~~ASTDOC58~~/RHF/BJR/PAGS-12FEB81

ASSESSMENT OF POTENTIAL INTERFERENCE FROM MINING OPERATIONS NEAR PARKES

1. POSSIBLE MINING OPERATIONS

Drilling for mineral exploration has been under way west of Goonumbla about 24km from the Parkes Observatory (see Parkes *Champion Post*, 7 November 1980). It appears that the company may want to operate an open cut mine in the Bogan Creek area (see Fig. 1). Crushing and extraction plant associated with the mine could be a potential source of interference to the 64m telescope and, perhaps, the AST.

2. MEASUREMENTS AT WOODLAWN MINE

Some measurements have been made of radio interference from the CRA Woodlawn Mine east of Lake George. The Woodlawn mine uses similar equipment (crushers, extraction plant, etc.) to that which Peko would envisage using in the Parkes area. However, the Woodlawn mine is smaller, with a power consumption of 8 Mwatts, compared to 120 Mwatts for the proposed mining and extraction operations at Parkes.

Measurements were made during January 1981 at Woodlawn at frequencies of 600 MHz and 1400 MHz. The levels of interference, measured at two sites, were:

Table 1 : Interference observed from Woodlawn Mine

Frequency	Average interference level from Woodlawn mine	Interference scaled to D=24km and P=120MW
600 MHz	5×10^5 Jy at 0.8 km 6×10^4 Jy at 9.5 km	1.6×10^5 Jy
1400 MHz	7×10^4 Jy at 0.8 km $\leqslant 7 \times 10^4$ Jy at 9.5 km	1.8×10^5 Jy

The interference was found to be very impulsive, and is probably produced by motor speed controllers such as SCR controllers. This has yet to be verified.

3. INTERFERENCE to 64m DISH OBSERVATIONS

The interference levels measured at Woodlawn at 600 and 1400 MHz would be harmful for 64m single dish observations if the proposed mine at Bogan Creek were to go ahead. The CCIR has laid down harmful interference levels at 1400 MHz for continuum (3 Jy) and spectral line (125 Jy) observations [CCIR Report 224, Kyoto Plenary Assembly, 1978]. The levels measured at the Woodlawn mine (Table 1) far exceed the CCIR limits. The impulsive nature of the interference would also be very troublesome for observations of pulsars, scintillation, occultations, etc.

If mining operations are established at Bogan Creek (with a power consumption 15 times Woodlawn), single dish observations with the 64m telescope would cease at 600 and 1400 MHz. The situation at higher frequencies has yet to be explored. Measurements at higher frequencies need to be made near the Woodlawn mine.

4. POSSIBILITY of INTERFERENCE to AST

The CCIR has made no report on harmful interference to synthesis observations. Some measurements at 1400 MHz have been made at the VLA (A.R. Thompson). These have been supplemented by our own computations.

The way synthesis observations are made provides effective discrimination against interference as compared with the single-dish case discussed in #3 for the 64m telescope. Synthesis observations have a high degree of directionality because time delays are inserted to ensure that samples are taken on a wave front arriving from a specific direction. The interferometer fringe rates are also specific to a celestial source with a specific hour angle and declination. Thus the 64m telescope could operate satisfactorily as a part of the AST array while being useless for single dish work.

A terrestrial source of interference is stationary relative to a synthesis array, and appears in many respects like a source at the celestial pole. Mining interference would thus prevent any observations near the pole. For fixed phase and amplitude of interference there would be a series of grating rings around the pole of decreasing intensity as the region observed was further from the pole.

(a) Continuum case

For *wideband* (continuum) synthesis the grating ring intensity produced by the interference would be reduced by a number of factors:

(i) The sidelobe response. The *average* sidelobe response is taken to be -55 dB at 1400 MHz. [Assumes 20% of energy is distributed isotropically for the 22m dishes; the 64m sidelobe level would be somewhat lower.]

(ii) For an observing field θ° from the celestial pole the grating ring intensity is reduced by a factor

$$\pi \left[\frac{2 \times \text{array length} \times \sin\theta}{\text{wavelength } (\lambda)} \right]^{\frac{1}{2}}$$

(iii) The grating rings are dispersed by the finite width of the receiving bandwidth. The fractional wavelength change $\delta\lambda$ to move a grating ring by its width is

$$\frac{\delta\lambda}{\lambda} = \frac{\lambda}{\text{array length} \times \tan\theta}$$

The grating response will be reduced by the ratio of the receiver wavelength range $\Delta\lambda$ to $\delta\lambda$.

For observations at 1400 MHz of the Small Magellanic Cloud with θ = 15°, assuming measurements over a baseline B with bandwidth 50 MHz, the table lists the reduction factors (i), (ii) and (iii).

Table 2 : Interference Reduction - Continuum Case - 1400 MHz

Baseline B (m)	Interference Reduction (dB)				Interference Grating Intensity (Jy)	Confusion Limit (Jy)
	(i)	(ii)	(iii)	Total		
60	-55	-15.9	-4.6	-75.5	4.2×10^{-3}	N/A
600	-55	-20.9	-14.6	-90.5	1.3×10^{-4}	1.0×10^{-3}
1200	-55	-22.4	-17.6	-95.0	4.7×10^{-5}	2.6×10^{-4}
6000	-55	-25.9	-24.6	-105.5	4.2×10^{-6}	1.0×10^{-5}

This is a worst case calculation, which assumes that the interfering signals arrive in phase at all AST antennas. Table 2 shows that any interference will be reduced by factors greater than 90 dB. The interference levels measured at the Woodlawn mine would be reduced below the confusion level at the baselines considered in Table 2. [Confusion levels extrapolated from Wall and Cooke, MNRAS 171, 9 1975)]. The worst case is the 6 km baseline, where the interference is 4   below the confusion limit. The interference level for the 60m spacing could be troublesome in simulating broad structures in radio sources, etc.

(b) Spectral line case

Hydrogen line observations at λ = 21cm will use narrow bandwidths ($\leqslant$50 kHz) where the protection of grating dispersion [case (iii) in (a)] does not apply. However the system sensitivity is reduced by a factor of $[50 \text{ MHz} / 50 \text{ kHz}]^{\frac{1}{2}}$, or proportionately more for narrower bandwidths (e.g. 10 kHz for H-line absorption measurements).

Table 3 below lists for various baselines the protection factors (i) and (ii) and the interference remaining. θ has again been assumed to be 15°, corresponding to the polar distance of the SMC. The rms system noise has been computed for a 50 kHz bandwidth.

Table 3 : Interference Reduction - Hydrogen Line Case

Baseline B (m)	Interference Reduction (dB)				Interference Grating Intensity (Jy)	rms noise (Jy)
	(i)	(ii)	(iii)	Total		
60	-55	-15.9	0	-70.9	1.2×10^{-2}	3×10^{-4}
600	-55	-20.9	0	-75.9	3.8×10^{-3}	3×10^{-4}
1200	-55	-22.4	0	-77.4	2.7×10^{-3}	3×10^{-4}
6000	-55	-25.9	0	-80.9	1.2×10^{-3}	3×10^{-4}

The interference levels in Table 3 range from 6 dB to 16 dB above the rms system noise. For a bandwidth of 10 kHz the noise would be 3.5 dB higher. Thus the interference would limit the sensitivity of hydrogen line measurements, and be most serious for broad features on a map.

5. FURTHER REDUCTION of INTERFERENCE

The cases considered in para. 4 are worst case conditions. A number of factors could lead to a further reduction of interference to the AST.

(a) Factors under AST control -

(i) De-phasing : The computations of grating responses have assumed

that the signals would arrive in phase at all antennas. This is unlikely to occur frequently. Maximum expected improvement is (number of dishes)$^{-\frac{1}{2}}$.

(ii) Data editing : The interference seen at the Woodlawn mine is highly impulsive. The strongest impulses could be monitored prior to 2-bit sampling, and the data at those times could be rejected.

(iii) Rejection by 2-bit sampling : Short impulses, lasting for times $\approx$ $^{1}/_{\text{bandwidth}}$, would be clipped by the 2-bit samplers. They would not perturb the measurements as long as they did not bias the 2-bit sampling levels.

(b) Factors under control of mine -

(i) Locating crusher and ore extractor as far as possible off the projection of the AST east-west line.

(ii) Distributing the sources of interference (assumed to be mainly DC motor controllers)over an area.

(i) and (ii) together make the interference a large diameter source, resolved by the AST interferometers.

(iii) Taking advantage of the shielding any hills may provide between the crusher/extractor and the 22m AST antennas

(iv) Investigating the effectiveness of electrical shielding and filtering of the mine equipment. At present we do not know what equipment produces the interference or how it is radiated. We need to make further tests at the Woodlawn mine to identify the sources of interference and how they radiate.

(v) Improving the motor control equipment (the most likely source of interference) by using zero-crossing switching.

6. FURTHER INVESTIGATIONS REQUIRED

(i) Investigate effects on interference cancellation of fluctuations in the level of interference. Temporal variation of the interference may produce large-scale structure on a synthesized map because of incomplete cancellation.

(ii) Check whether there is frequency structure on the interference measured at the Woodlawn mine.

(iii) Identify sources of interference at Woodlawn mine, and radiation mechanisms with a view to specifying suppression devices or methods.

(iv) Measure interference from Woodlawn mine at high frequencies (e.g. 2.7, 5 GHz).

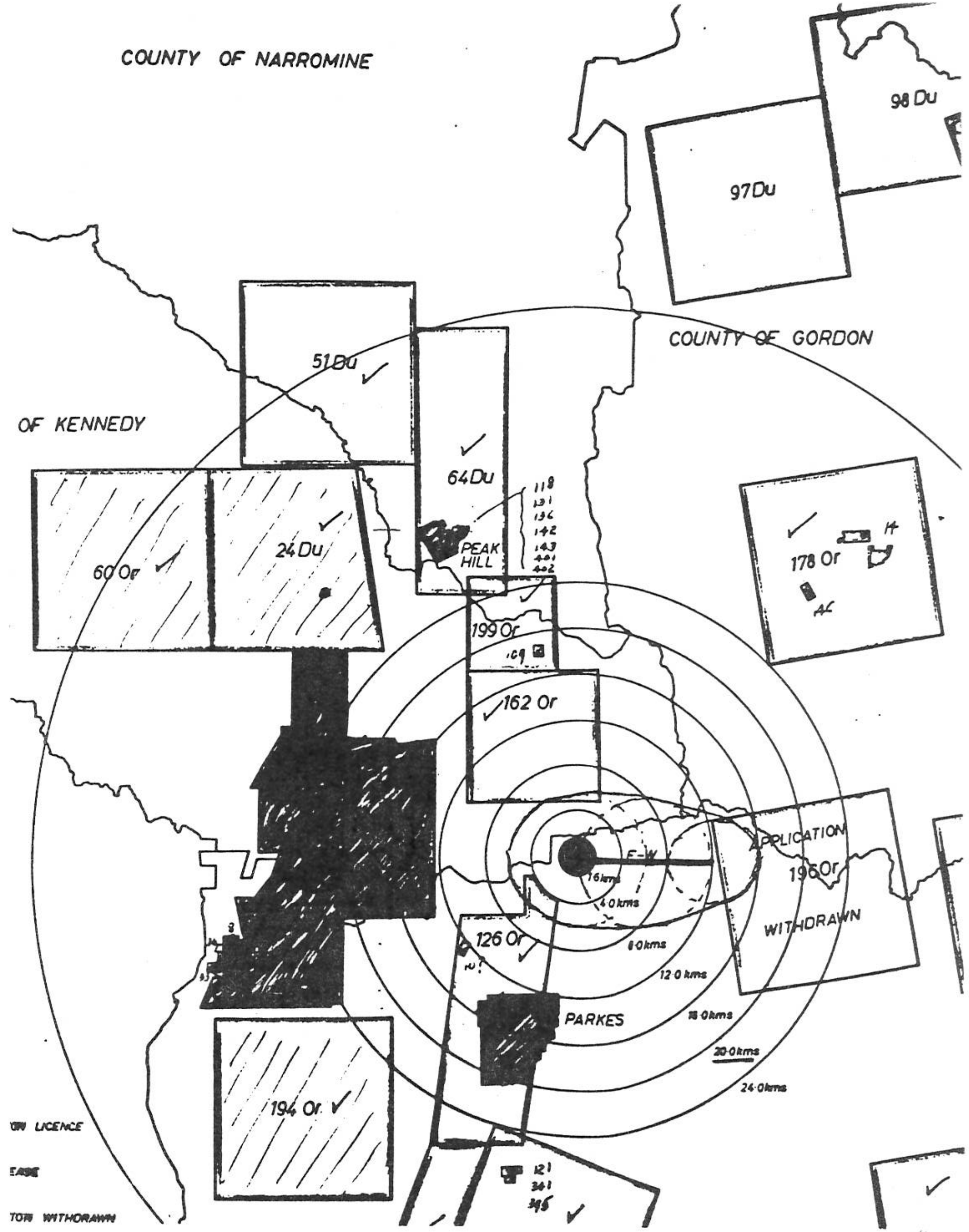

FIGURE 1: Map showing mineral exploration areas near the Parkes 64m telescope