying fluvial-lacustrine sequences, the marine Cretaceous units display extensive lateral continuity. A particularly strong, continuous seismic reflector known as the C horizon is present near the base of the Cretaceous. The C horizon represents a major marine transgression which places marine mudstone of the Bulldog Shale abruptly over the sandstones of the uppermost Cadna-owie Formation. Thus the C horizon is locally an excellent time line, and is the most commonly used datum to represent regional Eromanga Basin structure (Figures 6 and 8).

Cadna-owie Formation and Bulldog Shale

The Early Cretaceous Cadna-owie Fm is the principal seal for the Namur Sandstone (the primary target on most of the structures in PEL 50). Basinwide it is quite uniform in character, consisting of a single, coarsening-upwards unit, with interbedded basal shale and siltstone grading upward to fine-grained calcareous sandstone (Moore and Pitt, 1984). The basal shales demonstrate good-excellent sealing quality in Poonarunna 1 and Lake View 1 (Santos, 1988). In Poonarunna 1, the Cadna-owie seal consisted of 50 feet of shale and finely interbedded sands and siltstones.

Following Cadna-owie deposition, a major transgression ensued, represented by the Bulldog Shale. On logs the basal several meters of its dark organic shales display a high gamma response and low sonic velocity which is widely traceable throughout the basin. This organic rich shale also provides a regional seal to the Cadna-owie sandstones. Another organic rich unit, the Toolebuc Formation, occurs in the overlying section, and in the vicinity of PEL 50, fluorescence and gas shows are commonly encountered during drilling (Moore and Pitt, 1984).

Late Cretaceous to Recent

Rapid deposition of the thick, early Late Cretaceous terrestrial Winton Formation contributed to the onset of significant oil generation in the deeper portions of the Eromanga Basin (Alexander and Hough, 1990). Subsidence essentially ceased in the Late Cretaceous, and a period of erosion followed. The Tertiary is represented by only a thin veneer of terrestrial sediments.

PROSPECTS AND LEADS

At the time of relinquishment in early 1989, Santos Ltd had identified two drillable prospects (Lake Promise and Lake Kool), four strong leads (Lakeside, Tirari North, Tirari East and Warburton), and 24 other leads (see Figure 2). Although Santos identified Lakeside as a strong lead, Felstea Pty deems it a drillable prospect since a large closure is already shot out.

In general, the extensive seismic coverage over PEL 50 yields a clear picture of its structural framework and location of major structural prospects and leads (Plates 1-4). However, the sparse well control makes it difficult to recognize velocity gradients and accurately convert time structure to depth. Rapidly changing velocity gradients have proved troublesome, even in areas of closely spaced well control, such as the Poolowanna area (Figure 3). There, two recent wells came in about 80' low to seismic prognosis. After three wells within 4 km of one another, the Poolowanna structure still has not been tested in a crestal location (Baily, 1989). Similarly, it is possible that none of the wells in PEL 50 actually tested the crests of structures, and that hydrocarbon accumulations remain undiscovered on the Lake View and Tirari West features.

LAKE PROMISE PROSPECT

Lake Promise is a drillable prospect based on four way closure observed on 8 seismic lines (see Lake Promise montage). The structure contains 15,320 acres under closure at the C seismic horizon. The Namur Sandstone, the primary target, lies about 150 feet below the C horizon. The Namur is draped over a prominent basement structural high, and exhibits about 70 ms of time closure (253 feet). Southern, out of the basin, closure is particularly strong. About 800' of Namur is anticipated over the crest of the structure. Based on previous drilling in PEL 50, the upper 400' of Namur is expected to have about 20% porosity and excellent permeability. The Namur Sandstone is anticipated at a depth of 3,720 ft (1,135 m) on the crest of the structure. Traditional economic basement (Z seismic horizon) is anticipated at 4,520 ft (1,378 m). The Hutton Sandstone and Birkhead Fm are interpreted (Santos, 1988) to be absent due to onlap onto basement (Plate 2).

Recoverable reserves of 46 million barrels of oil can be assigned using conservative reservoir parameters of 15% porosity, 30% water saturation, 20 feet of pay, and 7,660 productive acres

(Table 3). Lake Promise could have reserves of over 400 million barrels recoverable using the same parameters but increasing the pay thickness to 177 feet (Table 4).

Lake Promise Prospect differs significantly in structural style from the previously drilled Lake View feature, located about 30 km to the north. Lake Promise is bounded on its northeast flank by a major thrust fault (for example, about SP 525 on Line 86-AGJ and SP 375 on Line 86-AGK). Lake Promise is predominantly a thrust-bounded anticlinal flexure (Figure 13) whereas Lake View is predominantly a draped, onlapped basement high. The basement high at Lake Promise is considerably broader than at Lake View. Although Lake View displays more C to Z thinning than Lake Promise, it is localized over a relatively small part of the C closure. At Lake Promise, strong C to Z thinning characterizes most of the area under C closure. The lack of onlap and the pronounced thinning at Lake Promise suggest recurrent structural movement, whereas Lake View appears to have had primarily late stage movement. Probably the Lake View structural closure formed after oil generation and migration, explaining the fresh water recovered on DST from the Namur Sandstone.

The pre-Jurassic hydrocarbon potential of the Lake Promise structure is unknown. The previous tests in PEL 50 penetrated up to 226 feet of Cambro-Ordovician rocks underlying the Eromanga Basin sequence, which displayed different lithologies and dips in all three wells. Numerous oil shows have been recorded in Cambrian carbonate and sandstone reservoirs throughout central Australia, and excellent permeability has been documented in the Cooper Basin region (see Basement Potential section of this report). The Lake Promise feature is characterized by numerous normal and reverse faults involving "basement". Because isochron thinning suggests recurrent movement on these faults, and because Lake Promise is such a large "basement" feature, the Cambro-Ordovician should be considered prospective. It would be prudent to penetrate over 500 feet of "basement" since the section could be structurally complex and potential pay zones might be present below sediments that currently have been penetrated.

LAKE KOOL PROSPECT

Lake Kool is a drillable prospect based on four-way closure observed on 10 seismic lines (see Lake Kool montage). At the C seismic horizon, the structure displays 40 ms time closure (144 feet), and covers 4,200 acres. The Namur Sandstone, the primary target, is about 150 ft below the Cadna-owie (C horizon). The Z seismic horizon ("basement") displays 120 ms of time closure (480 feet), and appears as a sharp, almost conical structure.

The Namur Sandstone is anticipated at a depth of 3,750 ft (1,145 m), draped over the crest of the structure. About 800 feet of Namur is anticipated. Previous drilling in PEL 50 indicates the upper 400' of Namur exhibits about 20% porosity and has excellent permeability. As at Lake View 1, no Birkhead or Hutton is interpreted by Santos (1988) over this pronounced basement topographic feature. Traditional economic basement (Cambro-Ordovician) is anticipated at about 4,680 ft (1,427 m).

Recoverable reserves of 13 million barrels of oil can be assigned to Lake Kool Prospect using conservative reservoir parameters of 15% porosity, 30% water saturation, 20 feet of pay and 2,225 productive acres (Table 5). Over 66 million barrels recoverable could be in the structure using the same parameters but increasing pay thickness to about 100 feet (Table 6).

Lake Kool is located about 9 km SSW of Lake View 1, drilled in 1988. That well was abandoned after a test of the upper Namur recovered water. Lake Kool is a separate basement structure as seen on both the C and Z time structure maps (Plates 1 and 3) and on the schematic cross section depicting time structure along Lines 85-YSA and 86-AGD as mapped by Santos (1988) (Figure 14). The Lake View structure is a broader feature with a strong northwest trend, in contrast to Lake Kool which is a more conical feature with a northeast orientation. The basement faulting associated with the Lake View structure is absent at Lake Kool Prospect. Regionally, structure on the "C" horizon (Figure 8) indicates a depocenter in the southern part of PEL 50. Lake Kool is better situated than Lake View to have trapped oil migrating out of this depocenter.

It is possible that Lake View 1 failed to encounter hydrocarbons because the oil column is relatively thin (for example, 10 or 20' vs 220' of closure) and because the drillsite was not located on the structurally highest part of the structure. To the north of PEL 50, similar problems with the velocity gradient resulted in Santos failing to get updip of the Poolowanna 1 oil show (96 BOPD) despite two subsequent tests (Baily, 1989).

LAKESIDE PROSPECT

Lakeside Prospect is a large, thrust-bounded anticline defined by seven seismic lines (see Lakeside montage). The existing seismic control confirms 90 ms (325 feet) of "C" time closure, encompassing an area of 15,400 acres at the lowest closing contour of 1,020 ms. The structure actually appears to be much larger than this in both amount of closure and areal extent. Santos' interpretation (1988), suggests the lowest closing contour might be as low as 1,050 ms, but additional seismic would be needed to confirm critical dip on the southern and western flanks. (For this reason, Santos classified Lakeside as a strong lead rather than a drillable prospect.) The structure probably has over 120 ms closure (435 feet) and covers 34,850 acres.

Lakeside is an especially attractive prospect since both the Namur and Hutton Sandstones can be tested in a crestal position. The Namur Sandstone is about 135 feet below the "C" seismic horizon (Cadna-owie Fm.). On the crest of the structure, the Namur is anticipated at a depth of 3,520' (1,073 m). About 1,125' of Namur is expected based on the section encountered at Tirari West 1, located about 21 km north. In that well, the upper 400' of Namur displayed about 20% porosity and had excellent permeability. Water recovered from the upper Namur in Tirari West 1 had an order of magnitude lower resistivity (0.195 ohm-m @ 25 deg C) than the water recovered from Lake View 1 (2.2 ohm-m @ 25 deg C). This suggests that the Lakeside-Tirari trend is in a more favorable hydrodynamic setting than the Lake View area. Also, as shown in Figure 15, Lakeside appears to be a better location to test the trend because it is so much larger than Tirari West (90 vs 10 ms closure and 15,400 vs 865 acres under closure).

The Hutton Sandstone is anticipated at a depth of 4,895' (1,492 m). It has not yet been penetrated in PEL 50, but is expected to display excellent reservoir characteristics. In the southeastern portion of the Eromanga Basin, the Hutton is a major producing zone typically having 15-30% porosity and 3-5 darcies permeability in the upper part. In parts of PEL 50, the Hutton may be up to 200' thick. On the crest of the Lakeside structure it is likely to be thinner due to onlap, and here it is conservatively estimated to be 100' thick. It is expected to thicken on the west flank of the structure (Plate 2). The overlying Birkhead Formation provides both source rock and seal for the Hutton. At Tirari West, the Birkhead was 256' thick, the maximum penetrated to date in PEL 50.

Recoverable reserves of 46 million barrels of oil can be assigned to the Lakeside closure as presently defined by seismic, using conservative reservoir parameters of 15% porosity, 30% water saturation, 20 feet of pay and 7,660 productive acres. Using the same parameters, but increasing pay thickness to about 225', recoverable reserves could exceed 500 million barrels (Tables 7 and 8). The structure could easily be a multi-billion barrel field (Table 9) if additional seismic confirmed the larger size of the structure as mapped by Santos (1988).

STRONG LEADS

Three strong leads identified by Santos (1988) are Tirari East, Tirari North and Warburton. The primary objective of Tirari East and North is the Namur Sandstone at a depth of about 4,000 feet, whereas Warburton's primary objective is the Hutton Sandstone at about 5,600 feet.

Tirari East and North Leads

Tirari East and North represent large onlapped basement features with subsequent drape, whereas the nearby Tirari West feature (drilled in 1989) is a small rollover related to reverse faulting. Santos' reinterpretation of the seismic after drilling Tirari West 1 (Plate 1) shows only 865 acres under closure at the "C" horizon. In contrast, their reinterpretation showed that Tirari East and North are considerably larger, with about 2,380 acres and 2,535 acres under closure, respectively. Because of the different structural styles involved, Tirari East and North are considered untested. Tirari East is developed over a more pronounced "basement" feature, and exhibits more closure than Tirari North. They are located about 6 km northeast of Tirari West 1. Additional seismic interpretations are available for the Tirari area in Teakle (1990 B).

The Tirari area is especially prospective since water resistivities in Tirari West 1 were significantly lower than measured in Lake View 1 (0.195 vs 2.2 ohm-m @ 25 deg C). This suggests that the Lakeside-Tirari trend is in a more favorable hydrodynamic setting than the Lake View area.

The Namur Sandstone, the primary target, is at a depth of about 4,000' (1,220 m) on the crests of both structures. According to Santos' (1988) interpretation, the Hutton Sandstone is absent in this area due to onlap, and the Birkhead Fm is thin or absent, also by onlap. Cambro-

Ordovician "basement" is anticipated at a depth of about 5,560' on Tirari North and about 5,360' on Tirari East.

Warburton Lead

Warburton, a strong lead seen on three seismic lines, is located in the northern part of PEL 50. The lead is centered at about SP 420 on Line 85-YSA and SP 1520 on 84-TZK. Santos (1988) interpreted the 8,500 acre feature as a subdued paleoflank enhanced by Tertiary structuring. Warburton is located in an area where both the Hutton Sandstone and the Birkhead Formation are relatively thick and well developed (Plate 2). The Hutton Sandstone is the primary objective on this lead, and is anticipated at a depth of about 5,600'. The Hutton is estimated to be at least 200' thick, although it has not yet been penetrated in PEL 50. The nearest penetration was at Mulapula 1 (about 95 km east), where it is 351' thick and has about 20% porosity. Elsewhere in the Eromanga Basin, the Hutton is a major producing horizon, and is characterized by porosities of 15-30% and permeabilities of 3-5 darcies. "Basement", probably Cambro-Ordovician sediments, is anticipated at a depth of about 6,050' (1,845 m). Santos (1988) conservatively estimated that Warburton contains recoverable reserves of about 15 million barrels of oil.

OTHER LEADS

Twenty four weak leads were defined by Santos (1990), as shown in Figure 2. Weak leads generally show rollover on a single seismic line, and display a variety of types of anomalies. Additional data on most of the weak leads is available in Santos (1988). In most cases, a copy of the pertinent seismic and/or a map of the lead on the "C" horizon is available in that report. Prospect summaries, including estimated reserves, are available in Teakle (1990 A).

Additional information on the Lake Peera area, located in the north-central part of PEL 50, is contained in Teakle (1990 B). Santos (1988) noted "there is also a seismically quiet zone at Lake Peera indicating the presence of a sandy Hutton section". To evaluate it for possible drilling, the Lake Peera area received 66 km of seismic during the 1988 seismic program. Teakle concluded that the original Lake Peera lead was resolved into a number of smaller strong and weak leads related to basement highs. The largest, Lake Peera South, is a large structure with 2720 acres at the Namur level. It is observed at about SP 640 on Line 88 BJB and about SP 460 on Line 88 BJD. Both the Hutton and Namur are prospective in the Lake Peera area. The Birkhead source rock is expected to be both organically rich and mature for hydrocarbon generation (Santos, 1988).

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APPENDIX 1: PEL 50 WORK PROGRAM

YEAR	ACTIVITY	EXPENDITURE	EXPENDITURE
		(A\$)	(US\$)
One	Geological and geophysical review	50,000	39,000
	Drill Lake Promise Prospect	<u>500,000</u>	<u>394,000</u>
	Total Year One	550,000	433,000
Two	Appraisal of Year 1 results	75,000	59,000
Three	200 km of seismic or drill one well	600,000	472,000
Four	200 km of seismic or drill one well	600,000	472,000
Five	Drill one well	600,000	472,000
	Five Year Total	2,425,000	1,908,000

APPENDIX 2: EXPENDITURES TO DATE (\$A), LAKE EYRE BLOCK (Santos, 1988, and Santos, 1989)

SEISMIC					
YEAR	SURVEY NAME	KM	ACTUAL \$	1987 \$	
1964	Kallakoopah-LEY	477	96,350	522,761	
1982	Christmas Creek-LEY	149	520,000	769,889	
1984	Hogarth-LEY	498	1,394,000	1,663,411	
1985	Morphett-LEY	422	1,309,000	1,507,084	
1986	Fletcher-LEY	203	633,000	677,943	
1987	Mitchell-LEY	132	317,300	339,828	
1988	Forrest-LEY	151	356,000	356,000	
TOTAL		2032	\$4,625,650	\$5,836,916	
WELLS					
YEAR	NAME	OPERATOR	TD (FT)	ACTUAL \$	1988 \$
1964	Poonarunna 1	FPC	5566	254,365	1,380,093
1988	Lake View 1	SANTOS	4861	653,310	653,310
1989	Tirari West 1	SANTOS	5856	1,187,000	1,187,000
TOTAL				\$2,094,675	\$3,220,403

APPENDIX 3: GRAVITY AND AEROMAGNETICS

The Lake Eyre Block is covered by various gravity and aeromagnetic surveys (Santos, 1988).

The Dalhousie gravity survey, carried out by Wongela Geophysical Corporation for French Petroleum Co (Australia) (now Total Exploration) in 1964, covers the entire block.

The Kallakoopah gravity survey carried out by United Geophysical Corporation for F.P.C.A. in 1964, covers the north-eastern quadrant.

The Oodnadatta Aeromagnetic Survey carried out for Delhi Petroleum Pty Ltd by Aeroservice Corporation in 1961-62 covers the entire block.

In addition, various BMR gravity and aeromagnetic surveys, carried out during the 1950's and 1960's also cover the area.

Two interpretations of depths to magnetic basement have been carried out by Aeroservice Corporation and by Compagnie General de Geophysique (C.G.G.). As shown in Figure 16, the interpretation by C.G.G. conforms fairly well to the structure defined by subsequent seismic (for example, Figure 8).

APPENDIX 4: LAKE EYRE NATIONAL PARK PROCLAMATION
(Extract from South Australian Government Gazette 31 October 1985)

1. The following Crown lands are constituted as a national park to be known as the 'Lake Eyre National Park:

Section 1466, Out of Hundreds (Curdimurka, Lake Eyre, Marree and Noolyeana) and Section 1468, Out of Hundreds (Curdimurka, Kopperamanna and Lake Eyre).

2. Subject to clause 4, existing rights of entry, prospecting, exploration or mining under the Mining Act, 1971, or the Petroleum Act, 1940, may continue to be exercised in respect of the lands constituting Lake Eyre National Park.

3. (1) Subject to subclause (2), rights of entry, prospecting, exploration or mining may, with the approval of the Minister for Environment and Planning, be acquired pursuant to the lands constituting Lake Eyre National Park.

(2) The approval of the Minister for Environment and Planning is not required for the acquisition of mining rights under the Petroleum Act, 1940, by the holder of an exploration license in force under that Act in relation to the lands immediately before the making of this proclamation.

4. A person in whom rights of entry, prospecting, exploration or mining are vested pursuant to the Mining Act, 1971, or the Petroleum Act, 1940 (whether those rights were acquired before or after the making of this proclamation) shall not exercise those rights in respect of the lands constituting Lake Eyre National Park unless he complies with the following conditions:

(a) at least 3 months before commencing any drilling or excavation, any drilling or excavation, any vegetation clearance, the making of any road, track or airstrip or the construction of any building or other structure, the person shall notify the Minister for Environment and Planning and the Minister of Mines and Energy of the proposed work and shall supply each Minister with such information relating to the proposed work as that Minister may require:

- (b) the person, in carrying out any work referred to in paragraph (a)-
- (i) shall comply with such directions as the Minister for Environment and Planning may give in writing in relation -
 - (A) to carrying out the work in a manner that minimizes damage to the lands or the environment or to vegetation or wildlife on the land;
 - (B) to preserving objects, structures or sites of historic, scientific or cultural interest; or
 - (C) to rehabilitating the land upon the completion of the work; and
 - (ii) if the work is being carried out in pursuance of a right of entry, prospecting, exploration or mining acquired after making of this proclamation (other than a mining right acquired under the Petroleum Act,

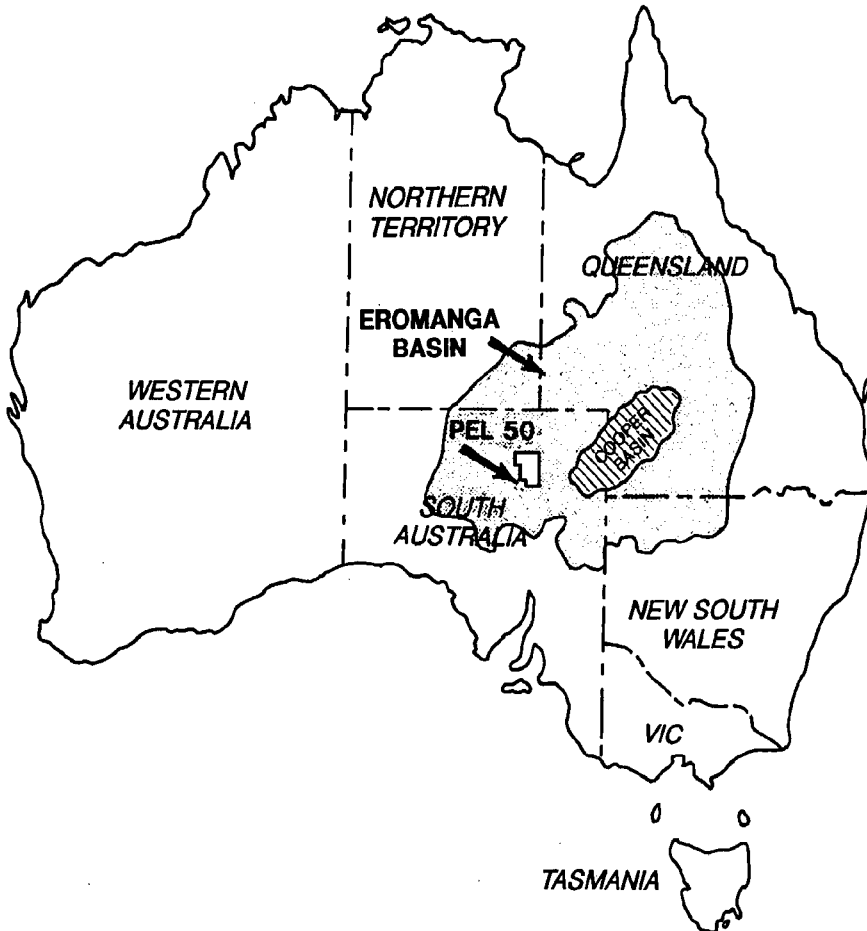
1940, by the holder of an exploration license in force under that Act immediately before the making of this proclamation), shall comply with such directions as the Minister for Environment and Planning or the Minister of Mines and Energy may give in writing in relation to prohibiting or restricting access to any specified area of the lands that the Minister believes would suffer significant detriment as a result of carrying out the work;

- (c) if a plan of management is in operation under Section 38 of the National Parks and Wildlife Act 1972, in respect of Lake Eyre National Park, the person shall have regard to the provisions of the plan of management;
- (d) the person, in addition to complying with any directions given under paragraph (b)-
 - (i) shall take such steps as are reasonably necessary to ensure that objects, structures and sites of historic, scientific or cultural interest, features of scientific or scenic interest and any wildlife on the lands are not unduly affected by the exercise of those rights;
 - (ii) shall take reasonable steps to minimize damage to vegetation;
 - (iii) shall maintain all work areas in a clean and tidy condition; and
 - (iv) shall, upon the completion of any work, obliterate or remove all roads, tracks, airstrips, buildings or other structures (other than a road, track, airstrip, building or structure designated by the Minister of Mines and Energy as suitable for retention) used exclusively for the purposes of that work.

PEL 50

SW EROMANGA BASIN

SOUTH AUSTRALIA



SUPPLEMENT TO GEOLOGICAL REPORT

FIGURES

TABLES

FELSTEAL PTY. LTD.
1801 Broadway, Suite 1550
Denver, Colorado USA

Tel - (303) 293-3953
Fax - (303) 293-3954

Mines & Energy SA

R95/00838



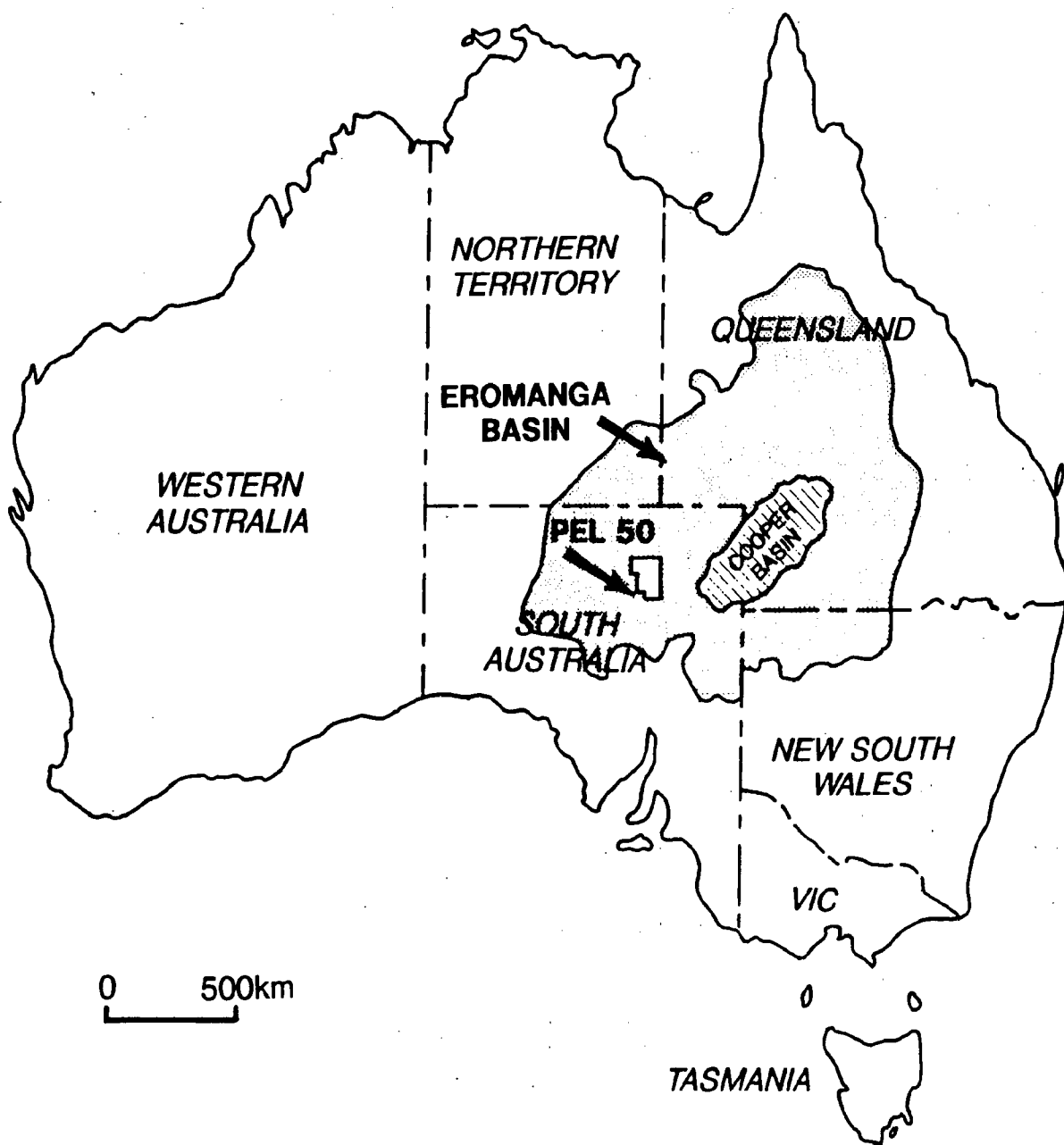


Figure 1. Location map, showing PEL 50 in the southwestern part of Australia's Eromanga Basin.

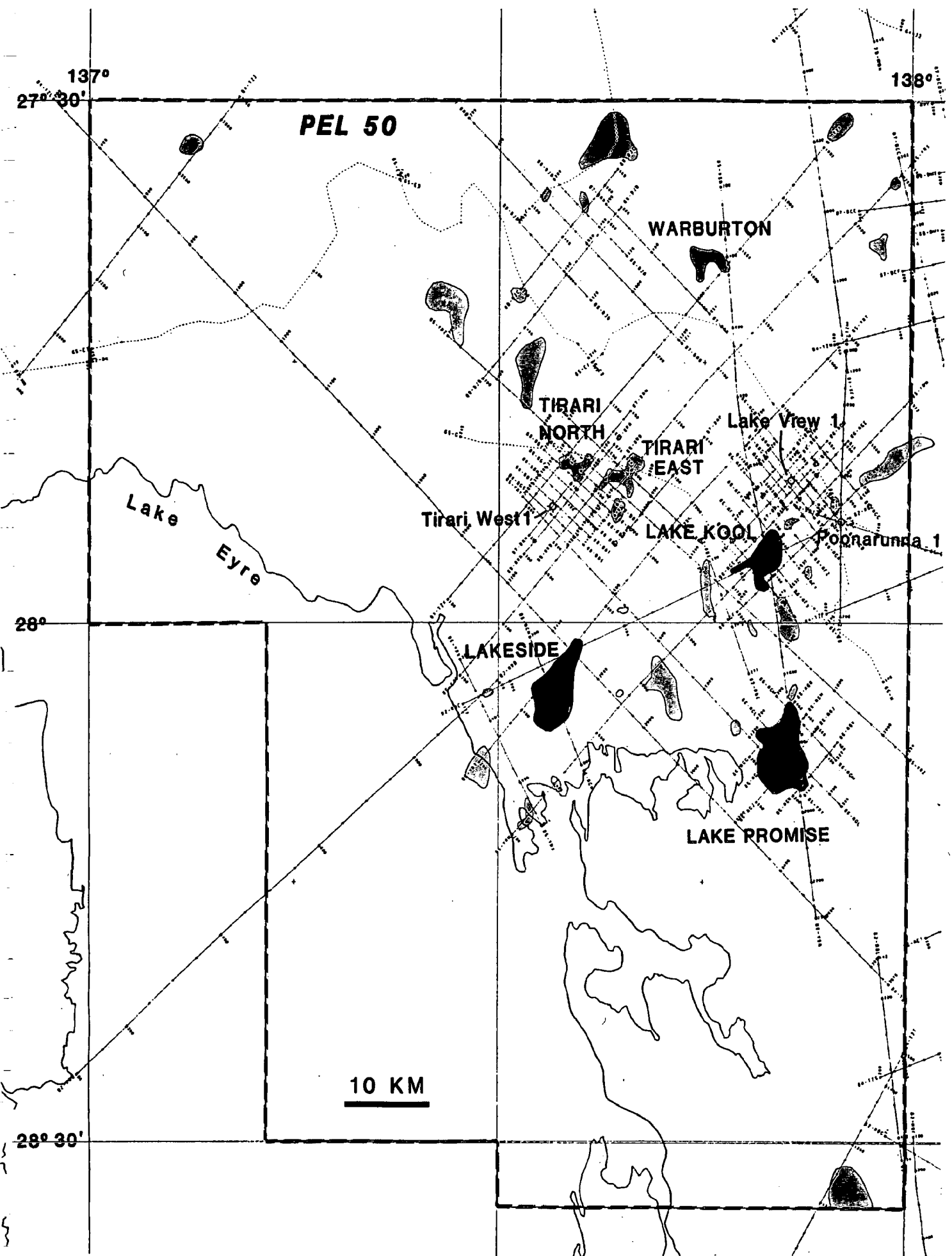


Figure 2. PEL 50 seismic coverage and location of three drillable prospects (Lake Promise, Lake Kool and Lakeside), three strong leads (Tirari North, Tirari East and Warburton), and 24 other leads interpreted by Santos (1989).

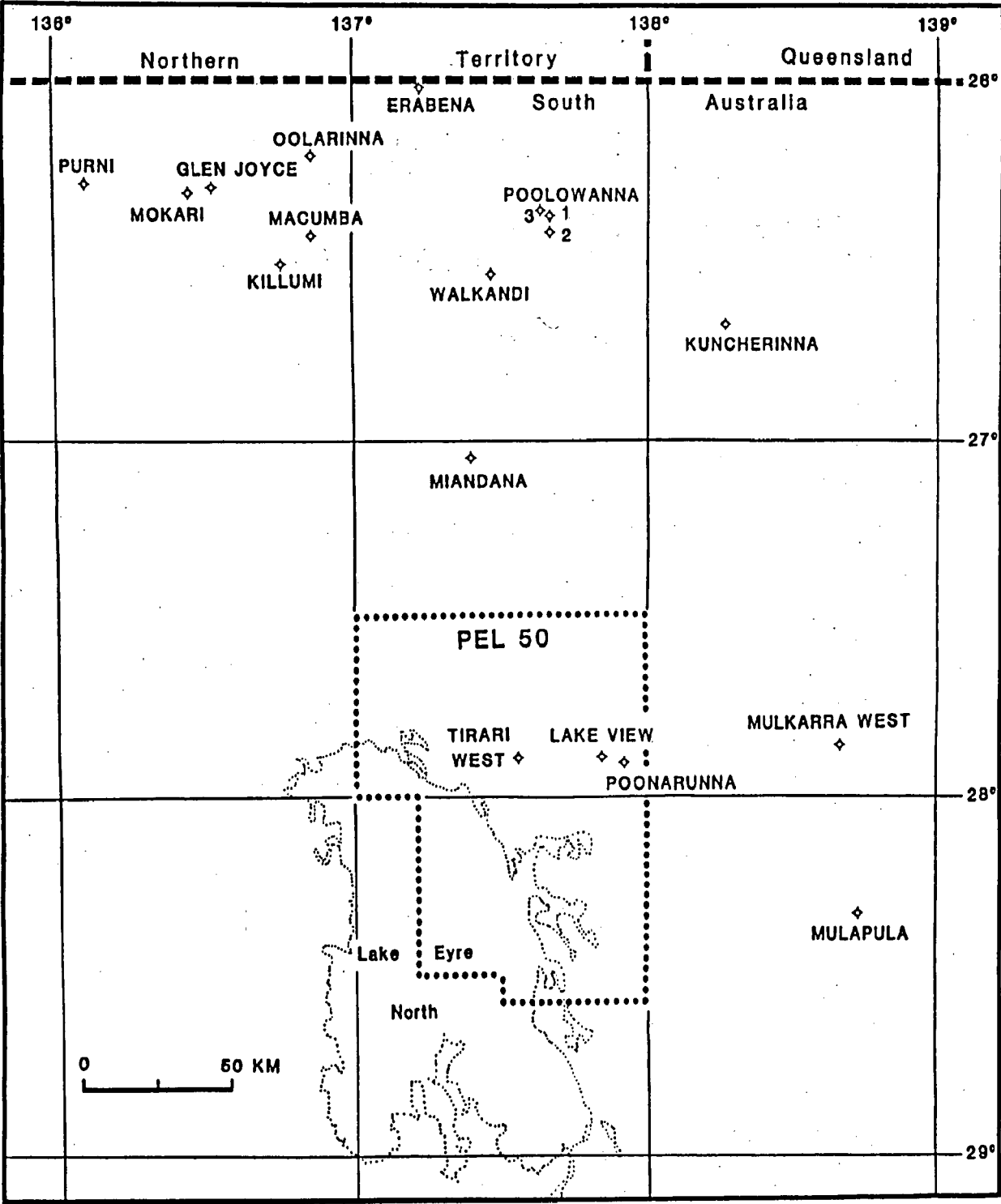


Figure 3. Key well control in the vicinity of PEL 50.

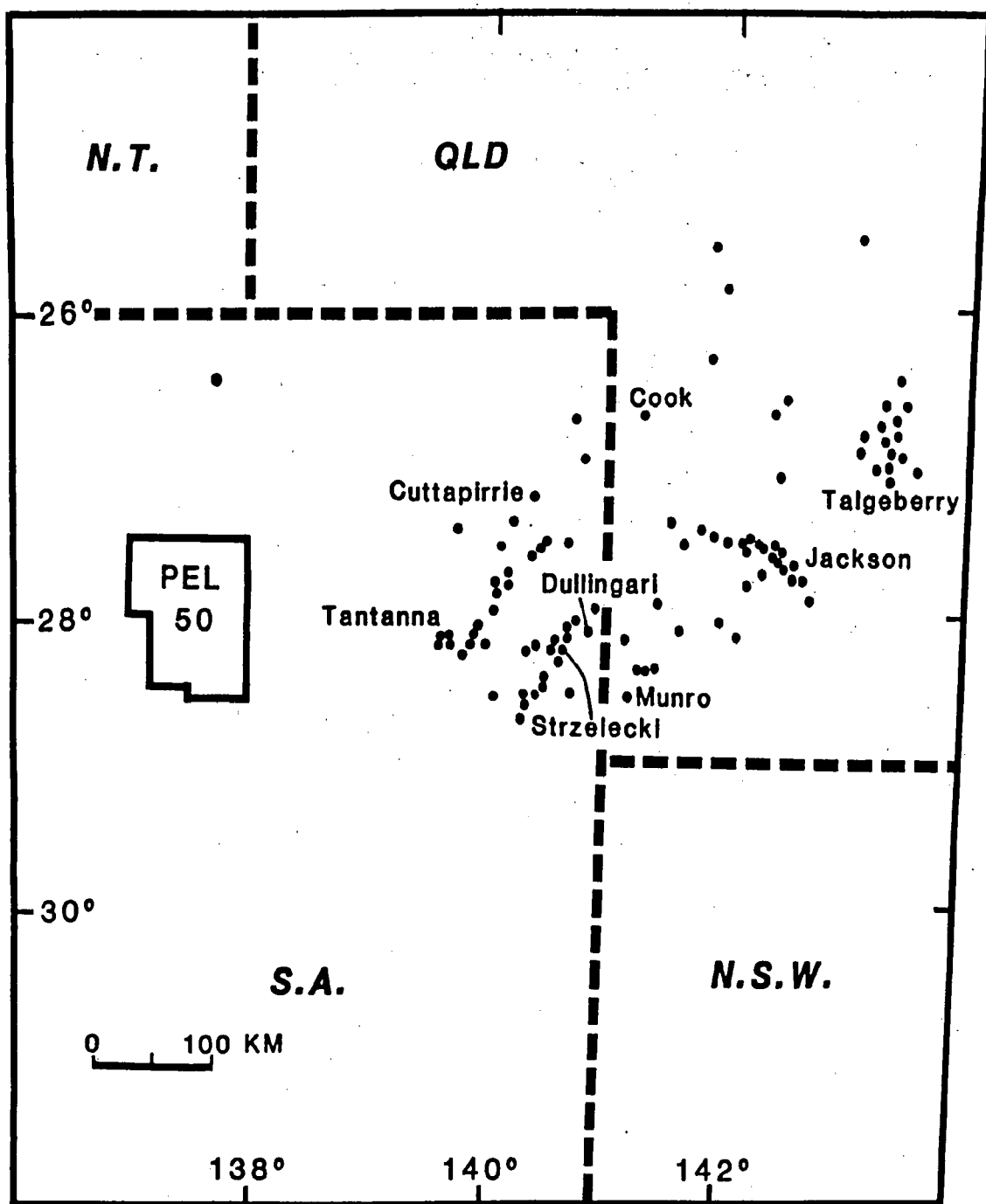


Figure 4. PEL 50 in relation to Eromanga Basin hydrocarbon discoveries (modified from Wecker, 1989).

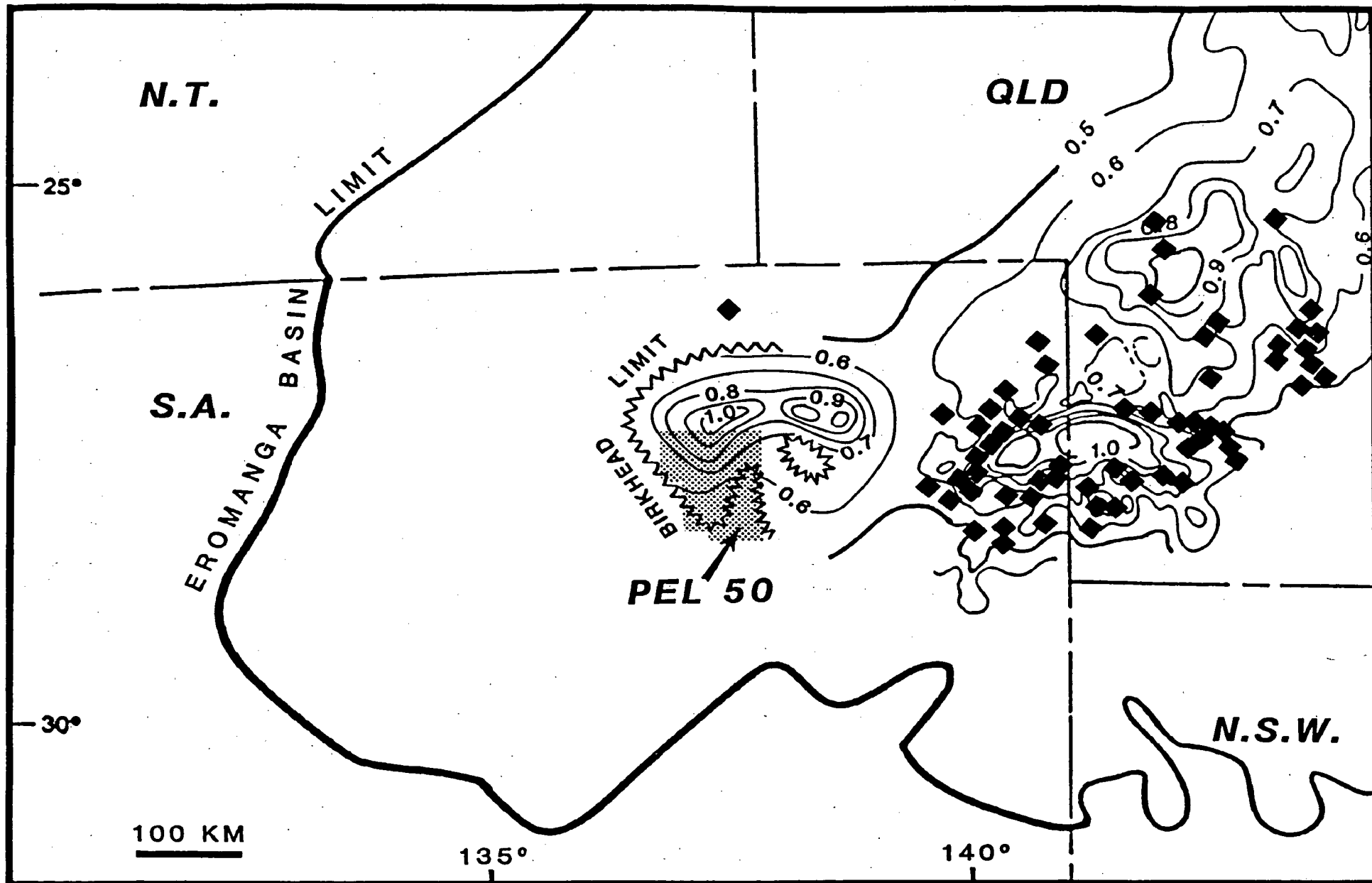


Figure 5. Birkhead vitrinite reflectance values in the vicinity of PEL 50 compare favorably to values determined for the existing production (black dots) in the Cooper sector of the Eromanga Basin (modified from Wecker, 1989 and Santos, 1988).

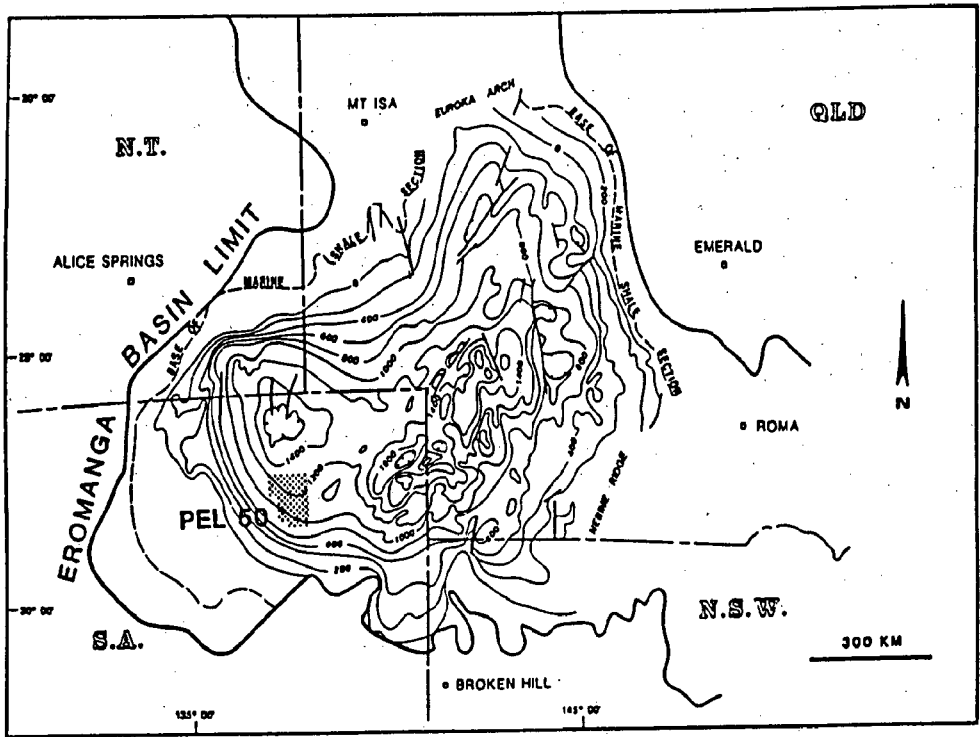


Figure 6. Eromanga Basin structure on the prominent "C" seismic horizon (Early Cretaceous Cadna-owie Formation) (modified from Wecker, 1989).

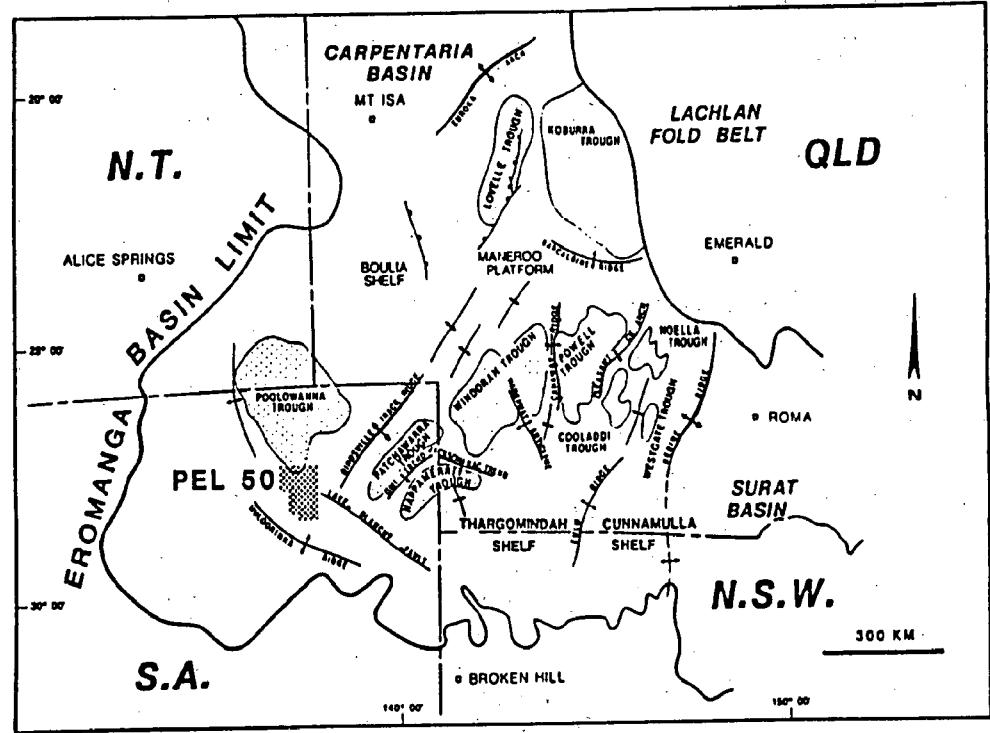


Figure 7. Principal tectonic elements of the Eromanga Basin (modified from Wecker, 1989).

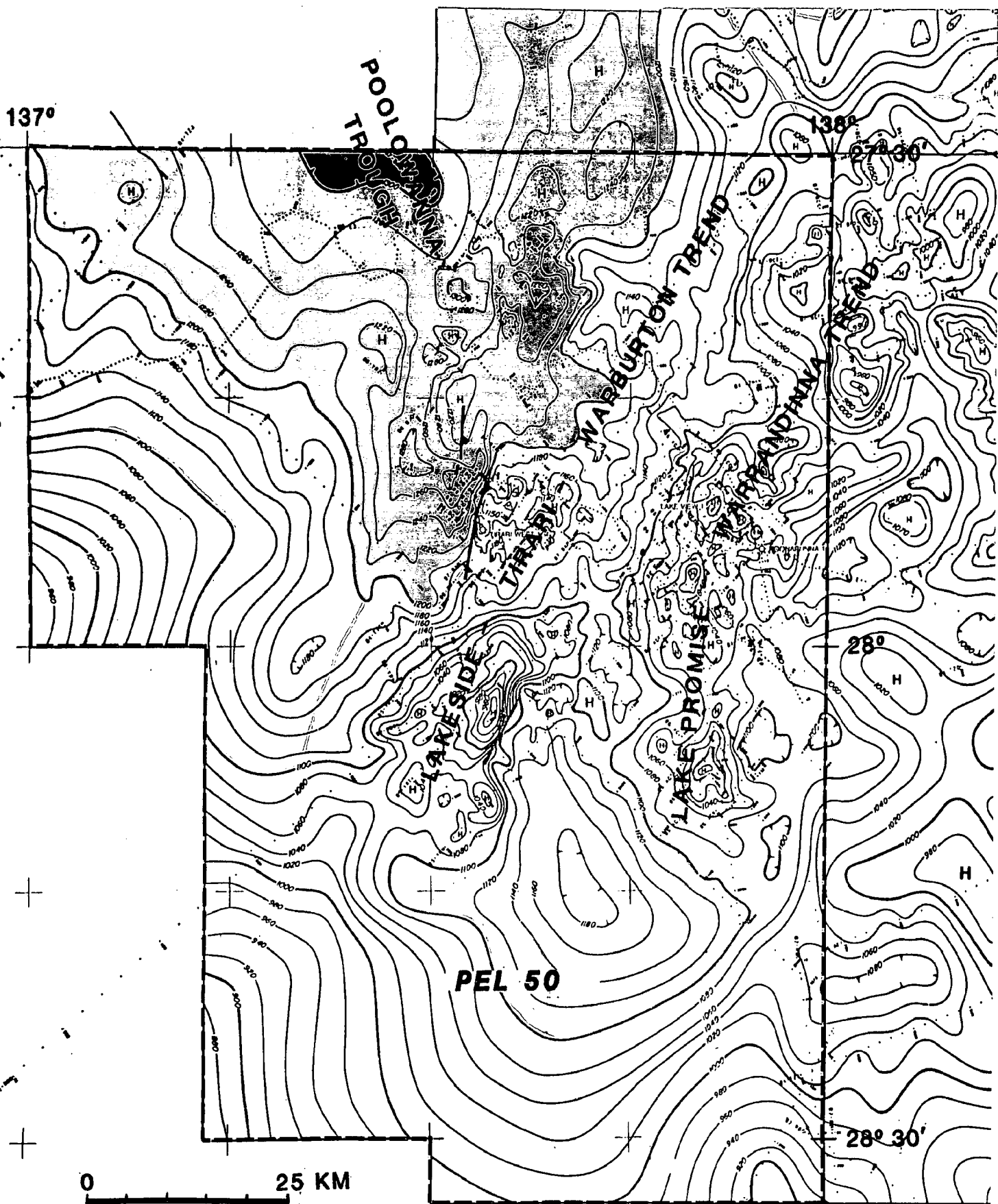


Figure 8. "C" time structure (Early Cretaceous) for PEL 50, showing the two principal structural trends (modified from Santos, 1989). C.I. = 20 ms. Refer to Plate 1 for a detailed version of this map.

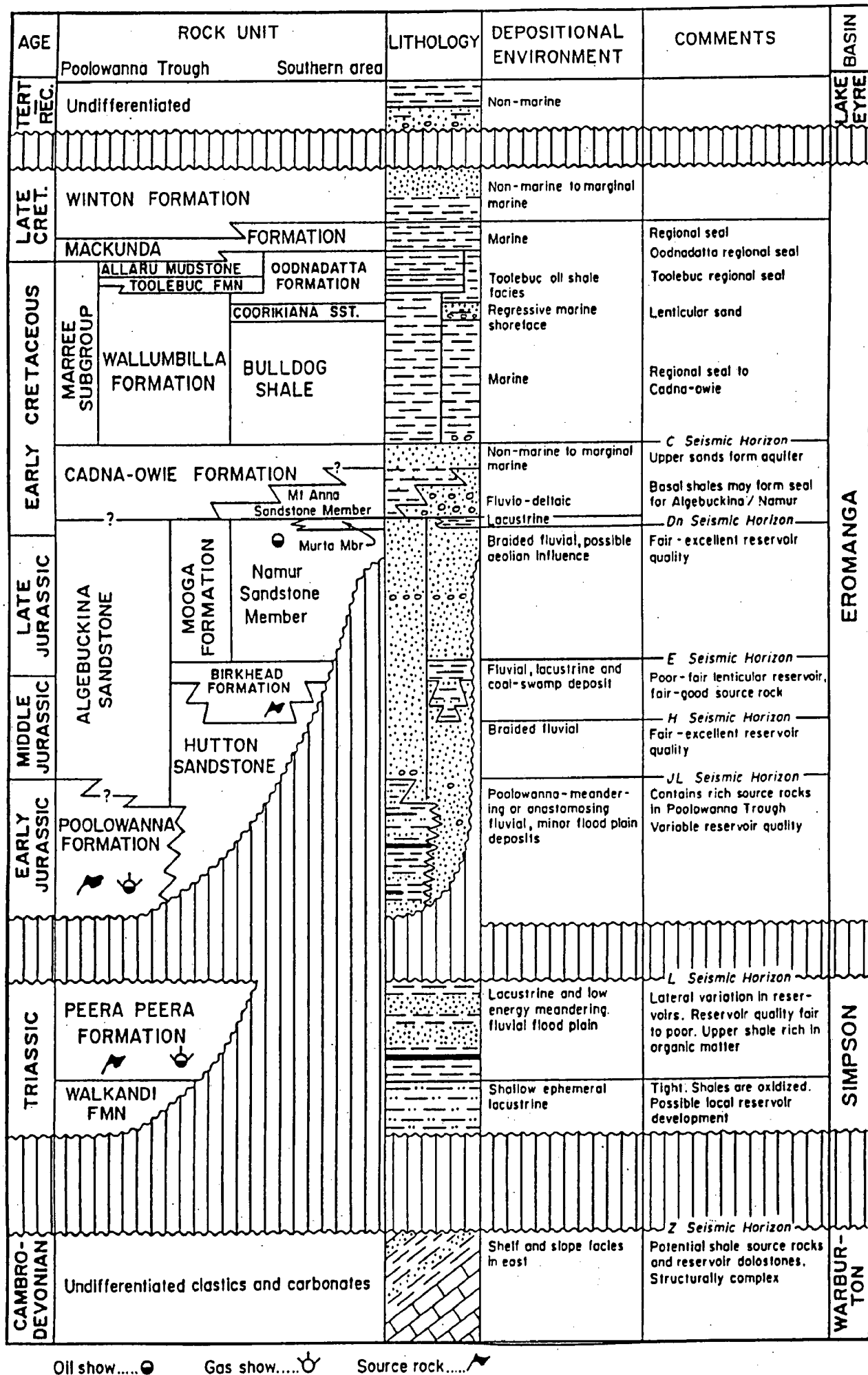


Figure 9. Stratigraphic section for PEL 50 (Alexander and Hough, 1990).

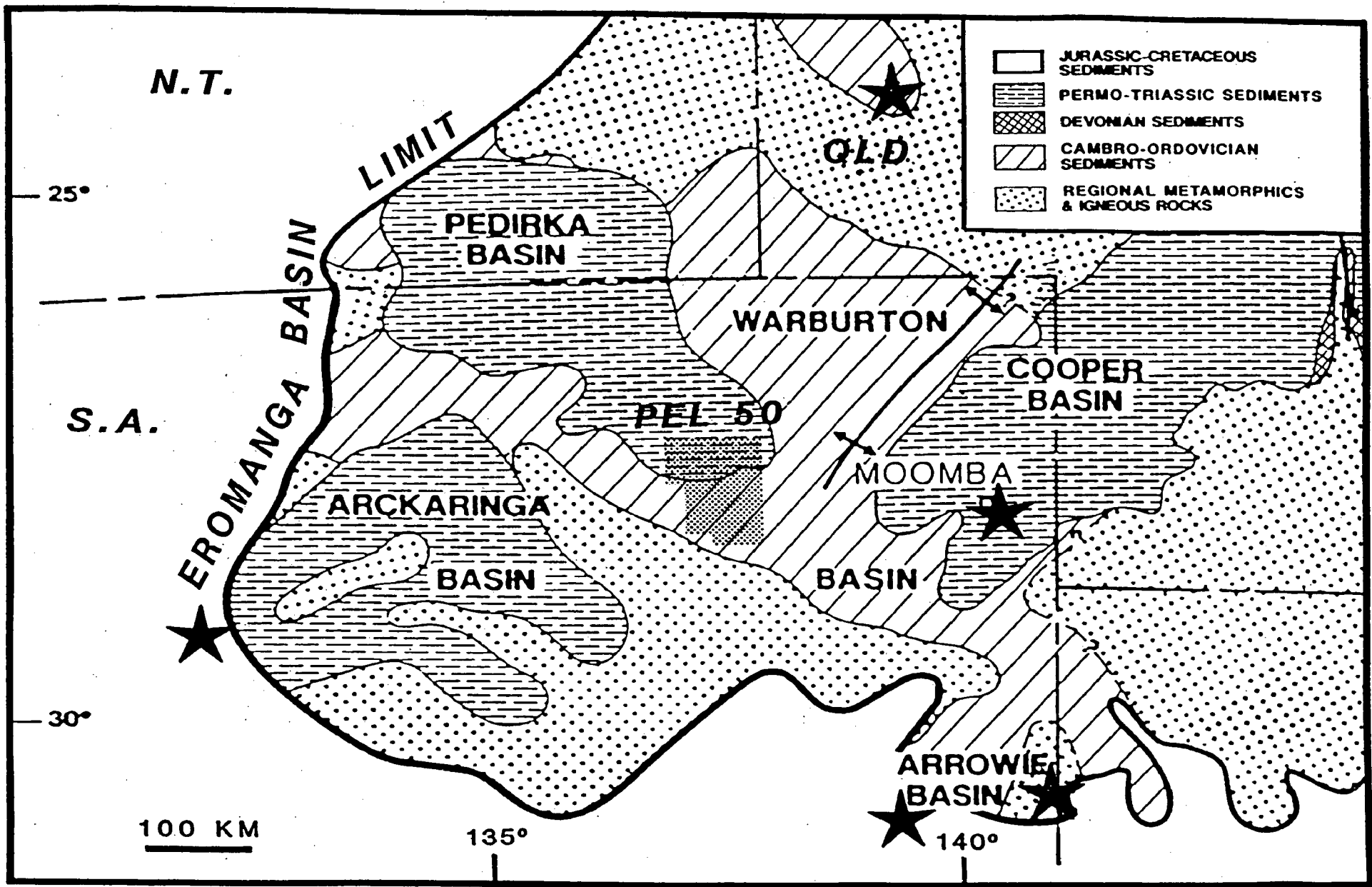


Figure 10. Pre-Mesozoic basins underlying the southwestern Eromanga Basin, showing the location of PEL 50 relative to the Warburton and Pedirka Basins (modified from Wecker, 1989). Stars denote oil shows in Cambro-Ordovician rocks.

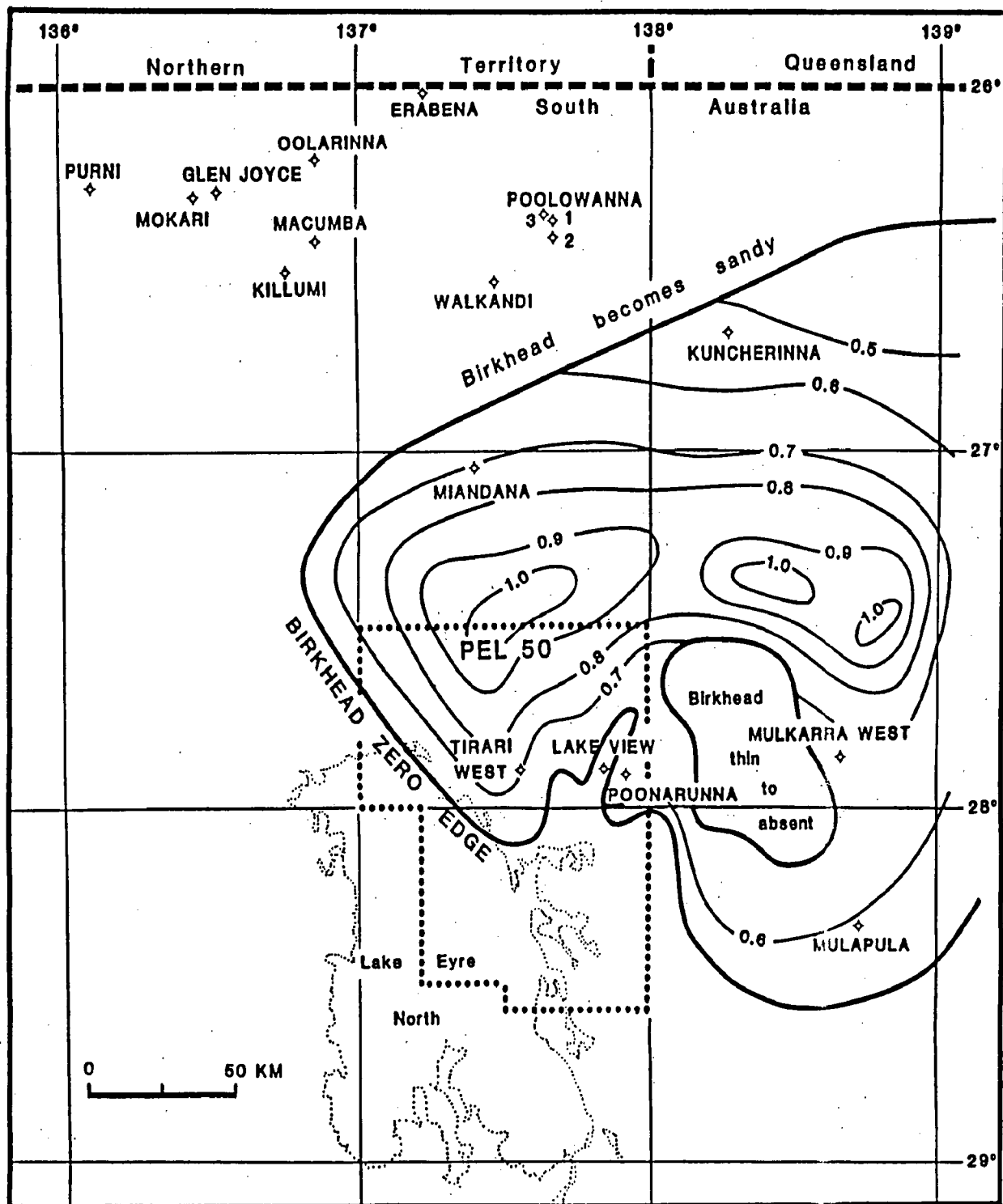


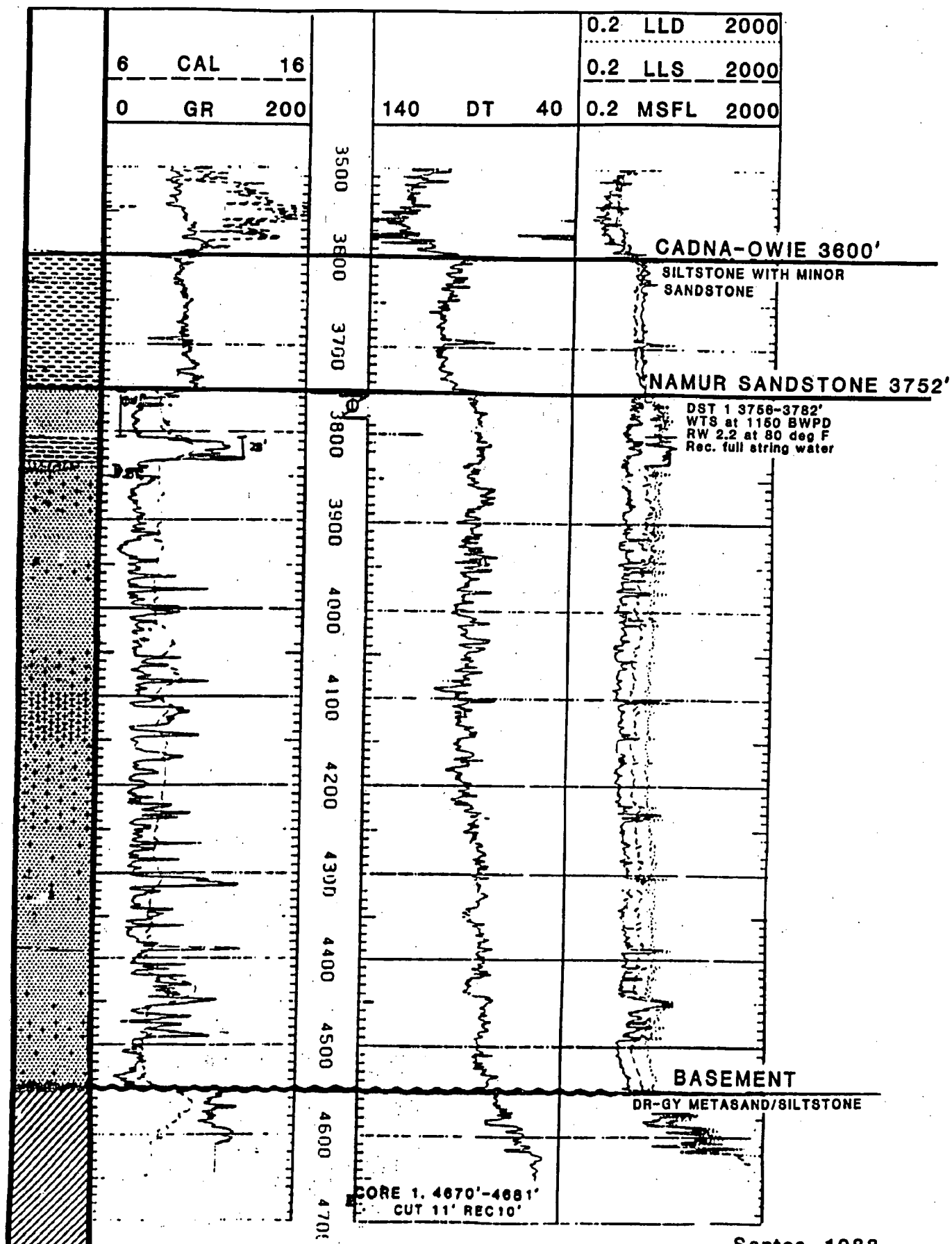
Figure 11. Birkhead vitrinite reflectance values. The vitrinite reflectance highs match areas with thick, shaly Birkhead deposited in a local depocenter (modified from Teakle, 1990).

LAKE VIEW 1

KB 68' TD 4681'

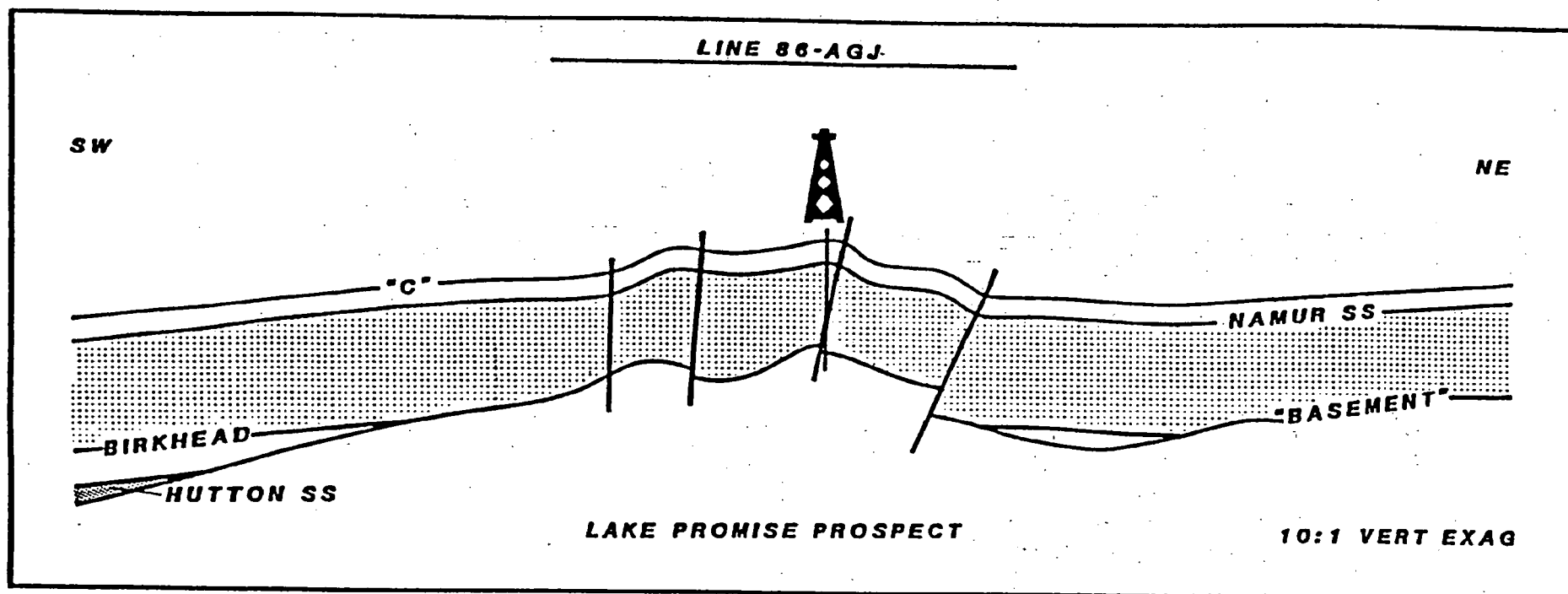
PLOT OUTPUT FROM LOGCALC

8 MAR 88



Santos, 1988

Figure 12. Log showing Namur Ss development at Lake View 1



SCHEMATIC CROSS SECTION

Figure 13. Lake Promise Prospect – Schematic Cross Section

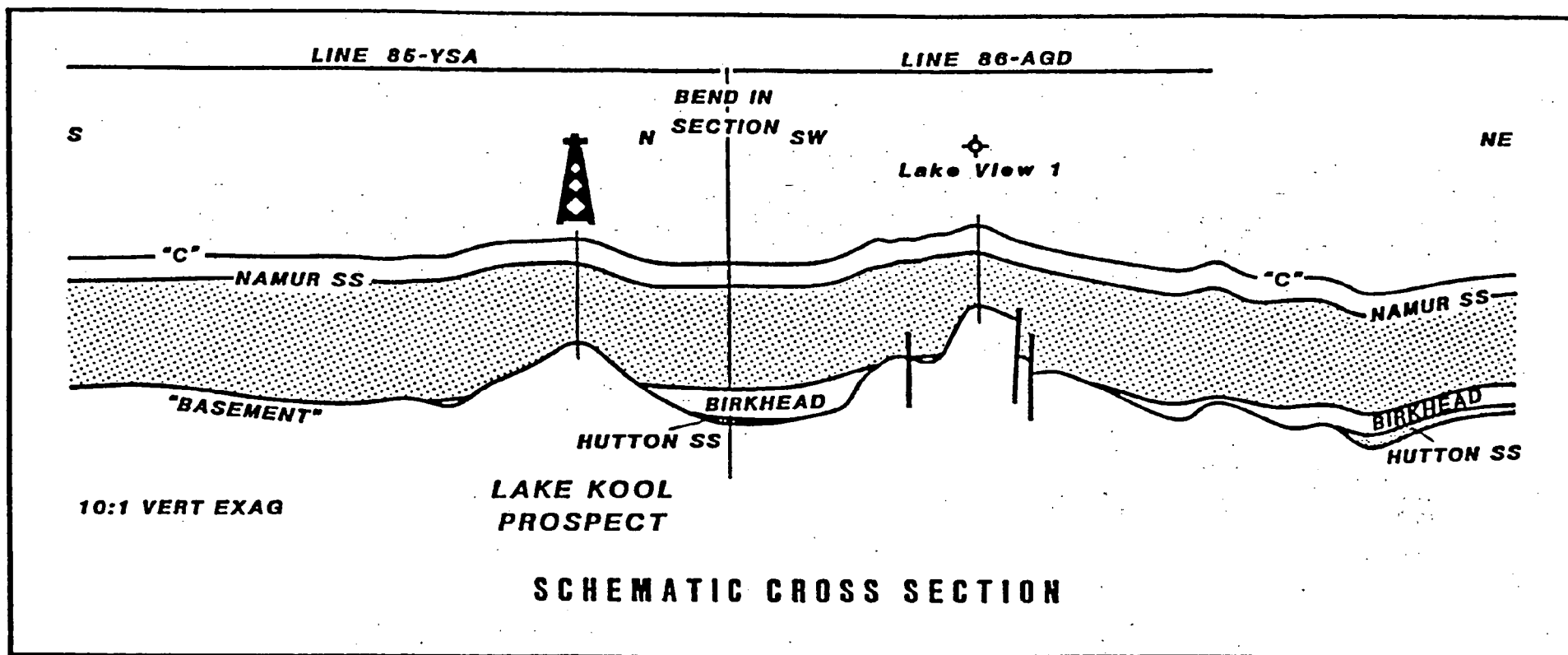


Figure 14. Lake Kool Prospect – Schematic Cross Section

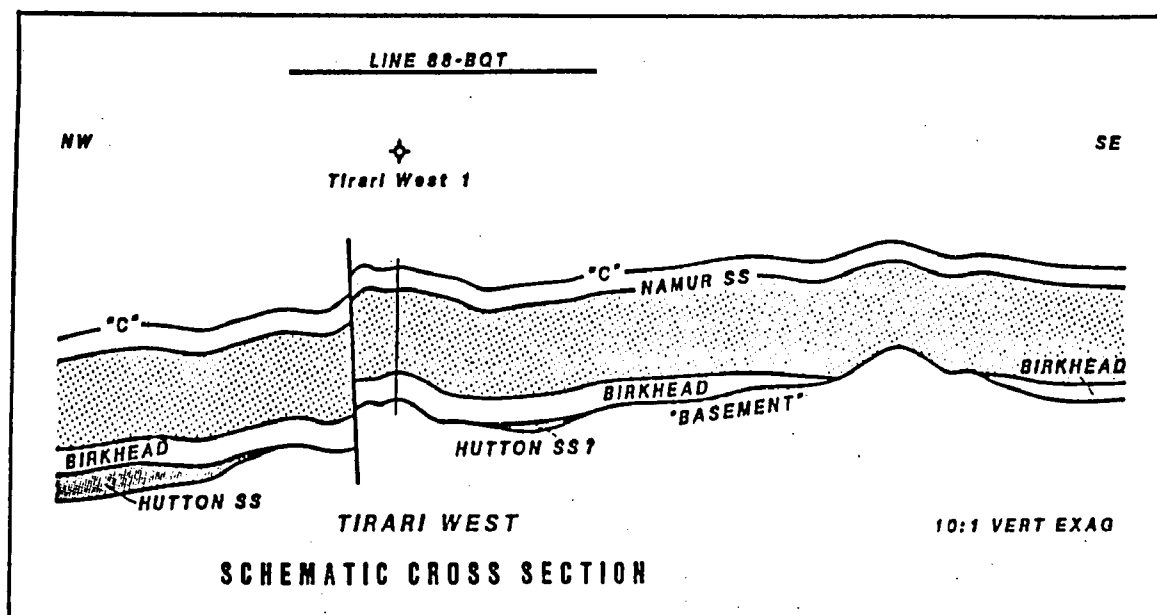
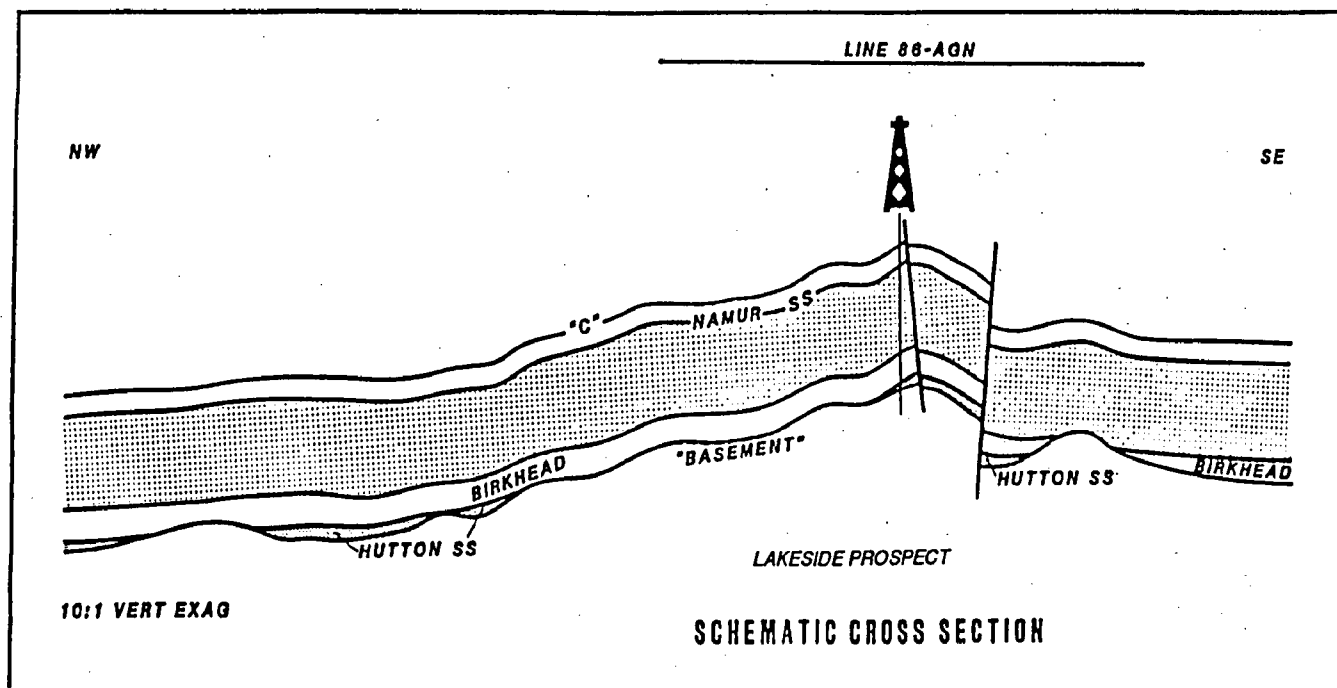


Figure 15. Schematic Cross Section of Lakeside Prospect (above) and Tirari West Lead (below)

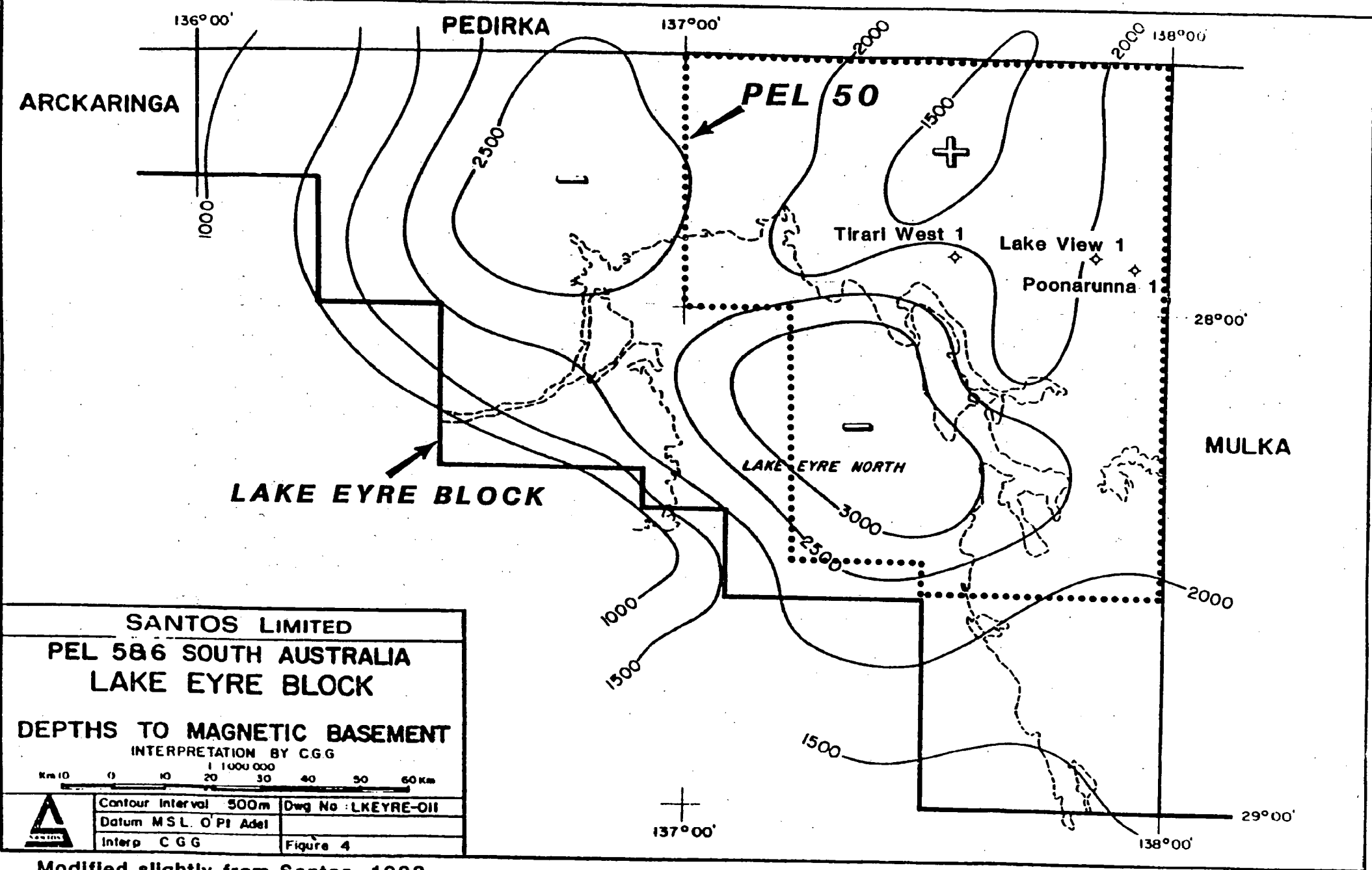


Figure 16. PEL 50 — depths to magnetic basement

TABLE 1
EROMANGA BASIN DISCOVERIES

DISC. DATE	FIELD	FORMATION	RESERVOIR DEPTH	CLOSURE AREA	ACCUM. AREA	MAX. PAY THICKNESS	OIL CHAR.		POROSITY	TEST RATE	PROVED/PROBABLE GIP/OIP
							GRAVITY	POUR PT.			
			feet	acres	acres	feet	oAPI	oC			(BCF)(MMSTB)
1976	Namur	Namur Mbr.	-5350	2477	1929	70	-	-	0.17	13.9 MMCFD	42.9 BCF
1977	Poolowanna	Basal Jurassic	-8100	11450	-	None	37	41	-	180 BOPD*	v. small
1978	Wackett	Birkhead Fm.	-5160	12600	400	34	-	-	0.15	2.2 MMCFD	18.8 BCF
1978	Strzelecki	Hutton Sst.	-5250	4200	664	56	45	8	0.17	2400 BOPD	22.4 MMSTB
1981	Strzelecki	Namur Mbr.	-4440	3934	465	50	41		0.17	700 BOPD	8.7 MMSTB
1982	Strzelecki	Coorikiana Sst.	-3037	3934	-	9	-	-	0.20	0.32 MMCFD	small
1979	Dullingari	Murta Mbr.	-4300	11500	9000	2	54	-3	0.14	450 BOPD	11.0 MMSTB
1982	Dullingari	Namur Mbr.	-4600	11500	900	40	53		0.18	2000 BOPD	9.3 MMSTB
1979	Nappacoongee	Birkhead Fm.	-5060	1350	-	3	45		0.12	20 BOPD*	v. small
1980	Cuttapirrie	Basal Jurassic	-7890	2913	932	14	53	4	0.10	160 BOPD	3.6 MMSTB
1981	Marabooka	Namur Mbr.	-4616	1050	805	19	-	-	0.20	7 MMCFD	17.0 BCF
1981	Moorari	Birkhead Fm.	-6900	3928	700	16	51		0.10	100 BOPD*	2.8 MMSTB
1981	McKinlay	Mooga Fm.	-3940	7500	-	9	41	15	0.15	8 BOPD*	v. small
1981	Merrimelia	Murta Mbr.	-5000	12500	-	2	51	-5	0.15	30 BOPD*	small
		Namur Mbr.	-5125	12500	300	8	51	-5	0.20	440 BOPD	1.0 MMSTB
		Hutton Sst.	-5975	12500	395	32	55	-5	0.22	2740 BOPD	5.5 MMSTB
1982	Merrimelia	Birkhead Fm.	-5972	12500	500	10	53	-5	0.13	75 BOPD*	small
1981	Jackson	Murta Mbr.	-3200	500	-	8	51	0	0.15	340 BOPD	0.1 MMSTB
		Westbourne Fm.	-4000	6360	1040	17	41	19	0.21	1350 BOPD	5.3 MMSTB
		Hutton Sst.	-4300	6350	1299	98	40	20	0.19	2375 BOPD	38.6 MMSTB
1981	Jackson South	Westbourne Fm.	-3900	6360	1300	16	40	14	0.13	640 BOPD	5.0 MMSTB
1982	Big Lake	Birkhead Fm.	-6293	8000	215	8	48	9	0.13	150 BOPD*	0.5 MMSTB

Abbreviations:

MMCFD = million cubic feet per day

BOPD = barrels oil per day

MMSTB = million standard tank barrels

BCF = billion cubic feet

GIP = gas in place

OIP = oil in place

* No flow to surface

NOTE: The proved, probable reserve estimates are in place figures as at July 1982 and reflect the estimates accepted by SANTOS Ltd.

TABLE 2

PRE-1986 OIL DISCOVERIES IN THE JURASSIC/CRETACEOUS EROMANGA BASIN SEQUENCE (LAVERING ET AL, 1986)

DATE	FIELD	RESERVOIR(S)	DATE	FIELD	RESERVOIR(S)
1976	Namur	Namur	1984	Charo	Birkhead
1977	Poolowanna	Basal Jurassic	1984	Kerinna	Hutton
1978	Wackett	Birkhead	1984	Limestone Cr	Murta
1978	Strzelecki	Namur, Birkhead, Hutton	1984	Gidgealpa	Hutton
1979	Nappacoongee	Birkhead	1984	Biala	Murta, Namur
1979	Dullingari	Murta	1984	Kobari	Murta
1980	Cuttapirrie	Basal Jurassic	1984	Narcoonowie	Murta
1981	Marabooka	Namur	1984	Naccowlah E	Murta
1981	Moorari	Birkhead	1984	Big Lake	Namur, Hutton
1981	McKinlay	Mooga	1984	Gidgealpa	Hutton
1981	Merrimelia	Murta, Namur, Hutton	1984	Wancoocha	Birkhead, Hutton
1981	Strzelecki	Namur	1984	Bookabourdie	Birkhead
1981	Jackson	Murta, Westbourne, Birkhead, Hutton	1984	Tickalara	Namur
1981	Jackson South	Westbourne	1984	Moothandella	Murta
1982	Strzelecki	Coorikiana	1984	Kercummurra	Cadna-owie
1982	Merrimelia	Birkhead	1985	Epsilon	Birkhead
1982	Dullingari	Namur	1985	Gidgealpa	Basal Jurassic
1982	Big Lake	Birkhead	1985	Ulandi	Murta, Birkhead, Hutton
1982	Kihee	Murta	1985	Alwyn	Murta
1983	Gunna	Murta	1985	Muteroo	Hutton
1983	Chookoo	Murta, Birkhead, Hutton, Westbourne	1985	Mooliampah	Murta, Namur, Adori
1983	Narcoonowie	Namur, Birkhead, Hutton	1985	Bodalla So	Basal Jurassic
1983	Nockatunga	Murta, Westbourne, Birkhead	1985	Jena	Murta
1983	Naccowlah So	Hutton	1985	Meranji	Namur
1983	Wilson	Murta, Namur, Westbourne, Hutton	1985	Moothandella	Murta
1983	Tinpilla	Murta, Birkhead	1985	Koorroopa	Adori
1983	Challum	Murta, Hutton	1985	Watson So	Hutton
1983	Naccowlah West	Murta, Hutton	1985	Kenmore	Hutton, Basal Jurassic
1983	Sigma	Murta, Namur	1986	Talgeberry	Cadna-owie, Murta, Westbourne, Birkhead
1983	Tintaburra	Cadna-owie, Hutton	1985	Nockatunga	Birkhead
1984	Yanda	Murta	1985	Cook	Namur, Hutton
1984	Bodalla So	Hutton, Basal Jurassic	1985	Glenvale	Westbourne
1984	Bogala	Murta, Hutton	1985	Koora	Adori

TABLE 3

LAKE PROMISE — SCENARIO C

FELSTEAL PTY. LTD. — VOLUMETRIC CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES				
PROSPECT: LAKE PROMISE		DATE: 05-Dec-91		
LOCATION: PEL 50				
STATE: SOUTH AUSTRALIA				
COUNTRY: AUSTRALIA				
REMARKS: CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES USING THE ASSUMPTIONS LISTED BELOW.				
PARAMETERS		RESULTS		
TWT CLOSURE (SECONDS)	0.07	PRIMARY	SECONDARY	ULTIMATE
DEPTH CLOSURE (FEET):	253			
AREAL EXTENT (SQ KM):	31			
AREAL EXTENT (ACRES):	7,657	RECOVERABLE		
POROSITY:	15%	BBL/ACRE FOOT:		
OIL SATURATION:	70%	222	74	296
SHRINKAGE FACTOR:	1.1			
PRIMARY REC. FACTOR:	30%			
ULTIMATE REC. FACTOR:	40%			
PRODUCTIVE ACRES:	7,657	TOTAL		
NET PAY (FEET):	20	RECOVERABLE		
PRODUCTIVE ACRE FEET	154,708	RESERVES (BBL):		
		34,400,000	11,500,000	45,800,000

NOTES:

- 1) ASSUMES 8% OF VERTICAL CLOSURE = EFFECTIVE NET PAY
- 2) ASSUMES 100% OF TOTAL AREAL EXTENT = PRODUCTIVE AREA
- 3) ASSUMES 2,200 M/S (7,216 FT/S) AVERAGE VELOCITY TO TOP NAMUR
- 4) TOTAL RECOVERABLE RESERVE FIGURES ARE ROUNDED TO NEAREST 100,000 BARRELS

TABLE 4

LAKE PROMISE — SCENARIO E

FELSTEAL PTY. LTD. — VOLUMETRIC CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES					
PROSPECT:		LAKE PROMISE		DATE: 05-Dec-91	
LOCATION:		PEL 50			
STATE:		SOUTH AUSTRALIA			
COUNTRY:		AUSTRALIA			
REMARKS:		CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES USING THE ASSUMPTIONS LISTED BELOW.			
PARAMETERS		RESULTS			
TWT CLOSURE (SECONDS)	0.07		PRIMARY	SECONDARY	ULTIMATE
DEPTH CLOSURE (FEET):	253	RECOVERABLE BBL/ACRE FOOT:	222	74	296
AREAL EXTENT (SQ KM):	31				
AREAL EXTENT (ACRES):	7,657				
POROSITY:	15%				
OIL SATURATION:	70%	TOTAL RECOVERABLE RESERVES (BBL):	300,700,000	100,200,000	401,000,000
SHRINKAGE FACTOR:	1.1				
PRIMARY REC. FACTOR:	30%				
ULTIMATE REC. FACTOR:	40%				
PRODUCTIVE ACRES:	7,657				
NET PAY (FEET):	177				
PRODUCTIVE ACRE FEET	1,353,696				

NOTES:

- 1) ASSUMES 70% OF VERTICAL CLOSURE = EFFECTIVE NET PAY
- 2) ASSUMES 100% OF TOTAL AREAL EXTENT = PRODUCTIVE AREA
- 3) ASSUMES 2,200 M/S (7,216 FT/S) AVERAGE VELOCITY TO TOP NAMUR
- 4) TOTAL RECOVERABLE RESERVE FIGURES ARE ROUNDED TO NEAREST 100,000 BARRELS

TABLE 5

LAKE KOOL — SCENARIO C

FELSTEAL PTY. LTD. — VOLUMETRIC CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES					
PROSPECT:		LAKE KOOL		DATE: 05-Dec-91	
LOCATION:		PEL 50			
STATE:		SOUTH AUSTRALIA			
COUNTRY:		AUSTRALIA			
REMARKS:		CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES USING THE ASSUMPTIONS LISTED BELOW.			
PARAMETERS		RESULTS			
TWT CLOSURE (SECONDS)	0.04		PRIMARY	SECONDARY	ULTIMATE
DEPTH CLOSURE (FEET):	144	RECOVERABLE BBL/ACRE FOOT:	222	74	296
AREAL EXTENT (SQ KM):	9				
AREAL EXTENT (ACRES):	2,223				
POROSITY:	15%				
OIL SATURATION:	70%				
SHRINKAGE FACTOR:	1.1				
PRIMARY REC. FACTOR:	30%				
ULTIMATE REC. FACTOR:	40%	TOTAL			
PRODUCTIVE ACRES:	2,223	RECOVERABLE	10,000,000	3,300,000	13,300,000
NET PAY (FEET):	20	RESERVES (BBL):			
PRODUCTIVE ACRE FEET	44,915				

NOTES:

- 1) ASSUMES 14% OF VERTICAL CLOSURE = EFFECTIVE NET PAY
- 2) ASSUMES 100% OF TOTAL AREAL EXTENT = PRODUCTIVE AREA
- 3) ASSUMES 2,200 M/S (7,216 FT/S) AVERAGE VELOCITY TO TOP NAMUR
- 4) TOTAL RECOVERABLE RESERVE FIGURES ARE ROUNDED TO NEAREST 100,000 BARRELS

TABLE 6

LAKE KOOL — SCENARIO E

FELSTEAL PTY. LTD. — VOLUMETRIC CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES					
PROSPECT:		LAKE KOOL		DATE: 05-Dec-91	
LOCATION:		PEL 50			
STATE:		SOUTH AUSTRALIA			
COUNTRY:		AUSTRALIA			
REMARKS:		CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES USING THE ASSUMPTIONS LISTED BELOW.			
PARAMETERS		RESULTS			
TWT CLOSURE (SECONDS)	0.04		PRIMARY	SECONDARY	ULTIMATE
DEPTH CLOSURE (FEET):	144	RECOVERABLE BBL/ACRE FOOT:	222	74	296
AREAL EXTENT (SQ KM):	9				
AREAL EXTENT (ACRES):	2,223				
POROSITY:	15%				
OIL SATURATION:	70%				
SHRINKAGE FACTOR:	1.1	TOTAL RECOVERABLE RESERVES (BBL):	49,900,000	16,600,000	66,500,000
PRIMARY REC. FACTOR:	30%				
ULTIMATE REC. FACTOR:	40%				
PRODUCTIVE ACRES:	2,223				
NET PAY (FEET):	101				
PRODUCTIVE ACRE FEET	224,576				

NOTES:

- 1) ASSUMES 70% OF VERTICAL CLOSURE = EFFECTIVE NET PAY
- 2) ASSUMES 100% OF TOTAL AREAL EXTENT = PRODUCTIVE AREA
- 3) ASSUMES 2,200 M/S (7,216 FT/S) AVERAGE VELOCITY TO TOP NAMUR
- 4) TOTAL RECOVERABLE RESERVE FIGURES ARE ROUNDED TO NEAREST 100,000 BARRELS

TABLE 7
LAKESIDE — SCENARIO 1C

FELSTEAL PTY. LTD. — VOLUMETRIC CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES					
PROSPECT: LAKESIDE		DATE: 05-Dec-91			
LOCATION: PEL 50					
STATE: SOUTH AUSTRALIA					
COUNTRY: AUSTRALIA					
REMARKS: CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES USING THE ASSUMPTIONS LISTED BELOW.					
PARAMETERS		RESULTS			
TWT CLOSURE (SECONDS)	0.09		PRIMARY	SECONDARY	ULTIMATE
DEPTH CLOSURE (FEET):	325	RECOVERABLE BBL/ACRE FOOT:	222	74	296
AREAL EXTENT (SQ KM):	31				
AREAL EXTENT (ACRES):	7,657				
POROSITY:	15%				
OIL SATURATION:	70%				
SHRINKAGE FACTOR:	1.1	TOTAL RECOVERABLE RESERVES (BBL):	34,800,000	11,600,000	46,400,000
PRIMARY REC. FACTOR:	30%				
ULTIMATE REC. FACTOR:	40%				
PRODUCTIVE ACRES:	7,657				
NET PAY (FEET):	20				
PRODUCTIVE ACRE FEET	156,642				

NOTES:

- 1) ASSUMES 6% OF VERTICAL CLOSURE = EFFECTIVE NET PAY
- 2) ASSUMES 100% OF TOTAL AREAL EXTENT = PRODUCTIVE AREA
- 3) ASSUMES 2,200 M/S (7,216 FT/S) AVERAGE VELOCITY TO TOP NAMUR
- 4) TOTAL RECOVERABLE RESERVE FIGURES ARE ROUNDED TO NEAREST 100,000 BARRELS

TABLE 8

LAKESIDE — SCENARIO 1E

FELSTEAL PTY. LTD. — VOLUMETRIC CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES					
PROSPECT: LAKESIDE		DATE: 05-Dec-91			
LOCATION: PEL 50					
STATE: SOUTH AUSTRALIA					
COUNTRY: AUSTRALIA					
REMARKS: CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES USING THE ASSUMPTIONS LISTED BELOW.					
PARAMETERS		RESULTS			
TWT CLOSURE (SECONDS)	0.09		PRIMARY	SECONDARY	ULTIMATE
DEPTH CLOSURE (FEET):	325	RECOVERABLE BBL/ACRE FOOT:	222	74	296
AREAL EXTENT (SQ KM):	31				
AREAL EXTENT (ACRES):	7,657				
POROSITY:	15%				
OIL SATURATION:	70%				
SHRINKAGE FACTOR:	1.1	TOTAL RECOVERABLE RESERVES (BBL):	386,700,000	128,900,000	515,600,000
PRIMARY REC. FACTOR:	30%				
ULTIMATE REC. FACTOR:	40%				
PRODUCTIVE ACRES:	7,657				
NET PAY (FEET):	227				
PRODUCTIVE ACRE FEET	1,740,467				

NOTES:

- 1) ASSUMES 70% OF VERTICAL CLOSURE = EFFECTIVE NET PAY
- 2) ASSUMES 100% OF TOTAL AREAL EXTENT = PRODUCTIVE AREA
- 3) ASSUMES 2,200 M/S (7,216 FT/S) AVERAGE VELOCITY TO TOP NAMUR
- 4) TOTAL RECOVERABLE RESERVE FIGURES ARE ROUNDED TO NEAREST 100,000 BARRELS

TABLE 9
LAKESIDE — SCENARIO 2E

FELSTEAL PTY. LTD. — VOLUMETRIC CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES					
PROSPECT:		LAKESIDE		DATE: 05-Dec-91	
LOCATION:		PEL 50			
STATE:		SOUTH AUSTRALIA			
COUNTRY:		AUSTRALIA			
REMARKS:		CALCULATION OF POTENTIAL RECOVERABLE OIL RESERVES USING THE ASSUMPTIONS LISTED BELOW.			
PARAMETERS		RESULTS			
			PRIMARY	SECONDARY	ULTIMATE
TWT CLOSURE (SECONDS)	0.12				
DEPTH CLOSURE (FEET):	433				
AREAL EXTENT (SQ KM):	70				
AREAL EXTENT (ACRES):	17,290	RECOVERABLE			
POROSITY:	15%	BBL/ACRE FOOT:	222	74	296
OIL SATURATION:	70%				
SHRINKAGE FACTOR:	1.1				
PRIMARY REC. FACTOR:	30%				
ULTIMATE REC. FACTOR:	40%				
PRODUCTIVE ACRES:	17,290	TOTAL			
NET PAY (FEET):	303	RECOVERABLE	1,164,100,000	388,000,000	1,552,200,000
PRODUCTIVE ACRE FEET	5,240,115	RESERVES (BBL):			

NOTES:

- 1) ASSUMES 70% OF VERTICAL CLOSURE = EFFECTIVE NET PAY
- 2) ASSUMES 100% OF TOTAL AREAL EXTENT = PRODUCTIVE AREA
- 3) ASSUMES 2,200 M/S (7,216 FT/S) AVERAGE VELOCITY TO TOP NAMUR
- 4) TOTAL RECOVERABLE RESERVE FIGURES ARE ROUNDED TO NEAREST 100,000 BARRELS

27°30'

137°30'

138°00'

27°30'

28°00'

28°00'

137°30'

138°00'

8553-1

FELSTEA PTY. LTD.1801 BROADWAY - SUITE 1550 - DENVER, COLORADO 80202 U.S.A.
PHONE (303) 293-3953 FAX (303) 293-3954**PEL 50 - S W EROMANGA BASIN****C TIME STRUCTURE****TOP CADNA-OWIE FM.**

C.I. 10 ms

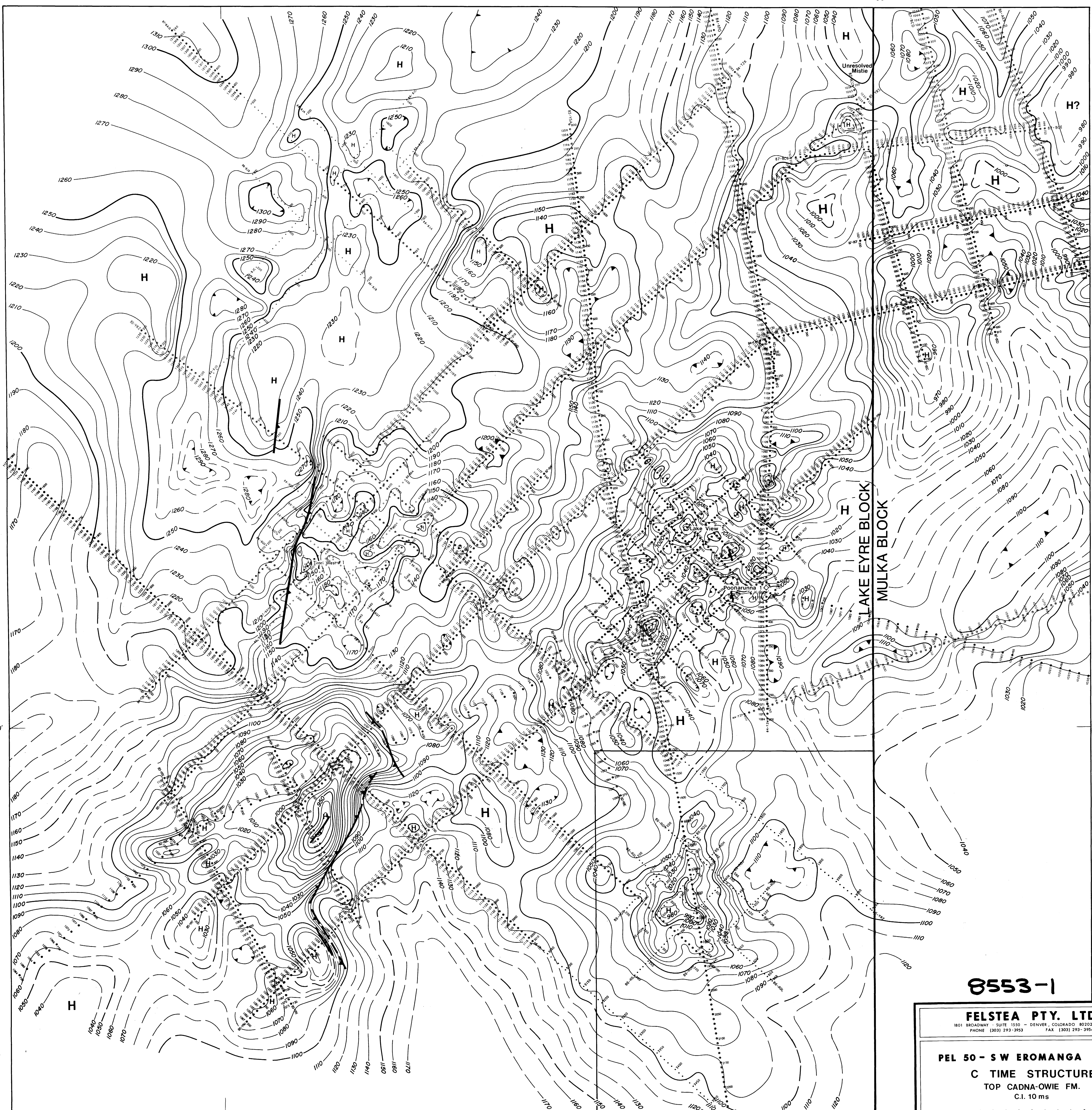
KILOMETRES 1 2 3 4 5 6 7 KILOMETRES

TRANSVERSE MERCATOR PROJECTION CLARKE 1858

DATUM: M. S. L. SOURCE: SANTOS LTD.

DATE: JANUARY, 1988 AUTHOR: N. GIBBONS

REVISED: PLATE 1



ENV. 5553

27°30'

137°30'

138°00'

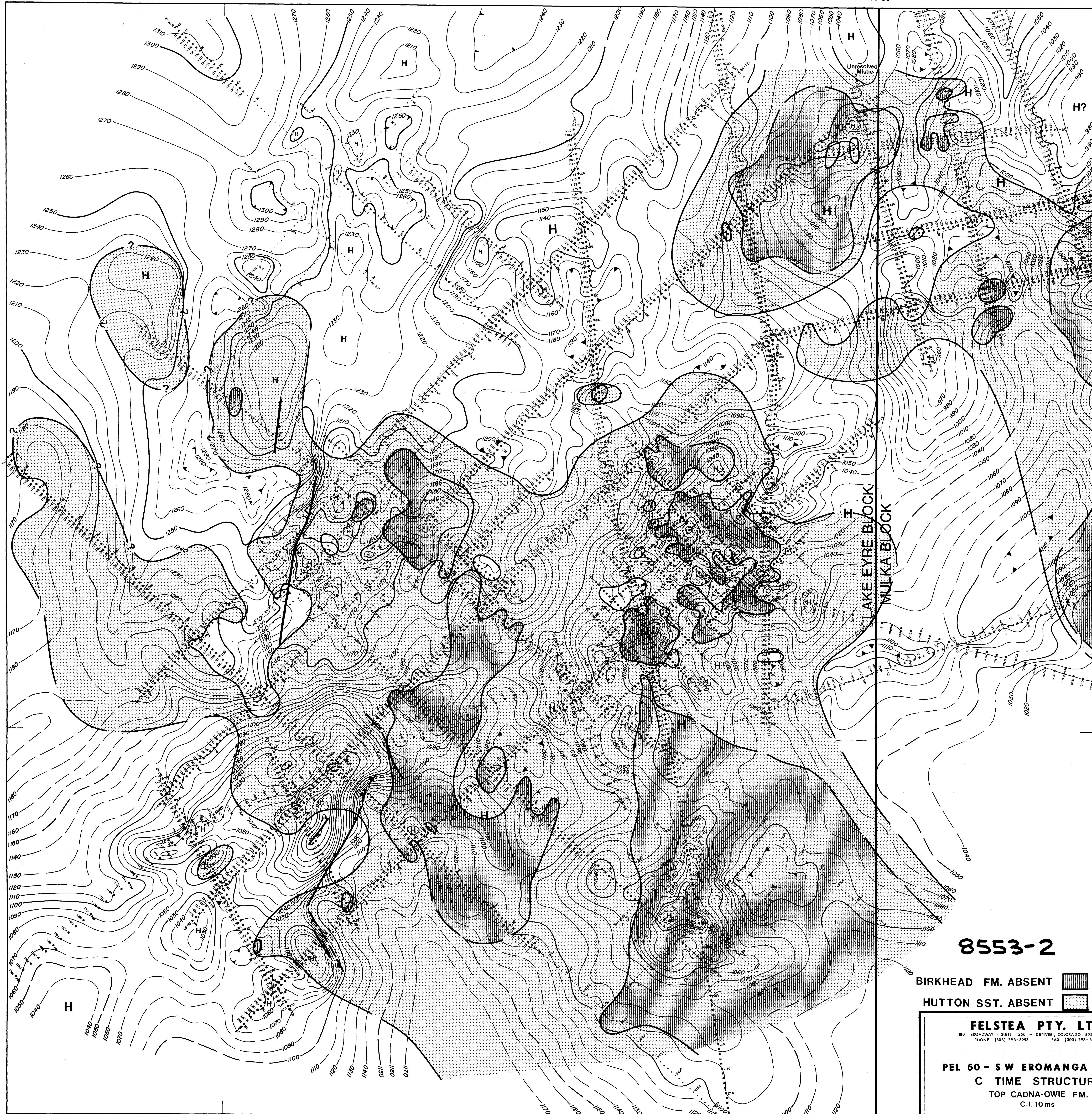
27°30'

28°00'

28°00'

137°30'

138°00'



8553-2

BIRKHEAD FM. ABSENT

HUTTON SST. ABSENT

FELSTEALTY. LTD.1801 BROADWAY SUITE 1550 - DENVER, COLORADO 80202 U.S.A.
PHONE (303) 293-3953 FAX (303) 293-3954

PEL 50 - SW EROMANGA BASIN
C TIME STRUCTURE
 TOP CADNA-OWIE FM.
 C.I. 10 ms

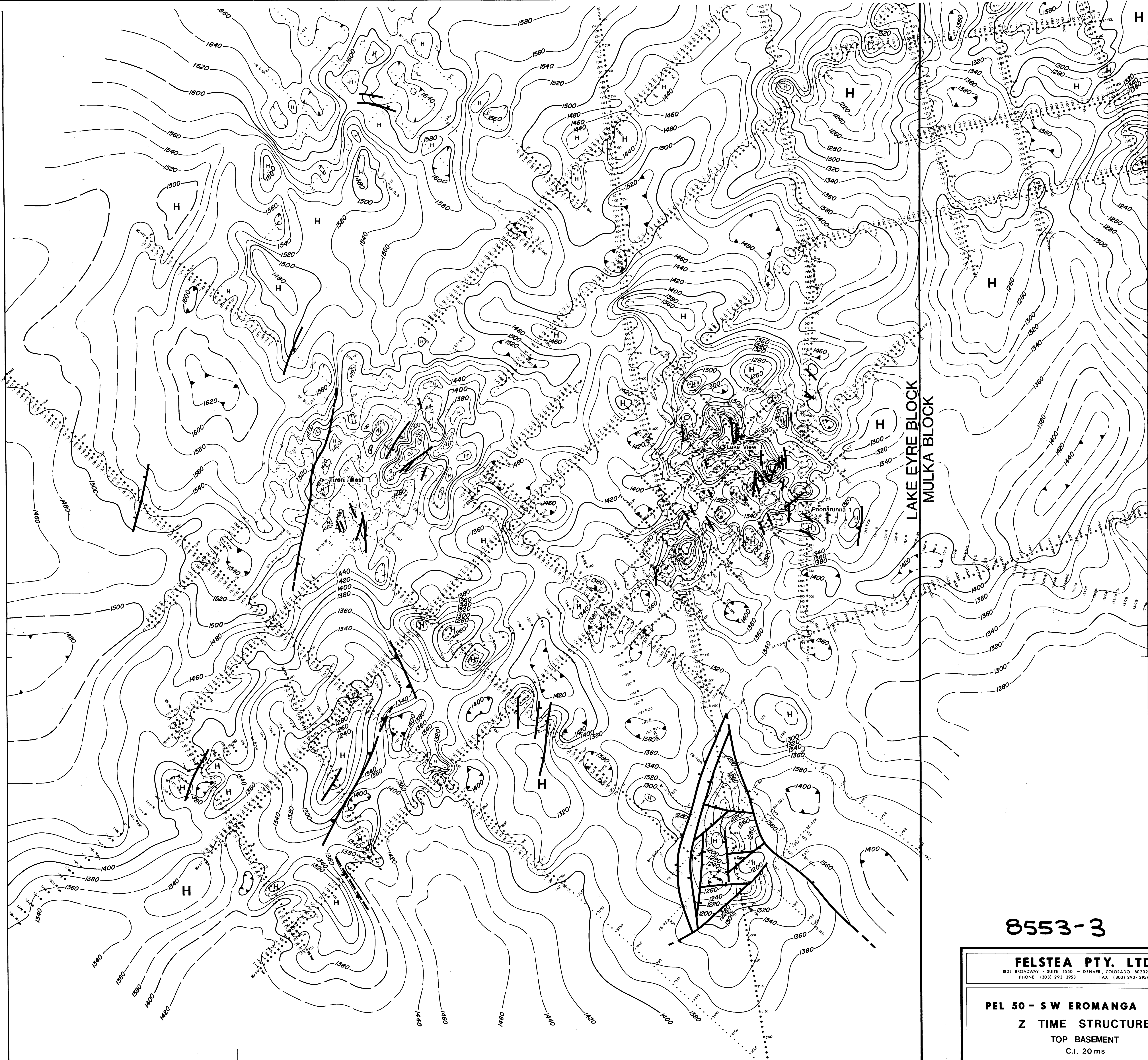
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TRANSVERSE MERCATOR PROJECTION CLARKE 1858

DATUM: M. S. L. SOURCE: SANTOS LTD.

DATE: JANUARY, 1988 AUTHOR: N. GIBBONS

REVISED: PLATE 2



8553-3

FELSTEA PTY. LTD.
1801 BROADWAY - SUITE 1550 - DENVER, COLORADO 80202 U.S.A.
PHONE (303) 293-3953 FAX (303) 293-3954

PEL 50 - S W EROMANGA BASIN
Z TIME STRUCTURE
TOP BASEMENT
C.I. 20 ms

1 0 2 3 4 5 7 KILOMETRES

TRANSVERSE MERCATOR PROJECTION CLARKE 1858

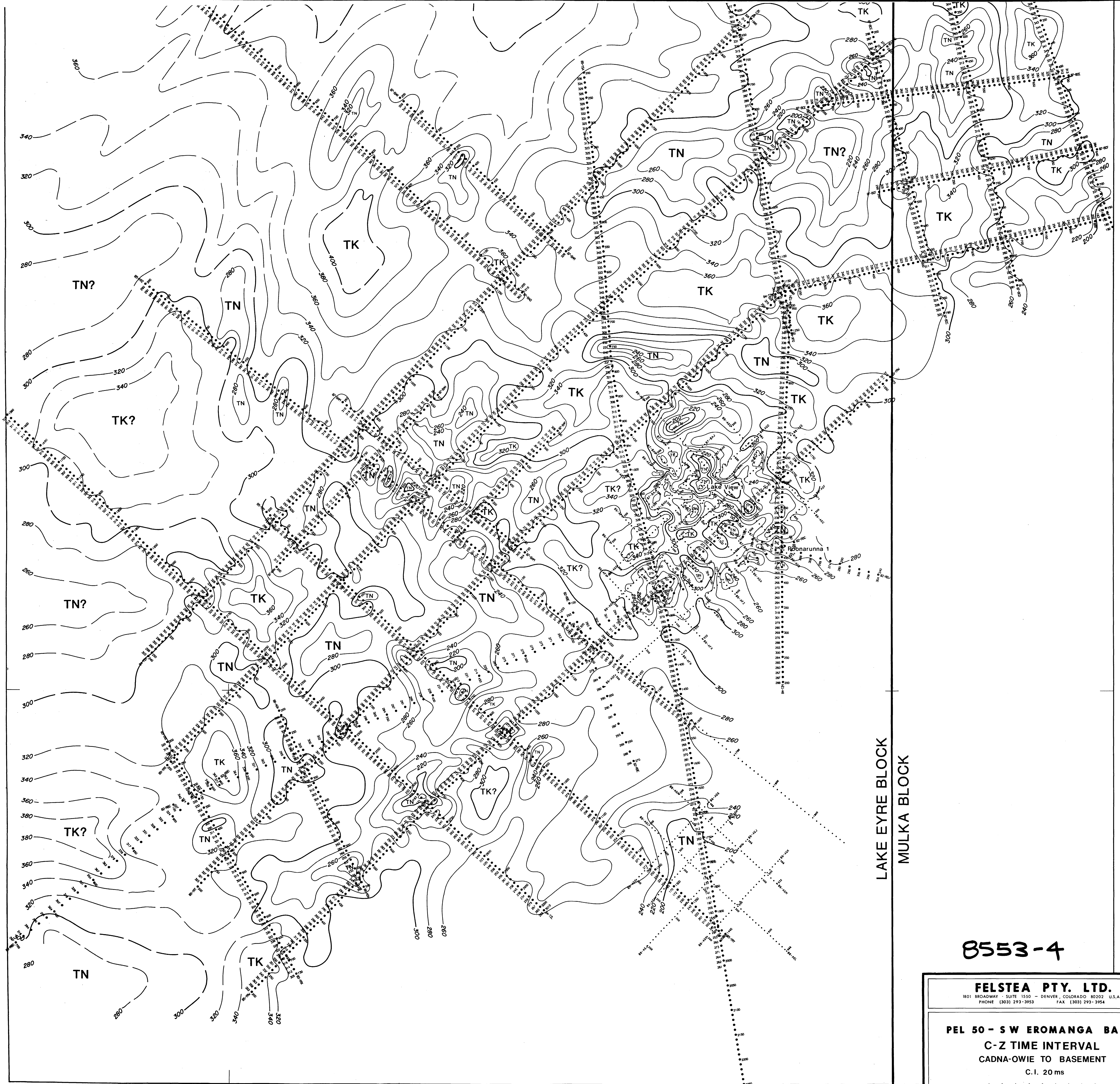
DATUM : M. S. L.	SOURCE : SANTOS LTD.
DATE : JANUARY, 1988	AUTHOR : N. GIBBONS
REVISED :	

PLATE 3

138°00'

137°30'

Env. 8553



LAKE EYRE BLOCK
MULKA BLOCK

8553-4

FELSTEAL PTY. LTD.
1801 BROADWAY SUITE 1550 - DENVER, COLORADO 80202 U.S.A.
PHONE (303) 293-3953 FAX (303) 293-3954

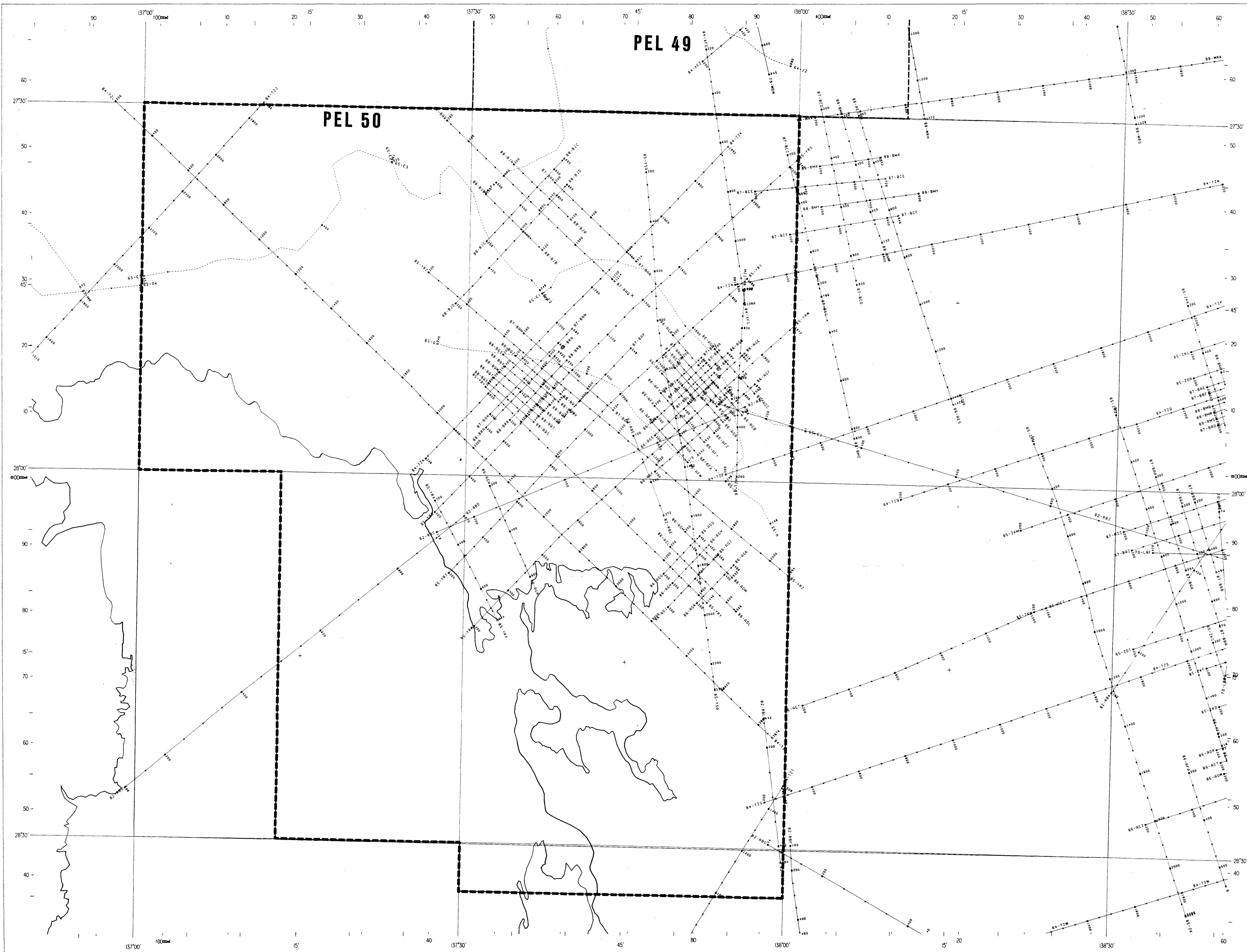
PEL 50 - SW EROMANGA BASIN
C-Z TIME INTERVAL
CADNA-OWIE TO BASEMENT
C.I. 20 ms

KILOMETRES 0 1 2 3 4 5 6 7 KILOMETRES
TRANSVERSE MERCATOR PROJECTION CLARKE 1858

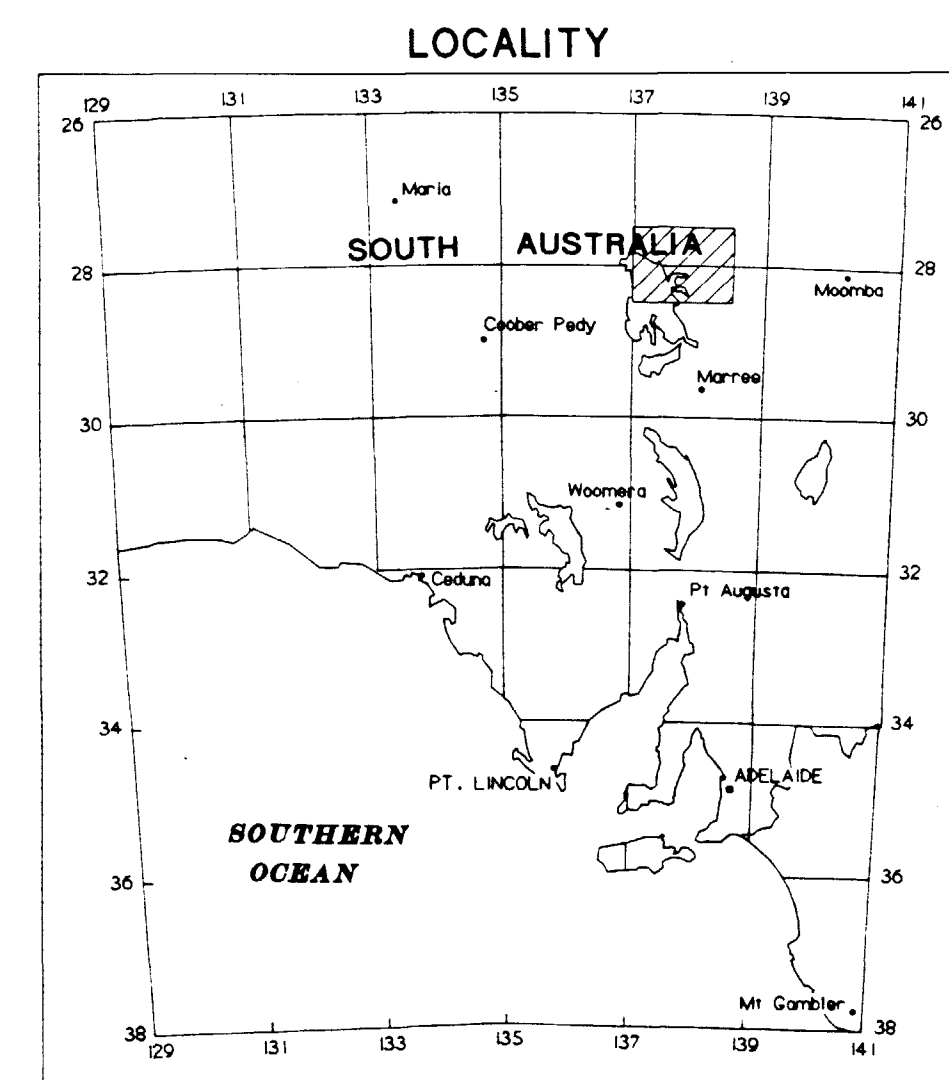
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DATE : JANUARY, 1988	AUTHOR : N. GIBBONS
REVISED :	

PLATE 4

ERN 8553



1962 - 1965



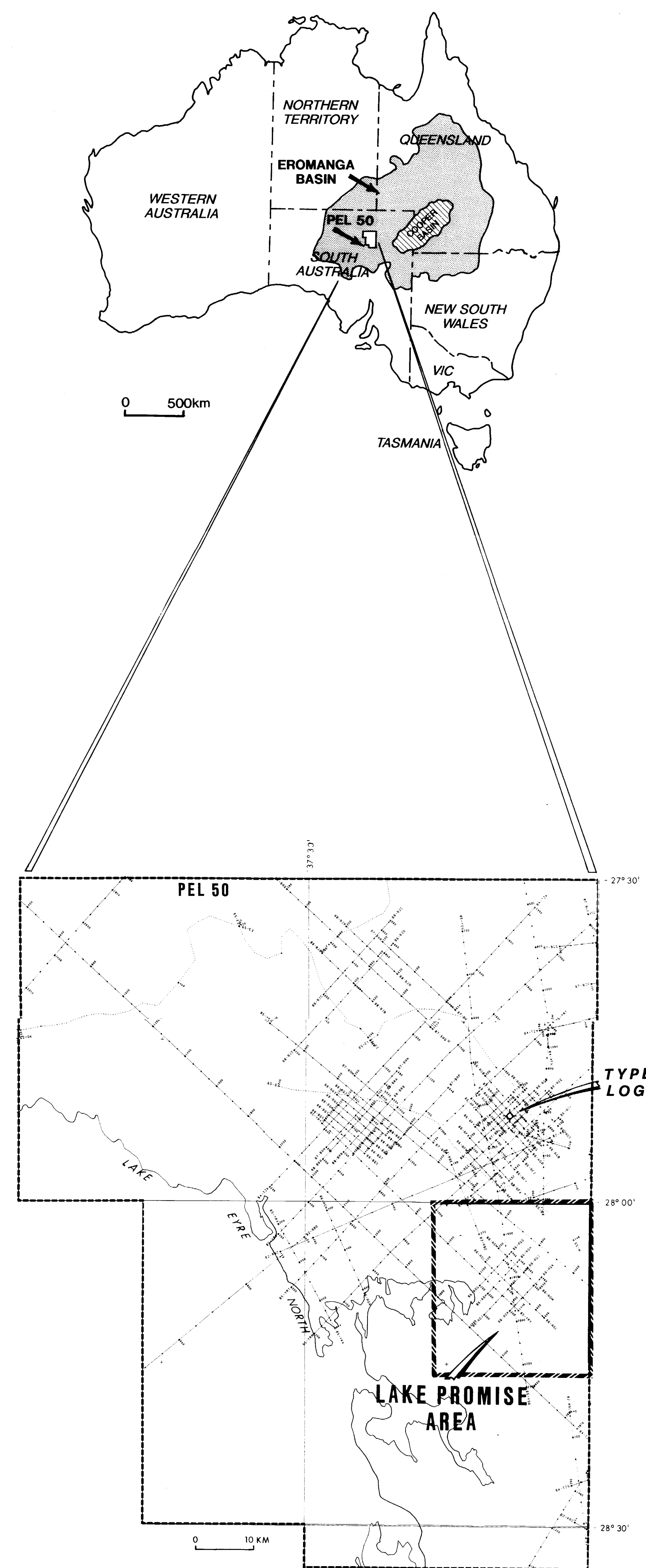
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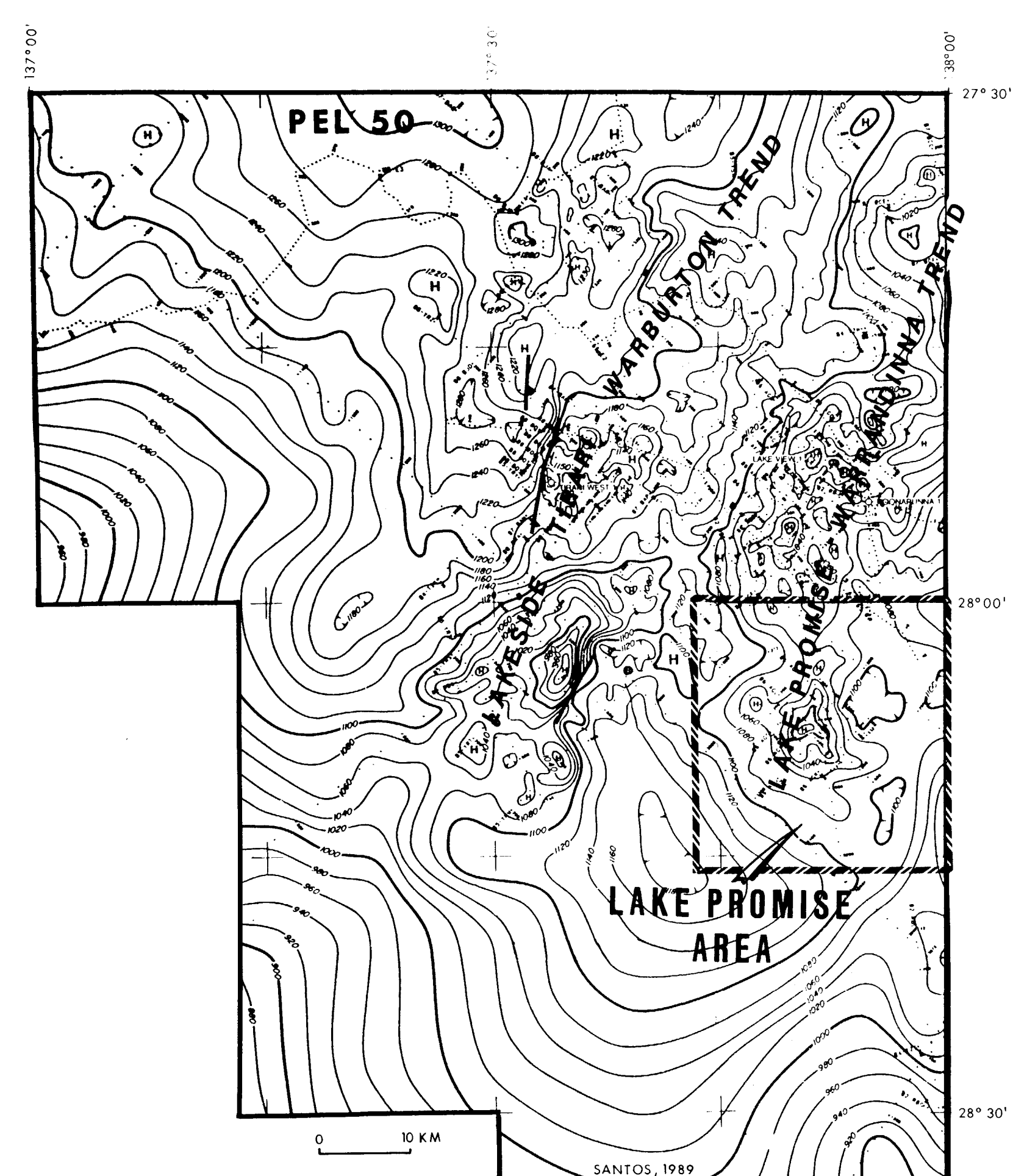
S.A. DEPT. OF MINES AND ENERGY
PETROLEUM GEOPHYSICS
SEISMIC LINE LOCATION MAP
PEL 50
1962 - 1988
TED/GEO - Digital Seismic Shotpoint Database
Date: July 1991 Scale: 1:250,000

Universal Transverse Mercator Projection
Australian National Spheroid
Central Meridian 135 00 00E

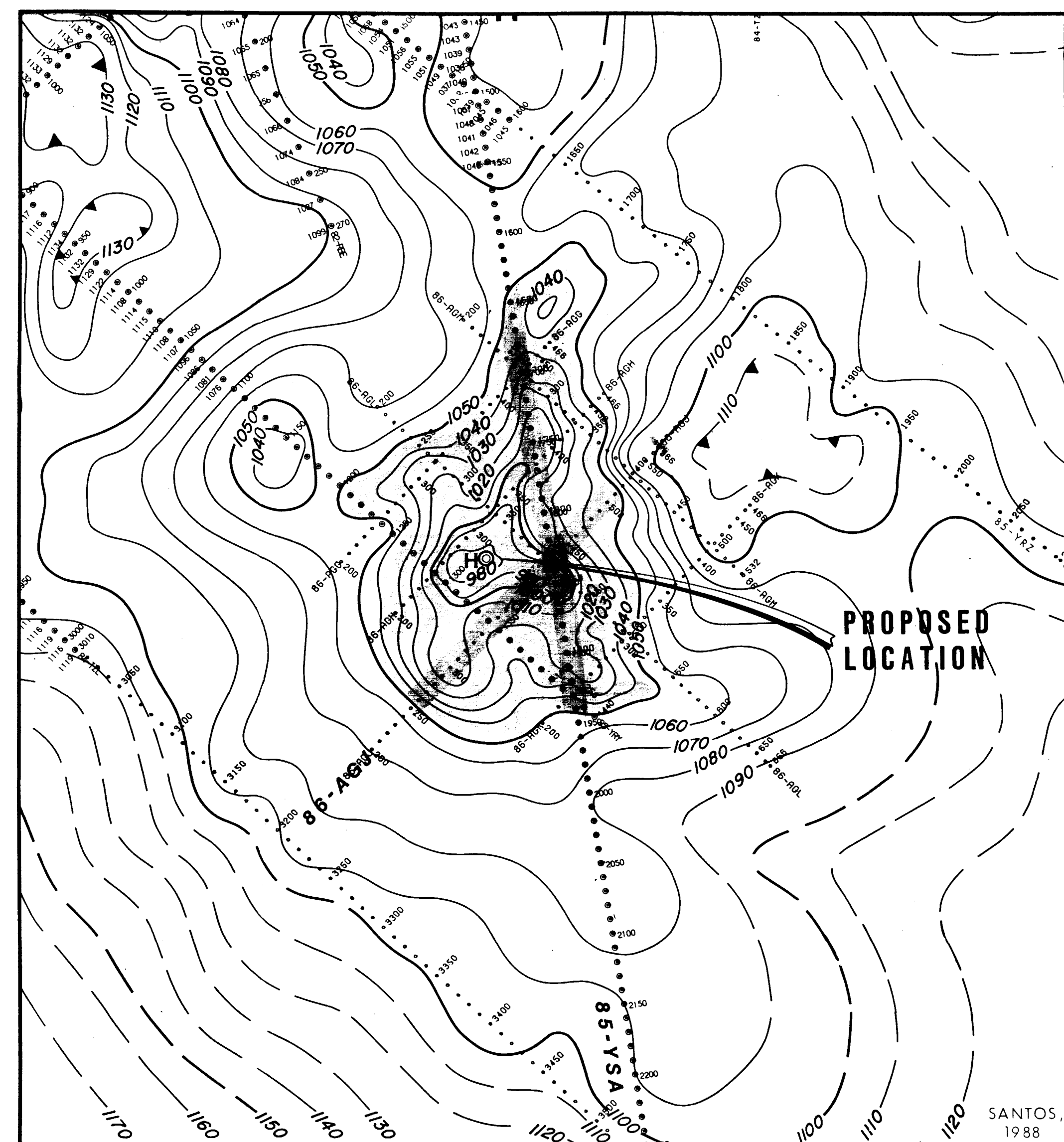
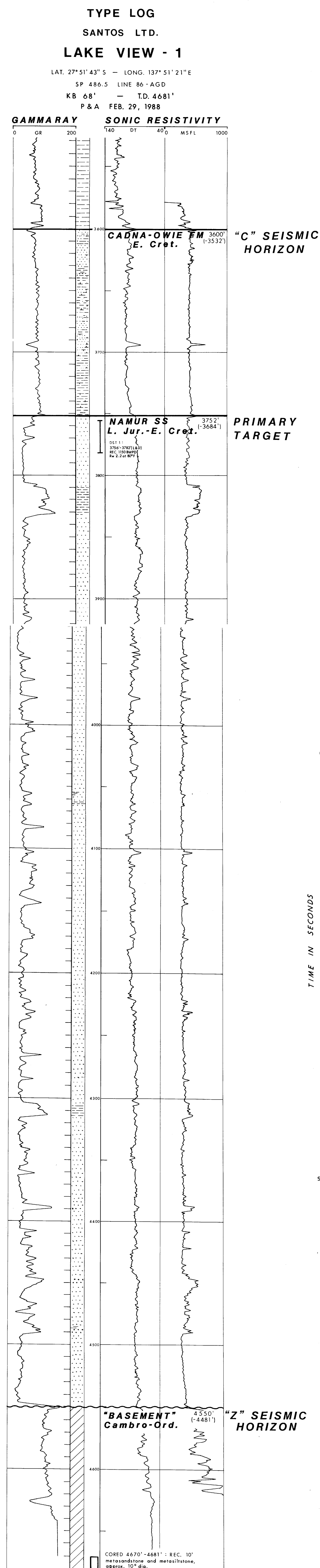
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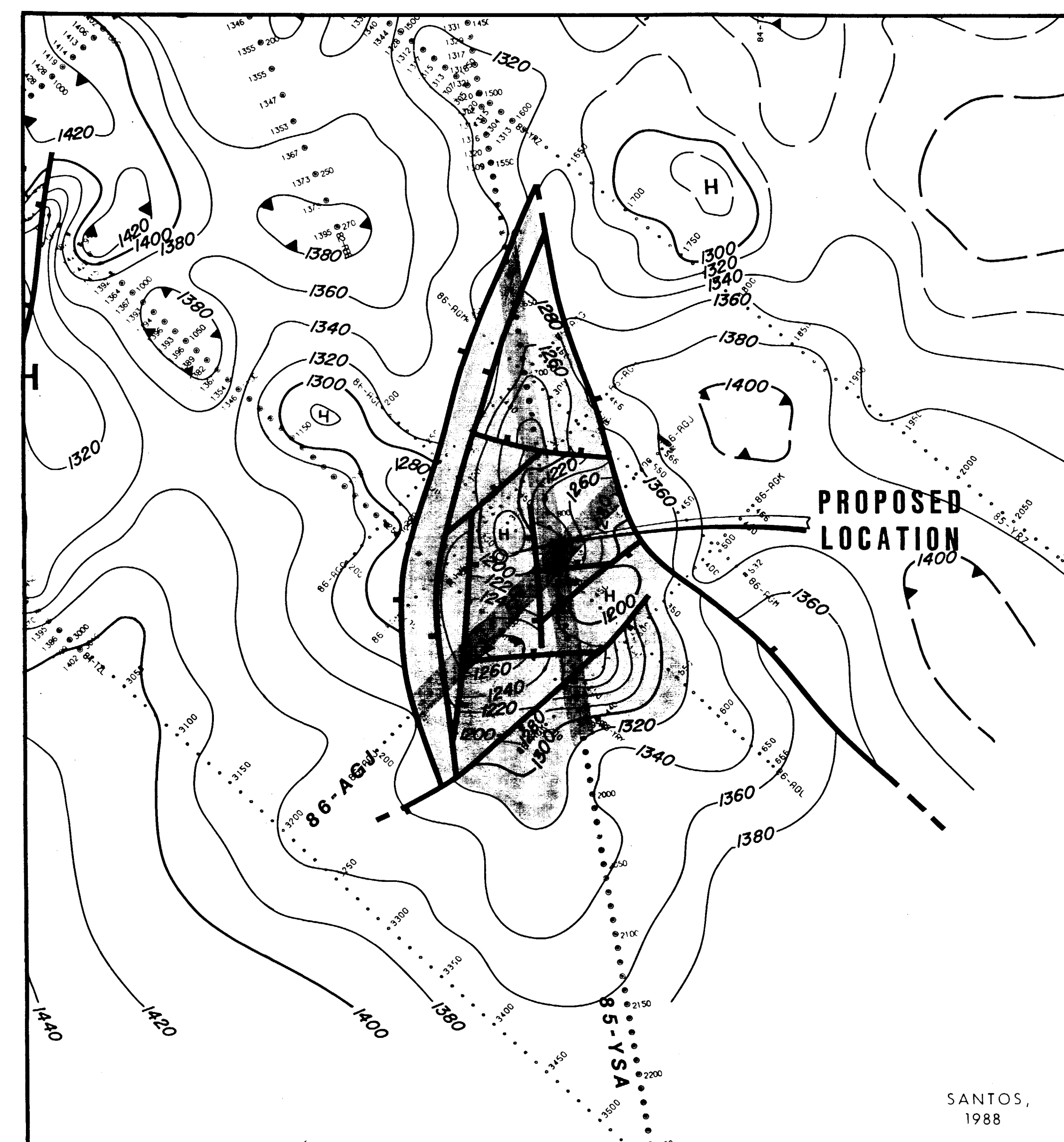
PEL 50
SEISMIC COVERAGE



EARLY CRETACEOUS
"C" HORIZON
TIME STRUCTURE
C.I. 20ms

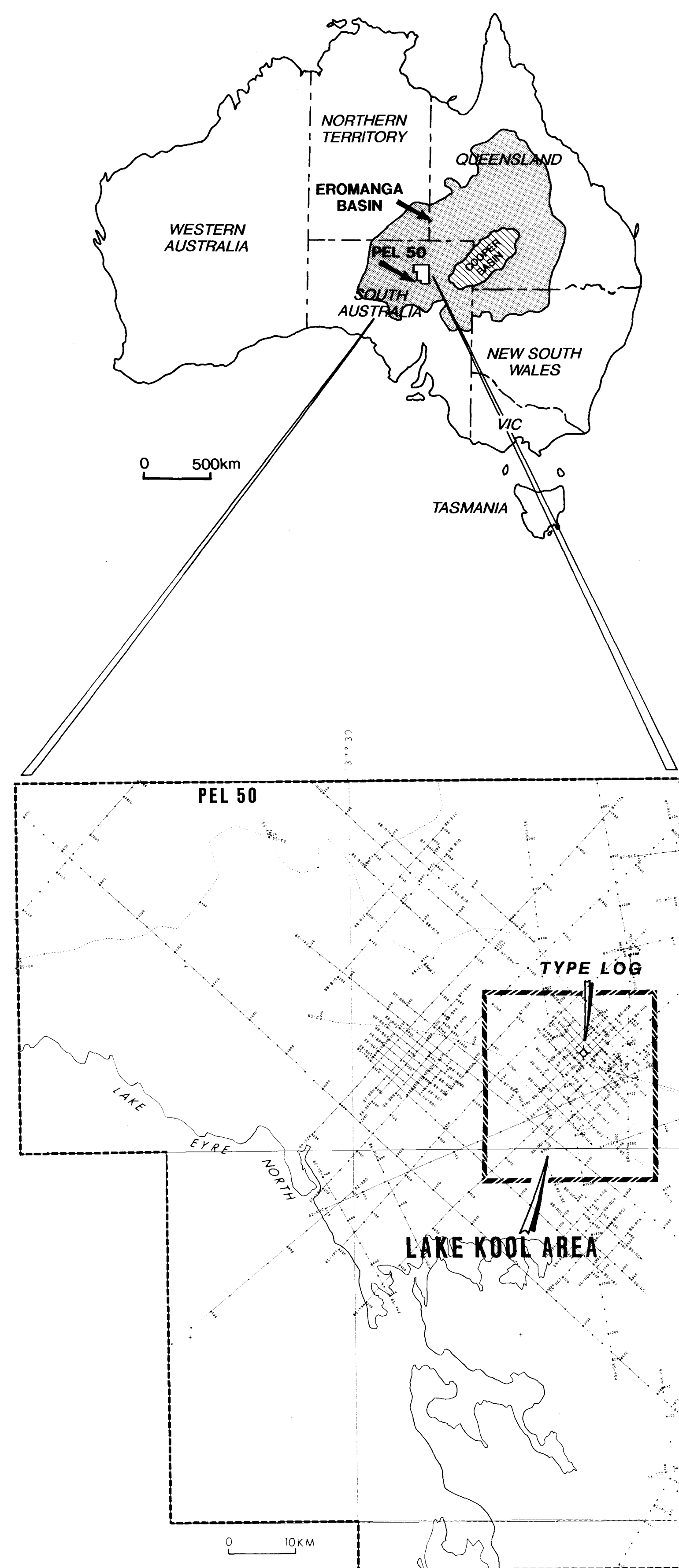
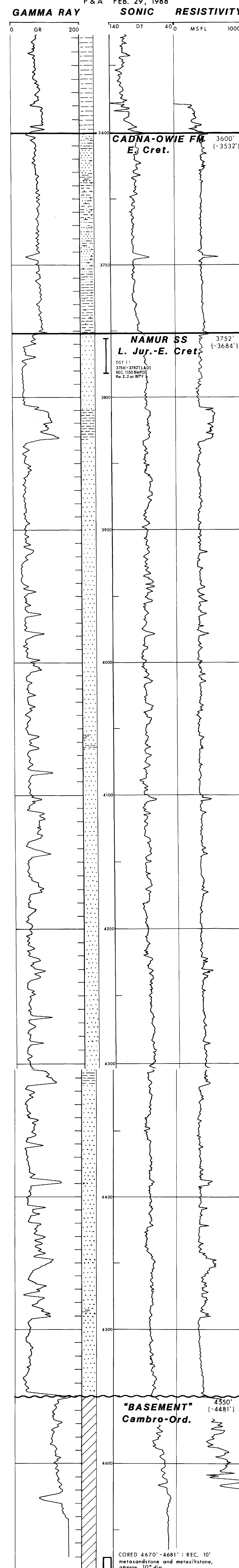


CADNA-OWIE ("C") TIME STRUCTURE
C.I. 10ms

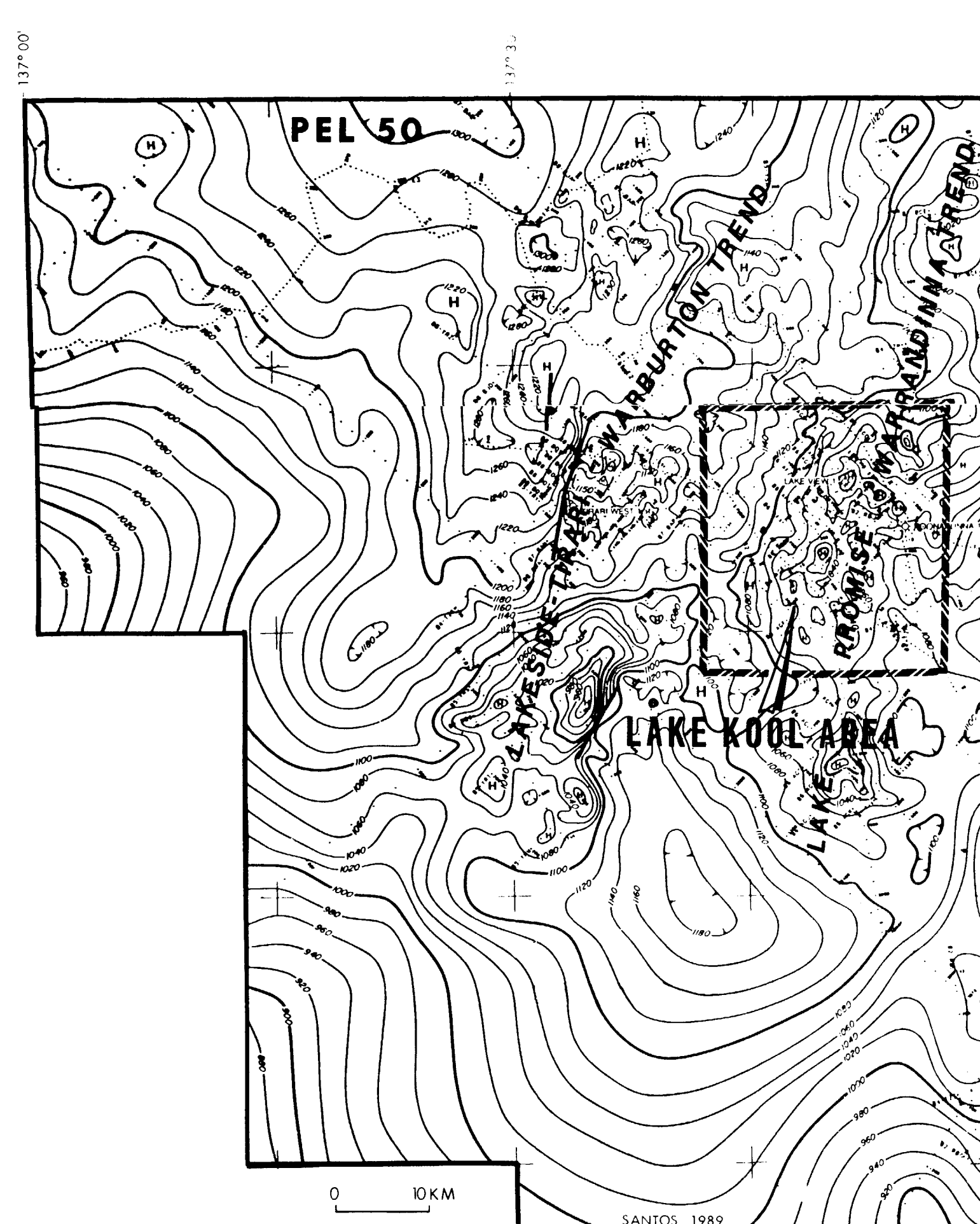


TYPE LOG
SANTOS LTD.
LAKE VIEW - 1

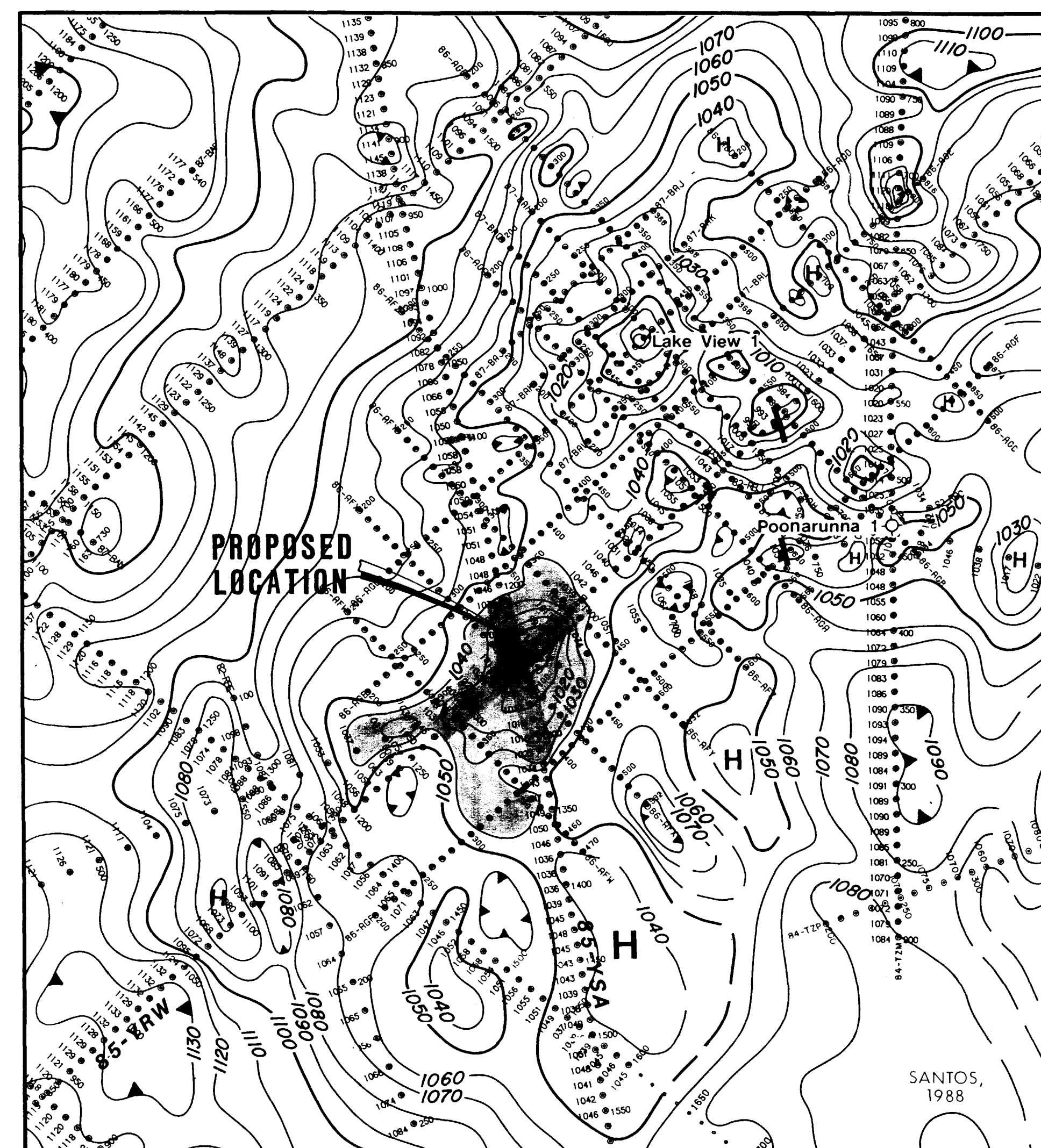
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SP 486.5 LINE 86-AGD
KB 68' FEB. 29, 1988 TD. 4681'
P&A



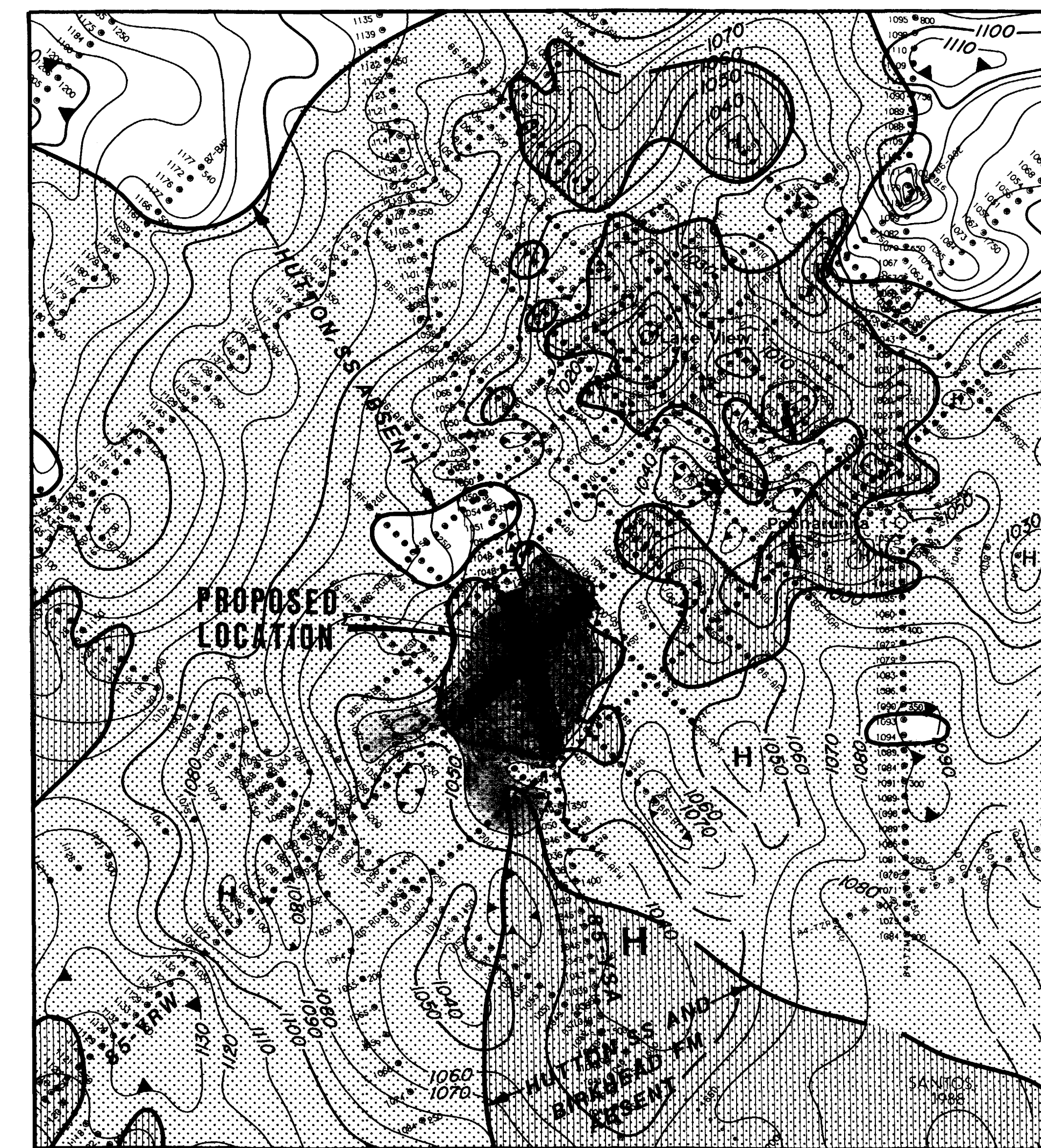
PEL 50
SEISMIC COVERAGE



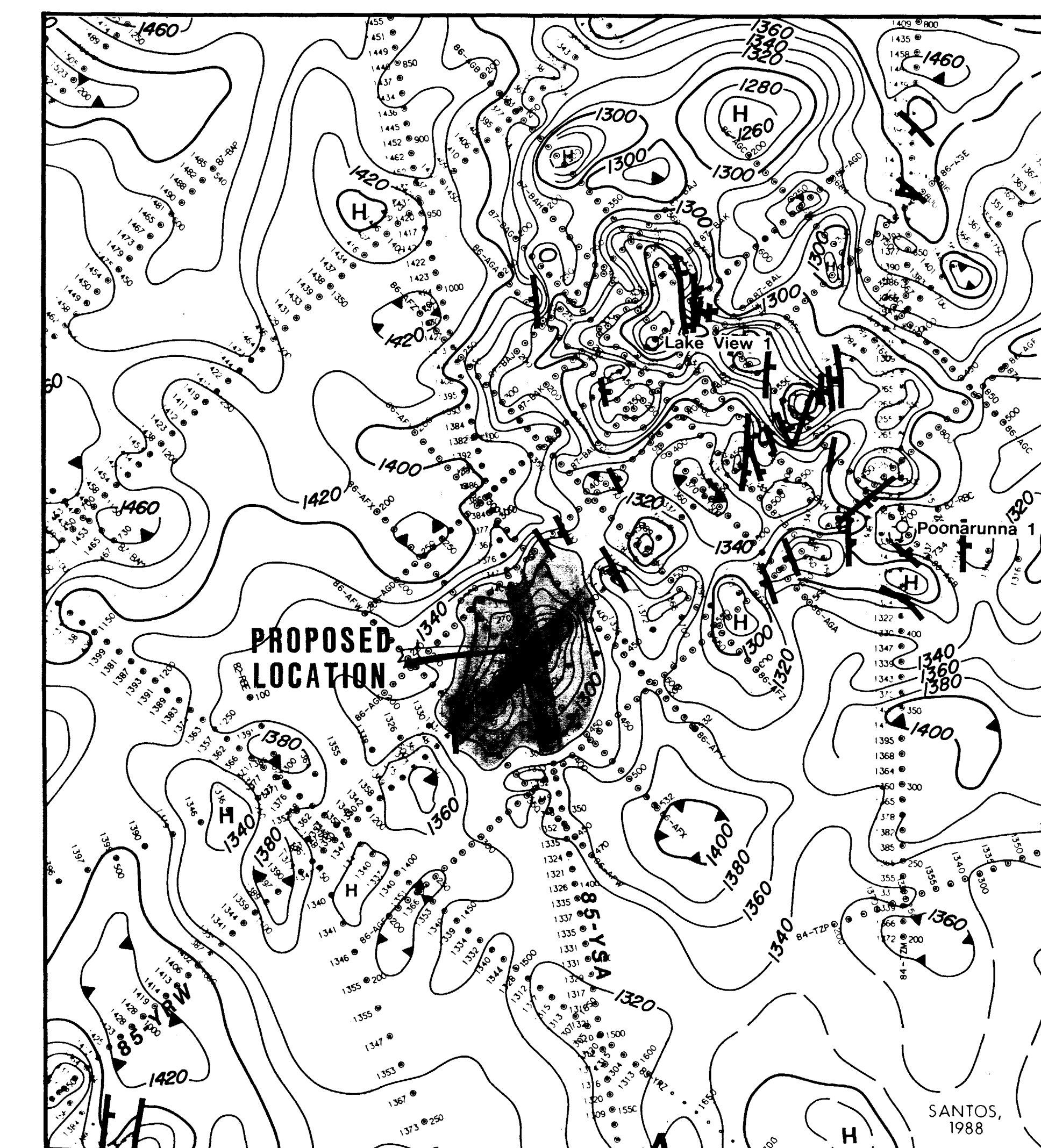
EARLY CRETACEOUS
"C" HORIZON
TIME STRUCTURE
C.I. 20ms



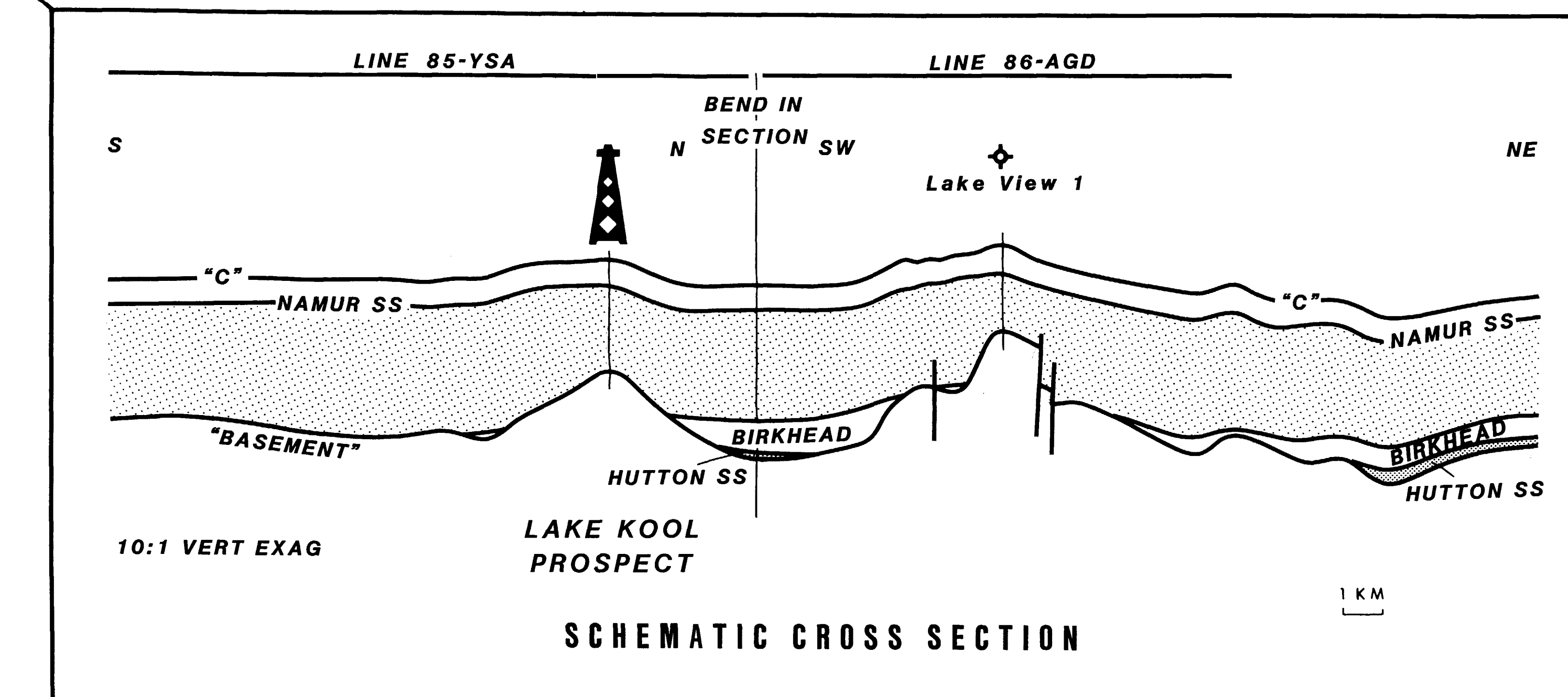
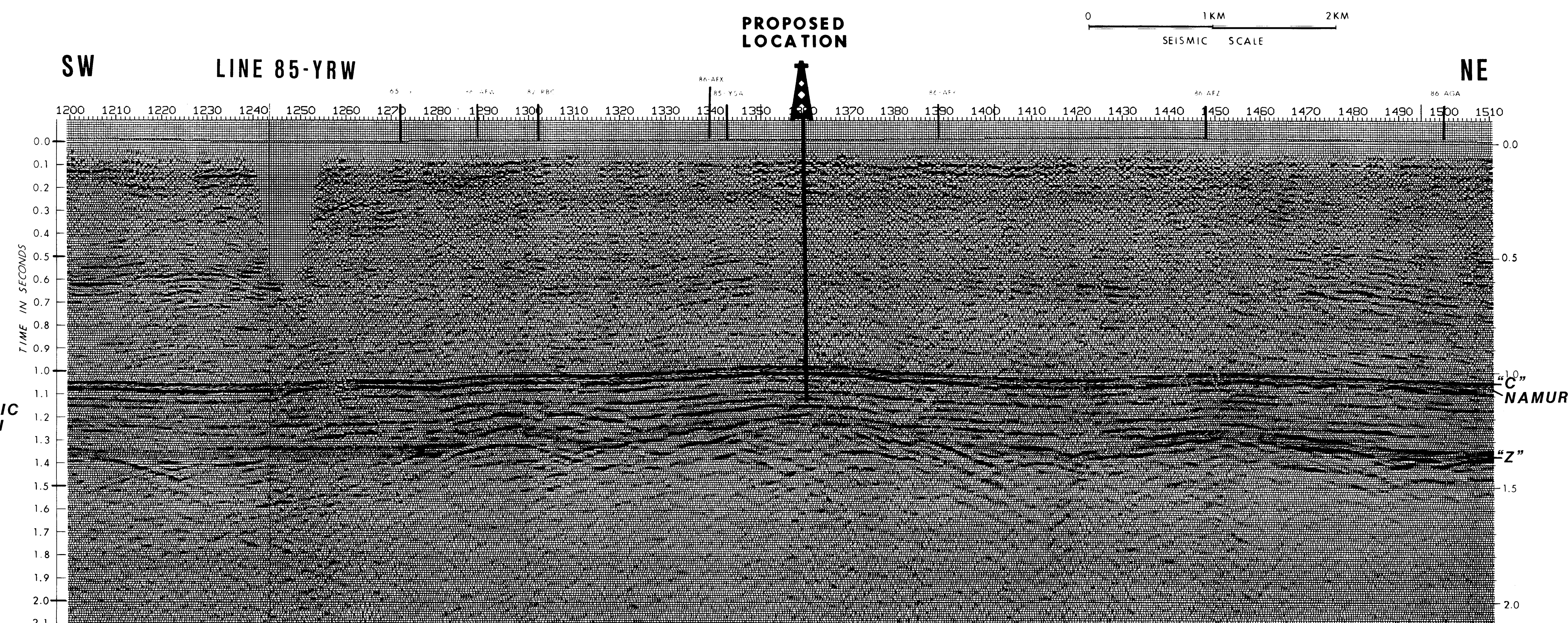
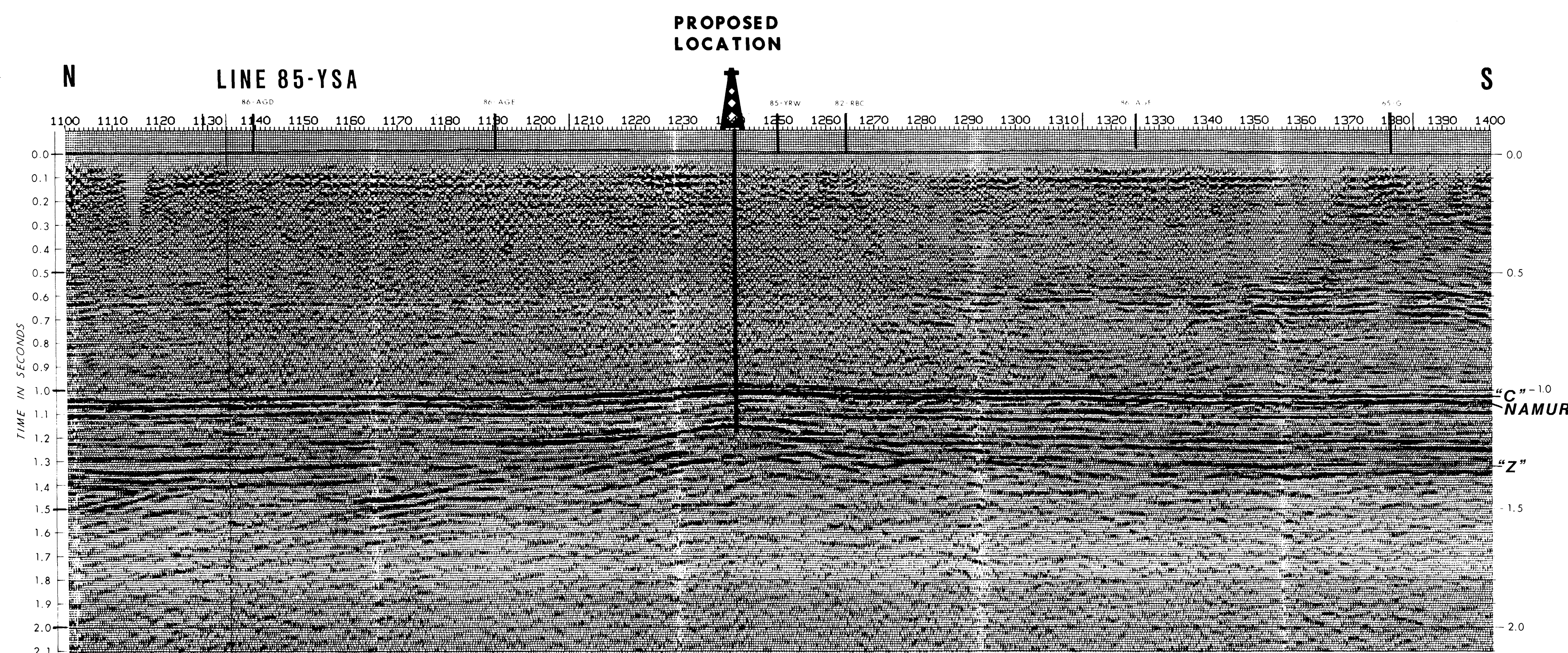
CADNA-OWIE "C" TIME STRUCTURE
C.I. 10ms



DISTRIBUTION OF HUTTON SS RESERVOIR
AND BIRKHEAD FM SOURCE ROCK
C.I. 10ms



"BASEMENT" ("Z") TIME STRUCTURE
C.I. 20ms



LAKE KOOL PROSPECT SUMMARY	
RESERVES:	13 MMBO RECOVERABLE (15% O, 30% Sw, 20' pay, 2225 acres)
CLOSURE:	4200 ACRES 40 ms (144')
TARGETS:	NAMUR SANDSTONE 3750' (1145m) "BASEMENT" 4680' (1427m)

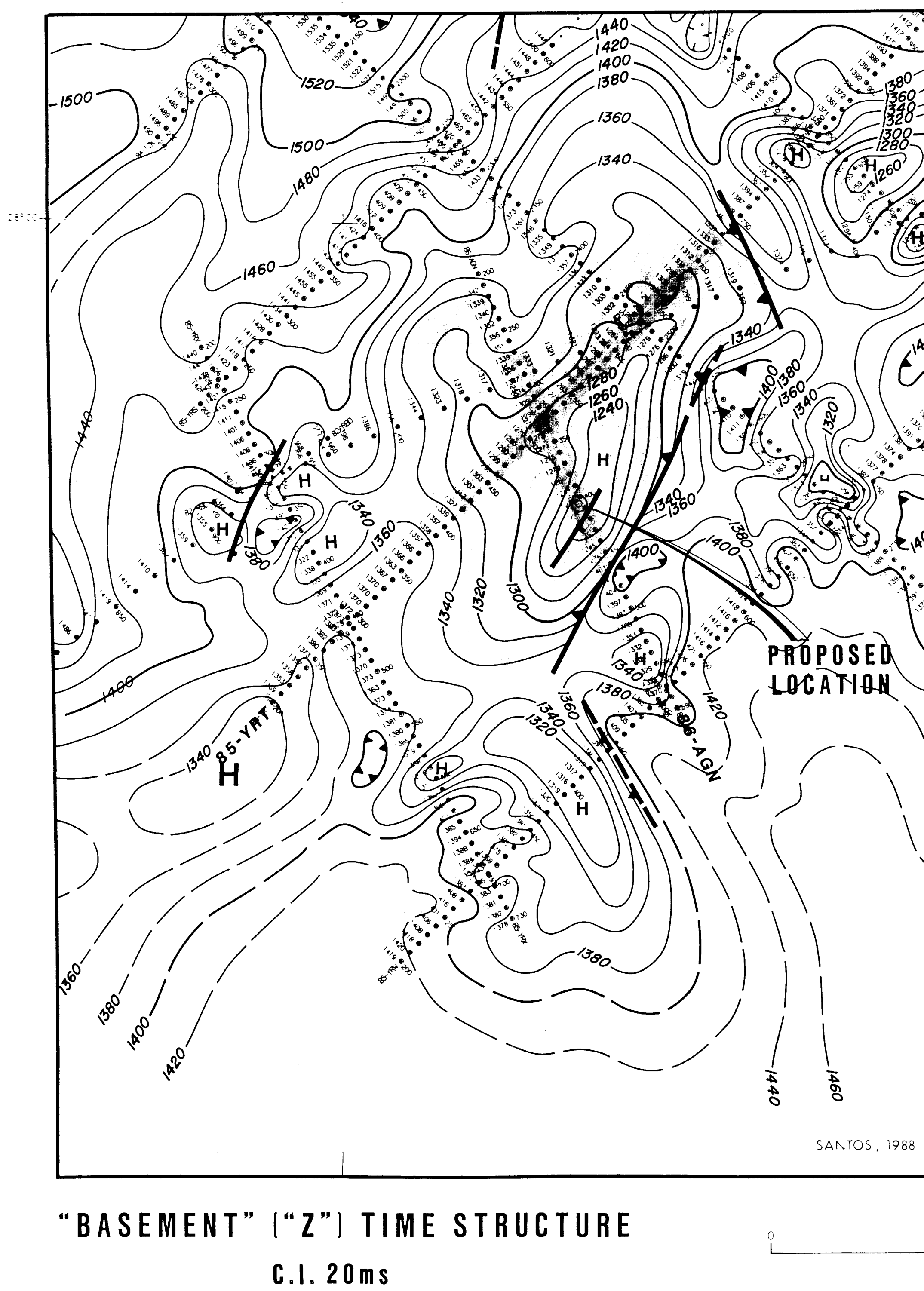
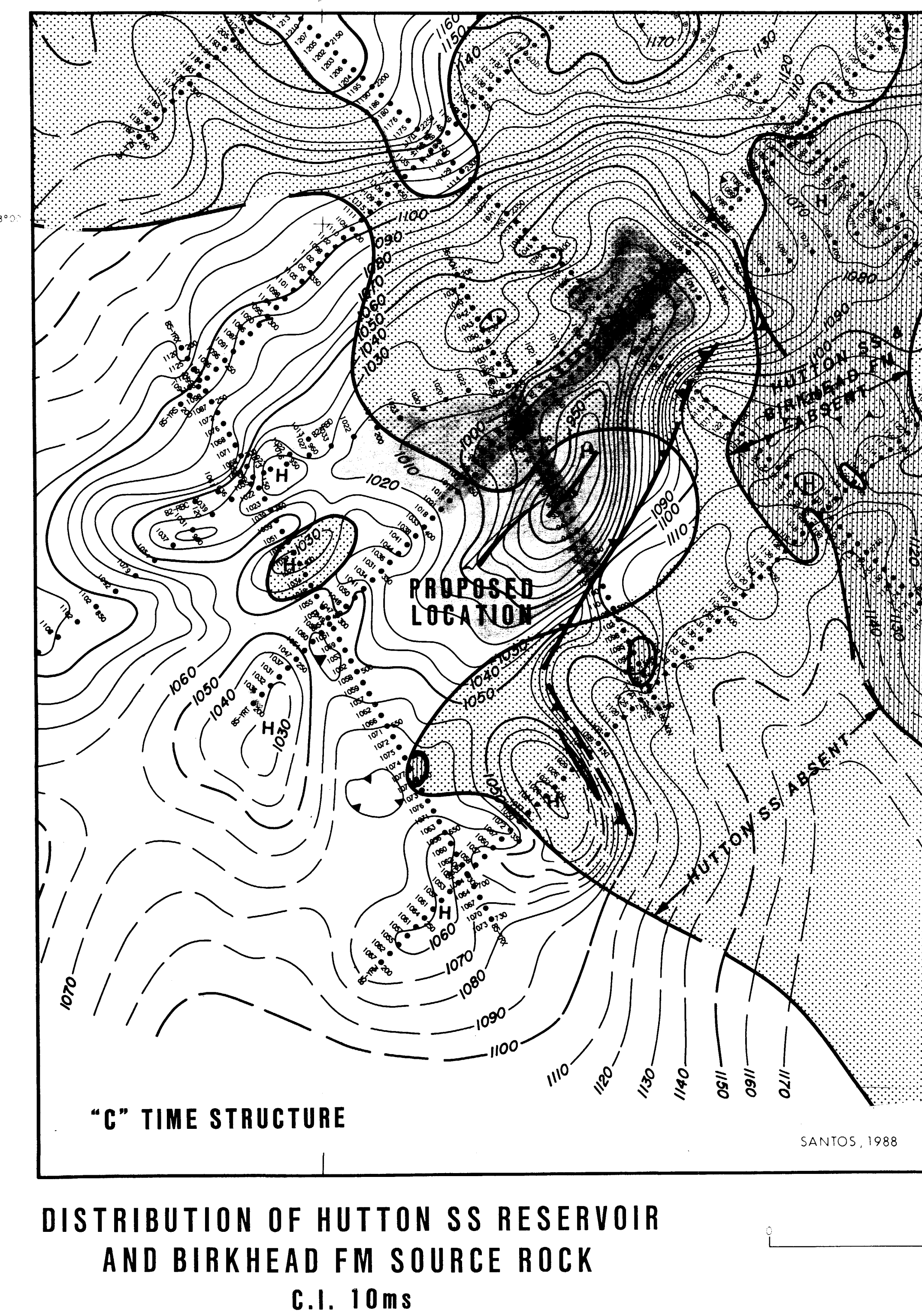
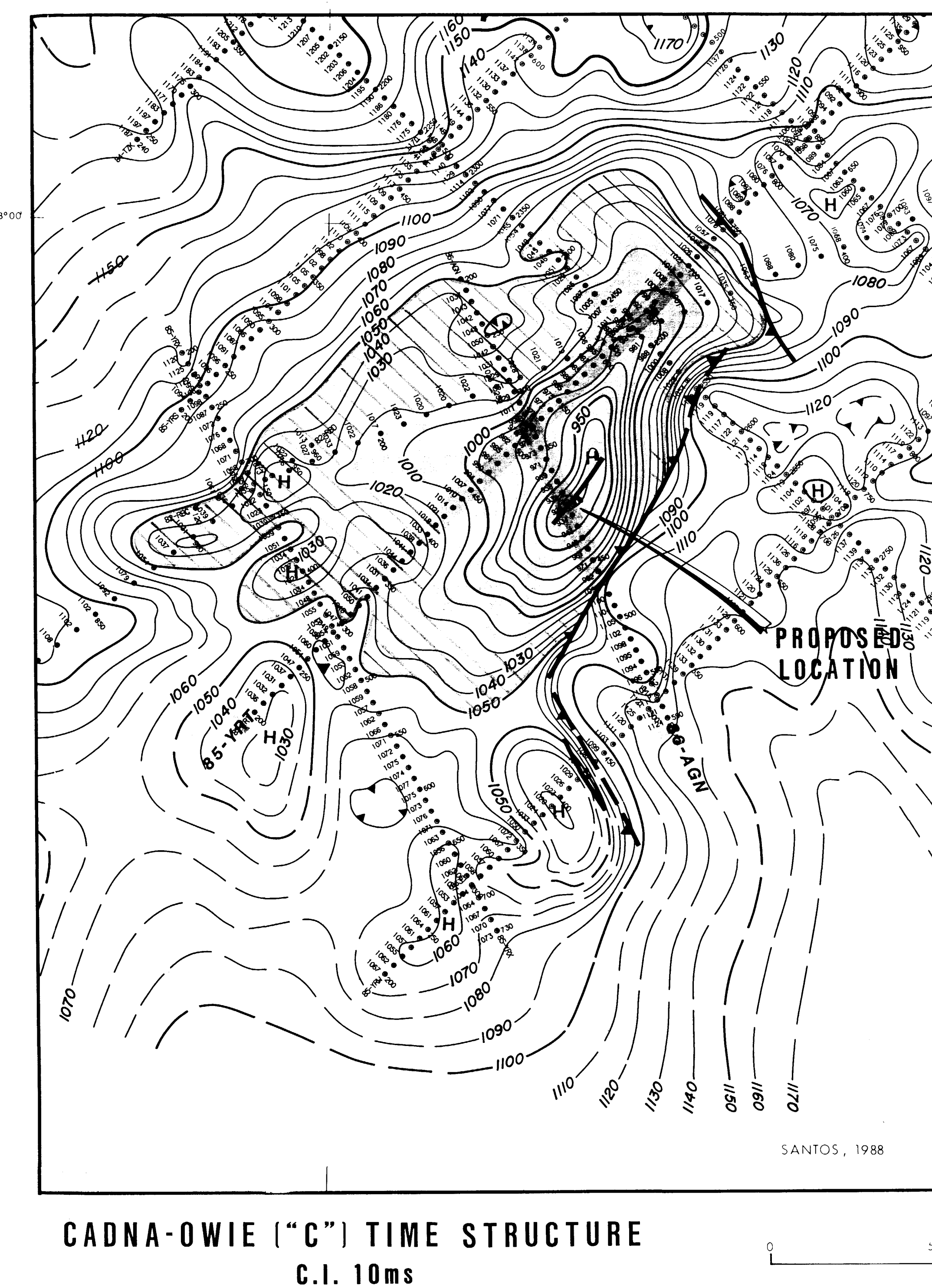
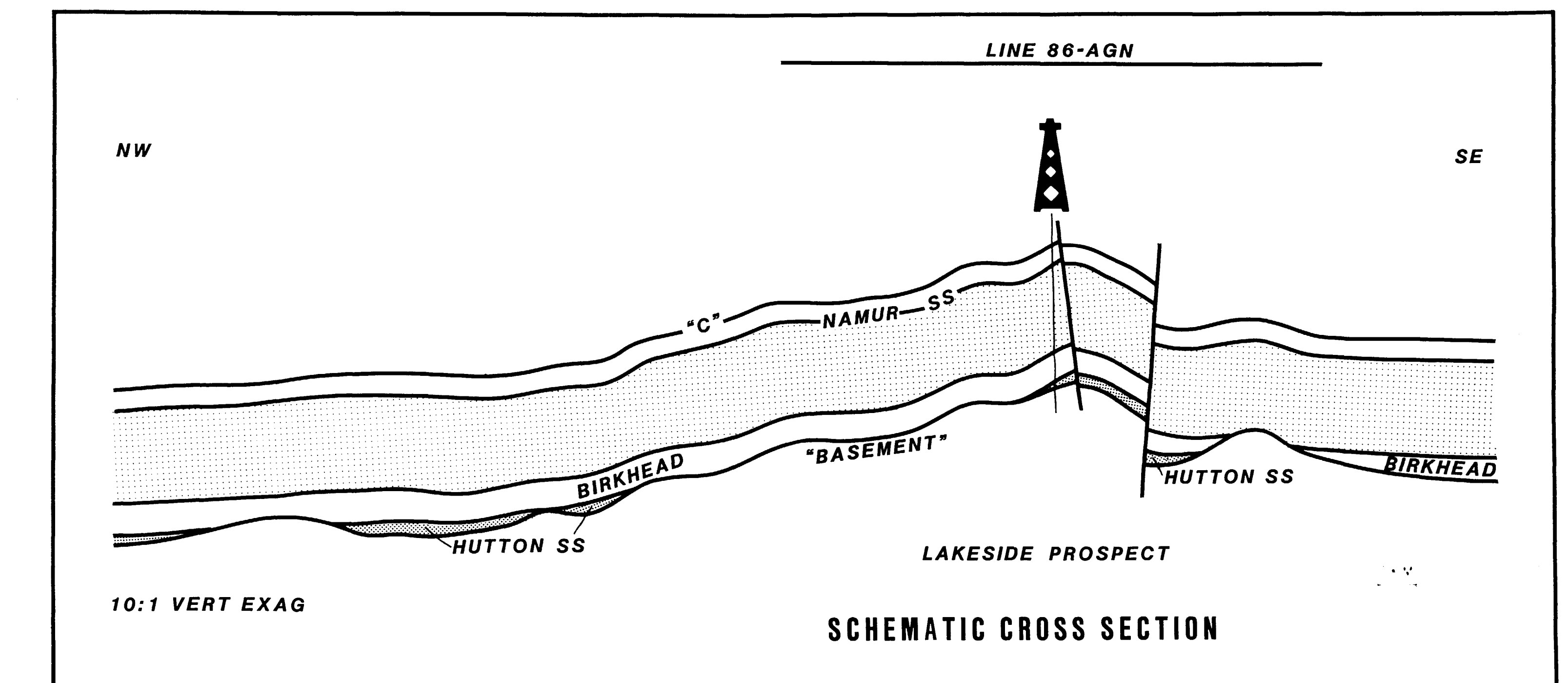
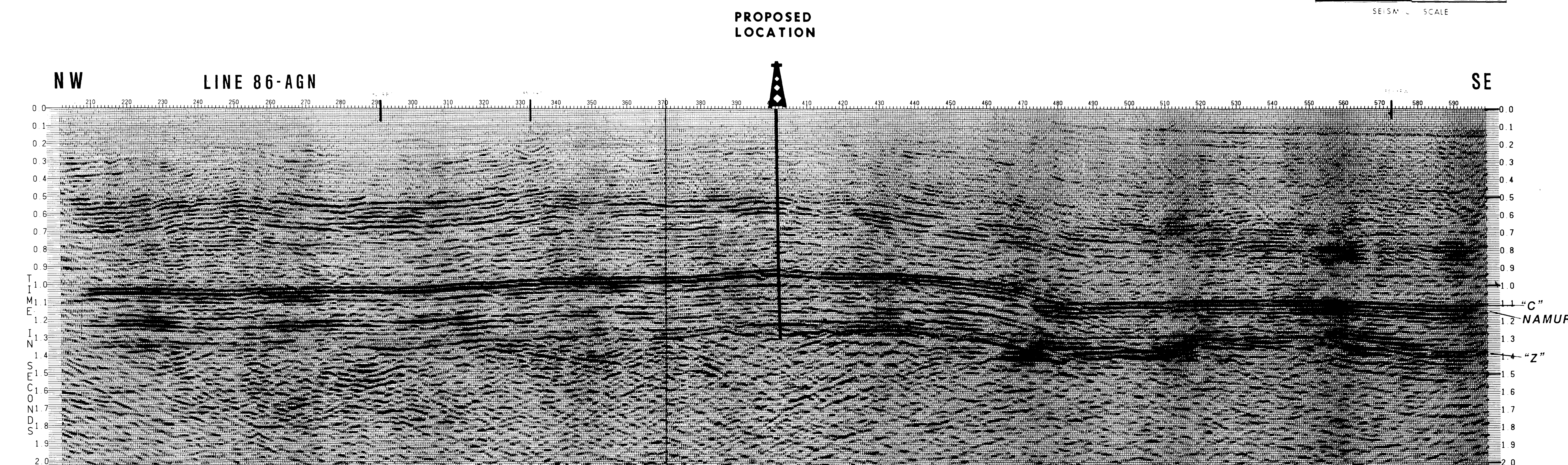
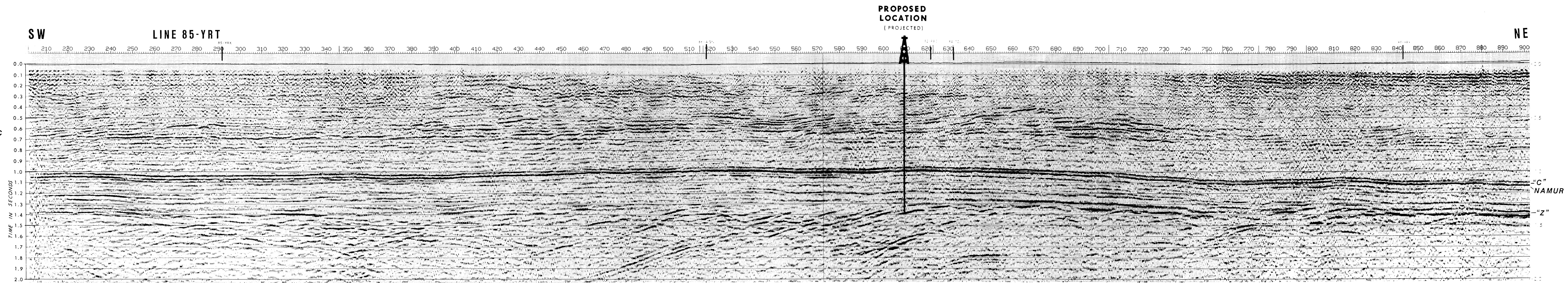
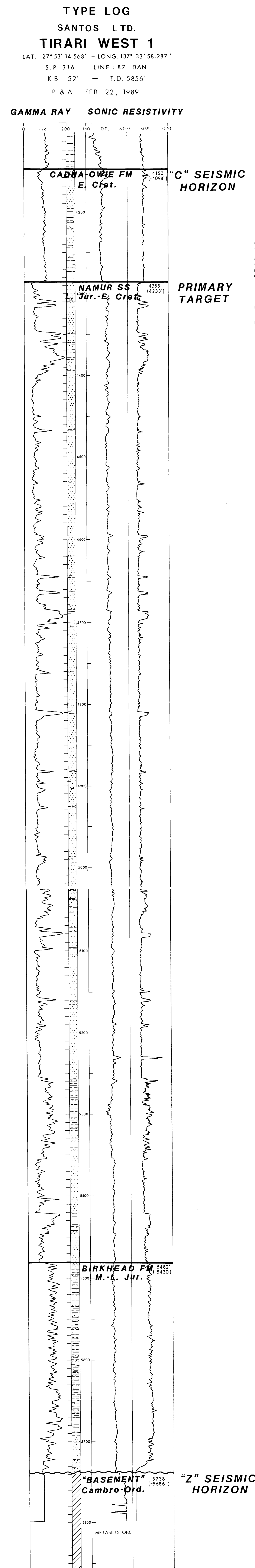
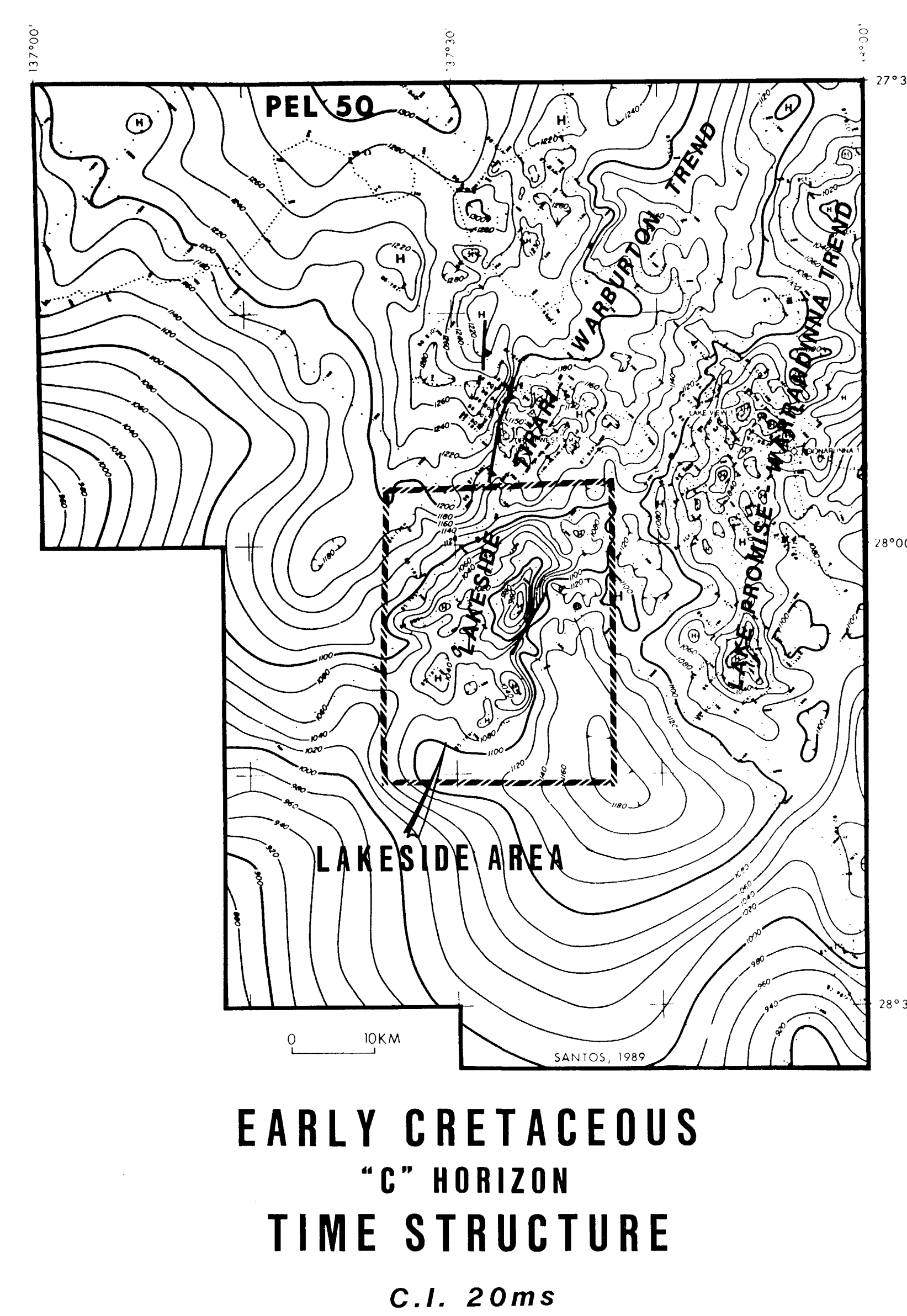
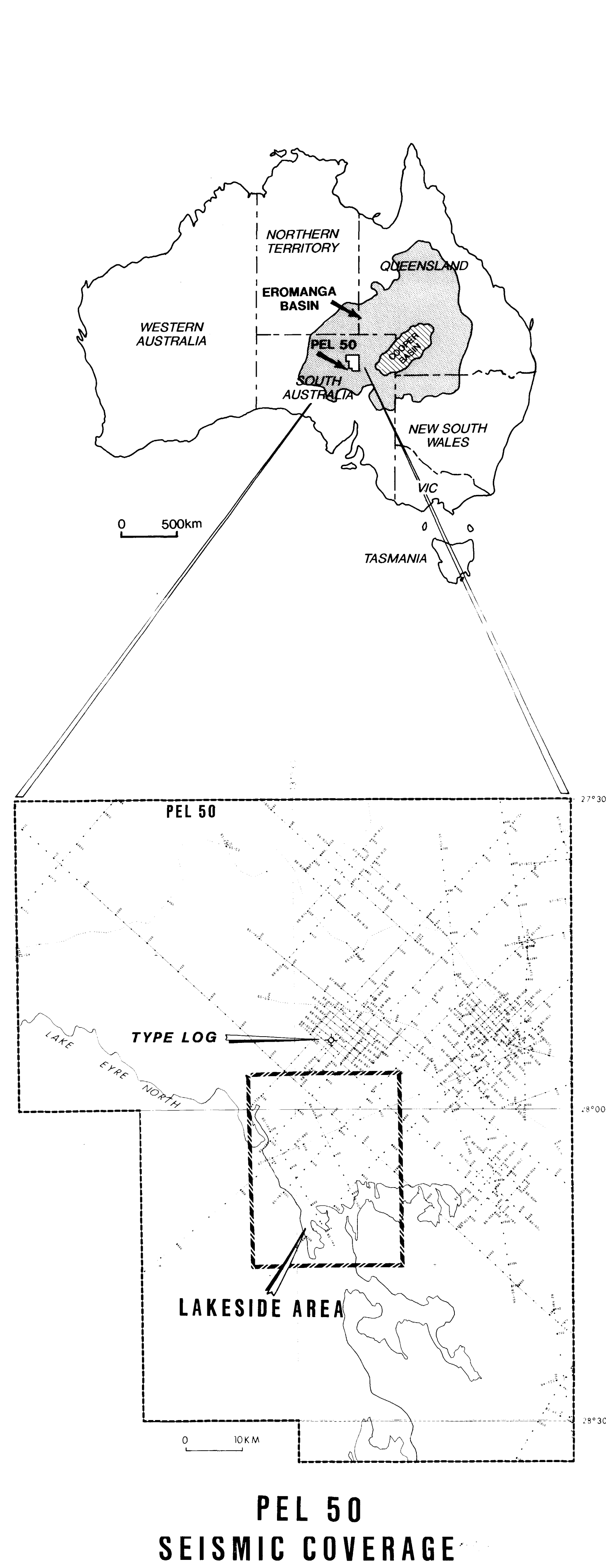
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PHONE (303) 293-3953 : FAX (303) 293-3954

PEL 50 - SW EROMANGA BASIN

**LAKE KOOL
PROSPECT**

SOUTH AUSTRALIA

DATE - NOVEMBER, 1991



LAKESIDE PROSPECT SUMMARY	
RESERVES:	45 MMBO RECOVERABLE (15% p, 30% Sw, 20' pay, 7660 acres)
CLOSURE:	15,400 ACRES 90ms (325')
TARGETS:	NAMUR SANDSTONE 3520' (1073m) HUTTON SANDSTONE 4895' (1492m) "BASEMENT" 4995' (1523m)

FELSTEA PTY. LTD.
181 BROADWAY SUITE 1500 DENVER, COLORADO 80202 U.S.A.
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PEL 50 - SW EROMANGA BASIN

LAKESIDE PROSPECT

SOUTH AUSTRALIA

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