DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
GEOPHYSICS DIVISION

REFRACTION SEISMIC SURVEY OVER THE LOCK COAL DEPOSIT

by

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Rept.Bk.No. 78/66
G.S. No. 6036
D.M. No. 125/77

21st June, 1978.

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PLANS

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

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ABSTRACT

A refraction seismic survey was carried out in the vicinity of the Lock coal prospect in order to delineate the general shape of the deposit and to test for a possible westerly extension. Difficulties caused by near surface calcrete, and 50 Hz pick up when operating near a 60 KV power line, made the quality of records poor. However, with the aid of logs of holes previously drilled, it was possible to interpret a basement depression in which the coal is confined.

The depression increases in depth west of the drilled area : further drilling to test for coal in the deeper area is recommended, along with suggestions which will improve the seismic interpretation of the area if more refraction seismic work is required.

INTRODUCTION

A refraction seismic survey was carried out in late 1977 in the vicinity of the Lock coal deposit in central Eyre Peninsula (Fig. 1). The aim of the survey was to delineate the limits of the deposit and find whether it is structurally controlled.

An initial survey was undertaken to test whether reliable results could be obtained, as it was considered that near surface calcrete over most of the area could cause secondary energy sources from membrane-type reverberations (Milton, 1974), making the timing of first breaks on the seismic records very difficult. The calcrete could also cause a velocity inversion, due to its high velocity, resulting in large errors in the interpretation of the time-distance curves. To reduce these effects the explosives were detonated in shot holes below the calcrete layer.

The initial work was interpreted and the results compared with information from drill holes in the area. It appeared that the interface between two refractors coincided, within acceptable limits, with the base of the bed containing the carbonaceous material. Further work was therefore carried out over a suspected westerly extension of the deposit so that the seismic results could be used to guide the location of further drill sites.

METHOD USED

Approximately 25 km of seismic traverse along five lines, as shown in Fig. 2, were surveyed during two one-week periods.

The seismic lines were cleared by a private contractor using a water-filled roller towed by a tractor, then the fallen scrub was cleared with an agricultural rake. Surveyors from ETSA supervised the clearing, then chained and levelled the shot points at 732 m intervals along the lines. Shot holes were drilled to kelly depth (approximately 7 m) by Department of Mines and Energy drillers using a Mayhew 1000 drill.

Seismic spreads consisted of 24 geophones spaced 60.9 m apart, i.e. a total spread length of 1 463 m, with shots detonated in shot holes which were approximately 30.5 m away from each end of the spread. After acceptable seismic records were obtained from these shots, half the spread, i.e. two 366 m seismic cables and 12 geophones, was picked up and placed at the other end of the spread, such that the new position of the 1 463 m spread was 732 m further along the line. After seismic records from shots at each end were obtained, the spread was moved on again thus providing seismic records with an overlap of 732 m.

The seismic equipment consisted of a 24 channel SIE PT100 seismic amplifier bank feeding an SIE ERC6 electrostatic oscillograph.

In order to obtain a better control of the near surface velocities and thicknesses, "weathering spreads" were shot at most shotpoints along the lines. These consisted of 24 geophones placed at 10 m intervals with a shot detonated at a depth of approximately 1 m below the surface at the centre of the spread.

All seismic records were timed for the first detectable arrival of energy at each geophone position, and results were then plotted as time-distance curves. Conventional seismic refraction interpretation techniques were used to determine velocities and thicknesses of the various refracting layers. Reciprocal analysis as reviewed by Hawkins (1961) was used where possible to obtain bedrock velocities.

RESULTS

Up-hole times were not recorded. Corrections for shot depth were obtained by superimposing the weathering shot time-distance curves on the time-distance curves of the larger spreads, and measuring the time displacements between coincident parts of the different time-distance curves with similar velocities.

Generally record quality was poor. This could possibly be due to the high attenuation of energy in the sand layers below the near surface calcrete layer. On some records, timing of first energy arrivals at the geophones furthest from the shot was difficult and second or third arrivals were timed instead.

Refraction spreads along the 66 KV power line traverse were affected by 50 Hz pick up from the power line. The pick up was so great that it could not be fully attenuated by the "hum bucking" devices and the high-cut filter settings available in the amplifier banks.

Preliminary cross sections showed discontinuities in some layers which were considered to be continuous. The requirements of the refraction method needed to estimate the depth and thickness of a separate layer of measureable velocity are (a) the velocities must increase with depth and (b) the layer thickness must exceed a minimum value before it can be distinguished on the time-distance curves. It was therefore considered that there was a continuity of the layers throughout the cross sections, but in some cases the layers were too thin to be "seen" on the time-distance curves. However, the maximum depth and thickness of a "blind" zone which would not be detected on the time-distance plots, were calculated for each shot point by the method described by Hawkins and Maggs (1961). The use of this technique allowed continuation of layers of similar velocity throughout the seismic section. Support for the existence of such blind zones has been obtained from the drill logs since utilisation of the hidden layer techniques gives a much closer approximation to results obtained by drilling than does the use of the data without allowance for the presence of blind zones.

Positions of seismic lines, shot points and drill sites, along with contours of interpreted depths below A.H.D. to the interface between the 1 890 m/s to 2 100 m/s layer and the 2 200 m/s to 2 600 m/s layer, which is considered to be the base of the coal sequence of Jurassic age, are shown on Fig. 2. Seismic cross sections of the lines surveyed along with drill information are shown on Figs 3 and 4. The interpreted seismic sections show up to seven layers increasing in velocity with depth.

Velocities within the range 1 800 m/s to 2 100 m/s are in the main associated with Jurassic coal formations (Figs 3 and 4). The boundary of material of this velocity with the formation below is considered to be the maximum depth at which coal may be found. Where the coal formations are nearer the surface as at the eastern end of the power line traverse then less compacted formations of the same material may have somewhat lower velocities, e.g. 1 580 m/s at SP.O.

The material underlying the coal formations is thought to be basement, with velocities ranging from 2 500 m/s to 3 500 m/s depending on the degree of weathering. Material with these higher velocity ranges has not yet been encountered in any of the drill holes so its exact nature is not known.

The seismic sections from the north-south lines show a depression which has the greatest thickness of both Tertiary and Jurassic sediments on Line 50E. It was considered that the interface between the 1 890 m/s to 2 100 m/s and 2 200 to 2 600 m/s layers was the depth limit below which coal would not be discovered. The depth to this interface below A.H.D. was plotted at the shot point locations on the plan and contoured at 10 m intervals as shown on Fig. 2 to give the general shape of the depression. There is insufficient seismic information to confidently interpret the slope of the northern side of the depression, as the traverses did not extend far enough in that direction to enable a reciprocal-method interpretation.

CONCLUSIONS AND RECOMMENDATIONS

Although the quality of the seismic data was poor, the general shape of a depression containing Jurassic and Tertiary sediments has been interpreted with the aid of previous drill hole information. It is relatively shallow in the eastern third but becomes much deeper below line 50E then tends to become less deep but wider with a shelf in the southern part of the survey area at the western end.

There are insufficient seismic data in the northern part of the area investigated, and there are insufficient north-south lines within the area of interest to confidently interpret in detail the shape of the depression. However, there are sufficient data to show the general trend, which should be useful in the preparation of a further drilling programme.

It is recommended that the drill hole P64, sited on line 50E be deepened, as it appears from a comparison of seismic velocities that the carbonaceous section intersected is of Tertiary age, and that there could be coal of Jurassic age below it. If there is insufficient coal in the deeper part of the depression to enable economical mining, it is recommended that a drill hole be sited to intersect the Jurassic sediments on a "shelf" between SP4 and SP5 on line 47E, where the Jurassic coal-bearing sediments are interpreted as being shallower.

If a more detailed seismic interpretation is required, it is suggested that the existing north-south lines be extended to the north by at least one seismic spread length, and that additional north-south seismic lines at 1 km intervals between the existing ones be traversed.

A high resolution reflection seismic survey may be of use to obtain information about the actual coal seams.

BJT:JS
21st June, 1978.

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Hawkins, L.V. and Maggs, D., 1961. Nomograms for determining maximum errors and limiting conditions in seismic refraction survey with a blind-zone problem. Geophys. Prospecting, 9, 528-532.

Milton, B.E., 1974. Seismic experiments in the northern Eucla Basin, S.A. Quart. geol. Notes, geol. Surv. S. Aust., 51.

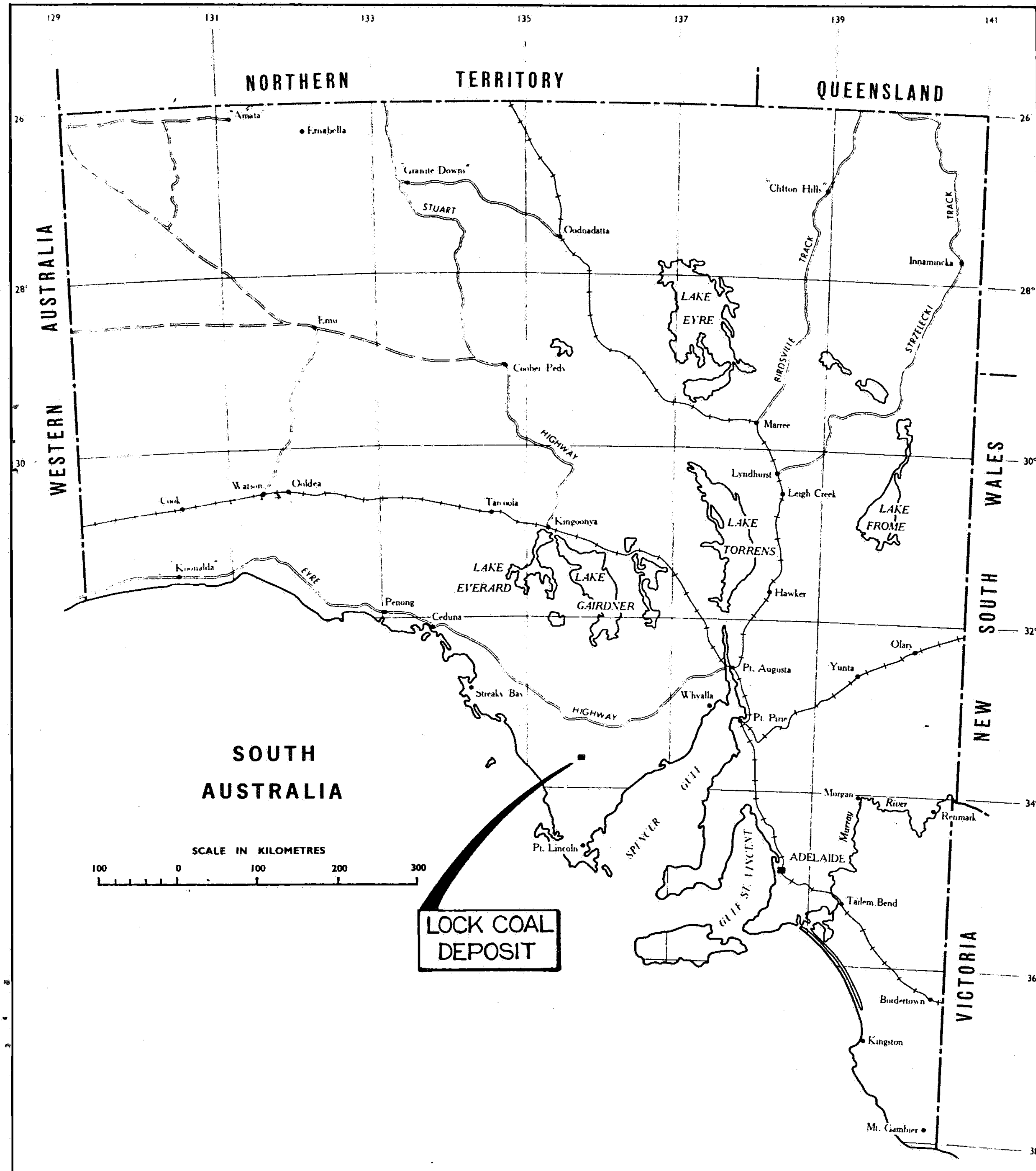

FIG. 1

DEPARTMENT OF MINES —— SOUTH AUSTRALIA

Compiled B.J. Taylor	LOCK COAL DEPOSITS LOCALITY PLAN	Date: April '78
Drn. J.W. Ckd.		Drg. No. S13348

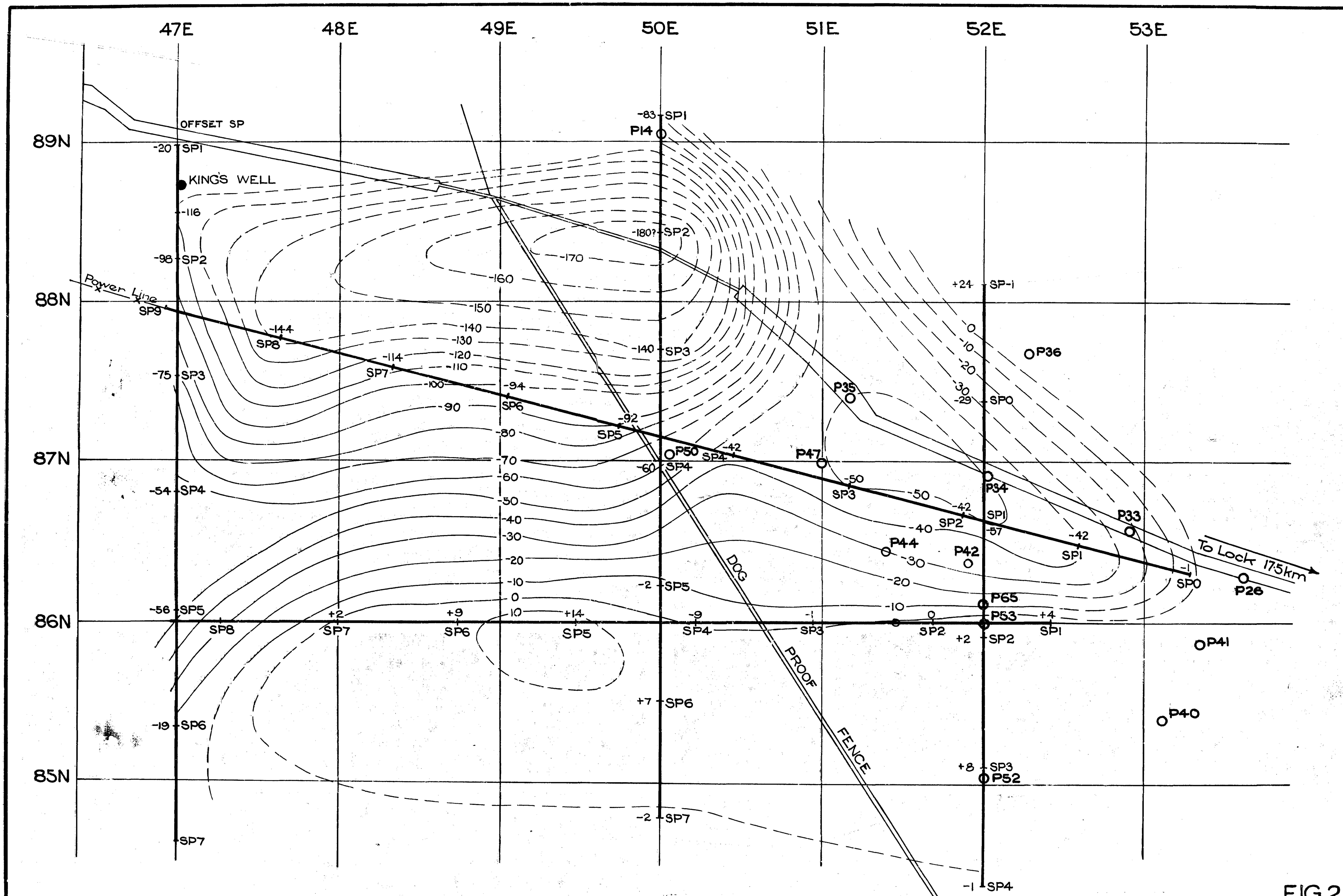

FIG.2

-50— Contours of Depth in metres below A.H.D. of interface between 1890m/s to 2100m/s and 2200m/s to 2600m/s Refractors.

-160— Contours of Tentative Interpretation.

86N Metric Grid.

SEISMIC TRAVERSE

Seismic Shotpoint.

-19 SP6 Interpreted Depth in metres below A.H.D. to Interface of Seismic Refractors as above.

KILOMETRES

0 1 2

DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA

LOCK COAL DEPOSITS

LOCATION OF SEISMIC TRAVERSES & DRILL HOLES

CONTOURS OF EST. DEPTH TO BASE OF JURASSIC COAL DEPOSIT

GEOPHYSICAL SERVICES SECTION	COMPILED: B.J.Taylor	DRN J.W.	SCALE 1:25,000	PLAN NUMBER 78-335
DIRECTOR GENERAL		CKD. A.F.	DATE April '78	

6030-IV

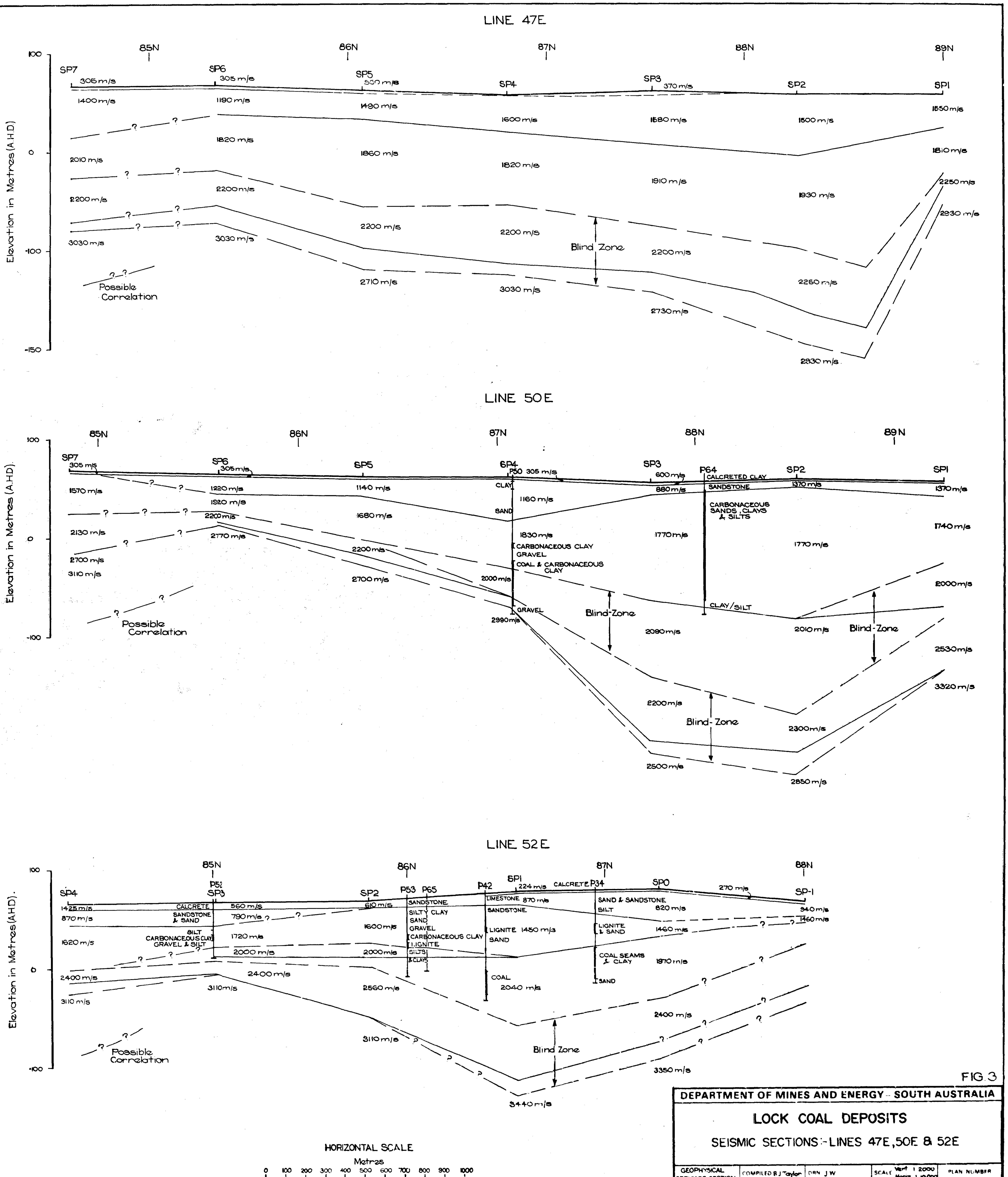

FIG. 3

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LOCK COAL DEPOSITS

SEISMIC SECTIONS:- LINES 47E, 50E & 52E

GEOPHYSICAL SERVICES SECTION	COMPILED R.J. Taylor	DRN J.W.	SCALE Vert 1:2000 Horiz 1:10,000	PLAN NUMBER
DIRECTOR GENERAL		CKD A.T.	ft April '78	78-336

6030 - IV

FIG. 4

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LOCK COAL DEPOSITS

SEISMIC SECTIONS :- LINE 86N & POWER LINE TRAVERSE

GEOPHYSICAL SERVICES SECTION	COMPILED B J TAYLOR	DRN J W	SCALE VERT 1:2000 HORIZ 1:10000	PLAN NUMBER 78-337
DIRECTOR GENERAL		CKD A F	DATE April '78	

6030-IV