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ENVIRONMENTAL STUDY OF TWO FLOODED OPENCUTS AND
SMALLER, ASSOCIATED WATER BODIES

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RUM JUNGLE; THIOBACILLUS FERROXIDANS; WATER POLLUTION; SEDIMENTS; WATER; PH VALUE; SULFURIC ACID; COPPER COMPOUNDS; IRON COMPOUNDS; MEDIUM TEMPERATURE; SPATIAL DISTRIBUTION; SOLID WASTES; EXPERIMENTAL DATA;

ABSTRACT

The microbial status of the flooded Intermediate and White's opencuts of the abandoned uranium mine at Rum Jungle was investigated by sampling the water column and sediments of several areas in each opencut. Smaller water bodies, associated with the experimental heap-leach pile, were also investigated. Several groups of bacteria were identified and population sizes were estimated using selective media techniques. Various physicochemical parameters of each sample were determined and correlated with the occurrence of bacteria.

Both opencuts, although behaving differently, were found to be heavily polluted by sulphuric acid and heavy metals, White's more so than Intermediate. White's opencut was found to be stratified into an aerobic zone, about five metres deep, and a microaerophilic zone below this. Large populations of *Thiobacillus ferrooxidans* and autotrophic sulphur-oxidising bacteria indicated that degradation of sulphidic minerals in the walls and floors of the opencuts was still occurring. The isolation of *T. ferrooxidans* from sediments also containing anaerobic bacterial species suggested that *T. ferrooxidans* was degrading sulphidic minerals, either anaerobically or microaerophilically.

The smaller water bodies also were found to be heavily polluted by acid and heavy metals from drainage and seepage from the sulphidic heap-leach pile.

CONTENTS

(Continued)

1. INTRODUCTION

When the uranium mine at Rum Jungle, N.T. was abandoned in 1971, three opencuts (White's, Dyson's and Intermediate) were left in the immediate neighbourhood of the Rum Jungle mine site. After mining was completed on each of the ore bodies the opencuts soon filled with water. In 1959, one year after mining had ceased on White's orebody, the copper and sulphate concentrations in the water were about 4 and 180 mg/L respectively and the pH had dropped to 4.75 [Davy 1975]. For some years before closure of the treatment plant in 1971, the opencut was used for dumping unneutralised tailings and raffinate from the treatment plant. In 1974 the pH of the water of White's opencut was about 2.4, with copper and sulphate levels of about 60 and 9000 mg/L respectively, while the water in the Intermediate opencut had a pH of about 3.5, with copper and sulphate levels of about 50 and 2000 mg/L respectively. It is not clear whether the deterioration in the water quality in these opencuts has been caused by the oxidation of pyritic material in the sides and floors of the opencuts, or by the seepage of polluted water from regions immediately adjacent to the opencuts or, in the case of White's, by the admixture of raffinate or by the leaching of tailings material dumped into the opencut.

As part of the AAEC program to try to determine the nature and extent of acid and solubilised heavy metal generation in the Rum Jungle area, the microbiological and physicochemical status of White's and Intermediate opencuts was investigated. These two opencuts were singled out for this study because, although geologically similar, they are behaving differently, mainly in respect to dissolved oxygen concentrations - White's has a sharply defined aerobic zone from the surface to 4-5 metres deep with microaerophilic conditions occurring below this level, whereas Intermediate shows no such stratification. It was suggested [Davy 1975] that the depletion of oxygen in the water of White's opencut may have been caused by biological activity and that such activity was not occurring in Intermediate opencut. A comparison of the microbiological and physicochemical properties of the water and bottom sediments from these two opencuts could indicate the mechanisms which have led to the continuing pollution of these two bodies of water and the extent to which these mechanisms still operate. Such a study is important in predicting the water quality to be expected in future opencuts which are left to fill with water after mining ceases and in which pyrite or other mineral sulphides are associated with the main orebody or with the overburden material.

Bacterial populations and physicochemical parameters (such as temperature, dissolved oxygen, pH, soluble metal concentrations and total water solubles) were measured throughout the water column and in the bottom sediments of the two opencuts. One set of measurements was carried out in June 1978, well into the dry season, and one set in May 1979 about one month after the last significant wet season rain in the Rum Jungle area for that year, but still under wet season conditions of temperature and humidity.

Measurements were also carried out on soil and water samples taken from a trench, dug between Intermediate opencut and Copper Creek (see Map 2) to determine whether or not seepage was occurring from the opencut to Copper Creek. Further measurements were carried out on samples taken from water that collected at the base of the sulphide/oxide heap-leach pile (see Map 2).

A brief description of the physical properties and histories of the waterbodies investigated is contained in the next section. The microbiological processes of interest and the characteristics of the microbiological populations isolated are described in the first report of the series [Goodman, Khalid and Ralph 1981].

2. WATER BODIES OF THE RUM JUNGLE MINE SITE

2.1 White's Opencut

Mining operations started on White's orebody in 1954 and were completed in 1958. In 1959 the opencut was full of water (see above). The area of the opencut is 10.5 ha (see Map 1) and the seepage loss is, at least, about 5 per cent of total water volume. Tailings material and raffinate were discharged into the opencut during 1965-71 and 1968-71 respectively. The aerobic/microaerophilic stratification which dissolved oxygen profiles show to be a distinct feature of the opencut is thought to be caused by biological activity rather than limitations on oxygen transport. It is estimated that seepage from the opencut will still be a significant source of pollution to the East Finniss River system in 25 years' time. In 1974 the concentration of copper was between 56 and 60 mg/L and the pH was between 2.2 and 2.4.

2.2 Intermediate Opencut

Mining operations started on the Intermediate orebody in 1963 and were completed by 1964. As was the case with White's opencut, Intermediate opencut filled with water soon after mining operations stopped. The opencut, which is some 4 ha in area, is thought to receive seepage water from White's opencut (the water level of which is higher than that of Intermediate) and also from the heap-leach pile. Observations of water level fluctuations and increasing manganese concentrations suggest that Intermediate and White's opencuts have a common aquifer [Davy 1975]. No stratification occurs in this opencut and, because of relatively high dissolved oxygen concentrations at the bottom, it is thought that there is little biological activity. At present, copper and sulphate lost by seepage is approximately 3 and 10 times respectively less than that lost from White's opencut. In 1974 the copper concentration was about 50 mg/L and the pH about 3.5.

2.3 Copper Leach Pile

A collection ditch, which provided some storage for the sulphide liquors, was built around the side of the sulphide heap (see Maps 1 and 2) and was called the sulphide pond. There are three other ponds at the base of the heap: the pregnant liquor pond which held the liquor that had passed through the copper leach pile, the barren pond which held the barren liquor from the launders and the acid pond which held the supply acid. All these ponds are above the local water table. At the end of the dry season, water levels drop in the ponds because of evaporation and seepage, but during the wet season the ponds collect drainage and runoff from the heap-leach pile and form a common lake which overflows into both the old bed of the East Finniss and Copper Creek. At the end of the wet season the ponds slowly dry out. In 1975, four years after being abandoned, the experimental heap-leach pile was found to be discharging copper at concentrations similar to those observed when the heap leach was in operation.

3. *MATERIALS AND METHODS*

3.1 Field Work

Soil samples from Hole R (Map 2) and shallow water samples (numbers 1-7 on Map 2) were collected as described previously [Goodman, Khalid and Ralph

1981].

Sampling areas on Intermediate and White's opencuts were located by reference to survey points (originally established by the Water Resources Branch, N.T.) using a compass and range finder. Samples were collected from a rowboat held at the desired point as well as possible and this proved difficult in windy conditions. Sampling areas are, therefore, approximate. Water and sediment samples were collected with a two litre Friedinger-type sampler [Collings et al. 1973] and transferred to sterile, plastic containers. In June 1978, depth was estimated by measuring metre lengths of the suspending cord. However, in May 1979 greater precision was achieved with the use of a winch, with a built-in calibrated depth-gauge, for sampling. Benches cut during the mining of the opencuts form ledges at various depths within the flooded opencuts. "Bottom" samples were taken from these ledges, except for the bottom samples from central areas which were taken from the deepest parts of the opencut. In situ temperature and dissolved oxygen (D.O.) measurements were made using a "Delta" combined temperature and D.O. probe fitted with automatic pressure adjustment. After each day's sampling an aliquot of each sample was filtered (for chemical analysis); the pH of each sample was measured using a portable pH meter with combined glass and KCl probe, calibrated with standard buffers, and both filtrates and samples for microbiological analysis were stored at 4°C. Selective liquid media for anaerobes were inoculated with sample aliquots and left at room temperature on site, and then incubated at 30°C in the Sydney laboratory (University of NSW, School of Biotechnology).

3.2 Laboratory Work

Chemical and microbiological analyses were carried out as described in Goodman, Khalid and Ralph 1981.

4. RESULTS

All the samples collected were analysed for pH; total soluble solid concentration; soluble copper, iron and zinc concentrations; numbers, or presence, of specified bacterial species; and, in the case of soil samples from hole R, moisture content. These results are contained in Appendices B,C,D,F,G and H. The location and description of sampling areas are set out in Appendices A and E.

As described previously [Goodman, Khalid and Ralph 1981], the logarithm of all variables, except pH, D.O. and temperature, was taken and statistical analysis carried out on the transformed data. The means and standard deviations (s.d.) of the transformed data are set out in Tables 1-3 for White's opencut and Tables 4 and 5 for Intermediate opencut. The mean values of the variables for Intermediate and White's opencuts are compared in Tables 6 and 7.

Results of the analysis of soil samples from hole R (a trench cut near Intermediate opencut) and other water systems of the site are contained in Tables 8 and 9 respectively.

The distributions of pH, soluble solids concentrations, D.O. and temperature with depth in Intermediate and White's opencuts are illustrated in Figures 1,2,3 and 4 respectively.

The sites of all sampling areas are shown in Maps 1 and 2.

5. DISCUSSION

5.1 White's Opencut

Analysis of samples taken in June 1978 showed that the surface water of the opencut (that is, water within the first metre) was not significantly different from the water throughout the rest of the water column, except for D.O. content, and that the sediments differed significantly from the water column (Table 1). The sediments had a lower pH and higher concentration of soluble iron than the overlying water. Also bacterial population levels were generally higher in the sediments than in the water column (numbers of *T. ferrooxidans* were 100 times higher in the sediments) and this has been reported previously as a general occurrence in aquatic ecosystems [Wood 1965; Rheinheimer 1974].

The sediments showed significant physicochemical differences between June 1978 and May 1979, although bacterial populations did not vary significantly (Table 2). The pH of the sediments was lower, by about a half a unit, in June than in May. Concentrations of soluble copper and iron were higher in the sediments in June than in May. Also, the dissolved oxygen was about three times higher in June than in May.

Similar differences were observed between June and May in the surface samples (Table 3). The pH of the water was significantly lower in June than in May. The dissolved oxygen in the water was higher in June than in May. The bacterial content of the water was higher and more diverse in June than in May.

It is interesting to note that numbers of T. ferrooxidans in the sediments remained unchanged between May and June and were about 10 to 100 times higher than numbers of this organism in soil from White's overburden dump and that the pH of the sediments was much lower than the pH of soil and water samples from the dump [Goodman, Khalid and Ralph 1981]. Brock [1978] found that sulphuric acid production (from sulphur or sulphides) per single bacterial cell was higher in an aquatic environment because water availability in such an environment was not a problem, whereas in soil, bacteria may suffer moisture stress if water availability becomes too low [Brock 1975].

During June, anaerobic sulphate-reducing bacteria (Desulfovibrio spp.) were isolated from four out of five sediment samples, whereas in May these organisms were found in only three out of nine sediment samples. T. denitrificans was not found in any sediment sample from White's opencut, probably because the pH was too low for the growth of this organism.

An interesting feature of both the water and sediment samples from the opencut in June, was the abundance of a single-cell algal species, identified as a Chlorella spp. [R. King, personal communication]. This alga grew as small green colonies on plates selective for acidophilic heterotrophs and pH 4.8 sulphur-oxidising bacteria. It is known that Chlorella continues to synthesise chlorophyll when grown heterotrophically in the dark, whereas Cyanidium, which has been found in hot, sulphuric acid environments, undergoes repression of chlorophyll and phycocyanin synthesis when grown heterotrophically in the dark [Brock 1978]. Also, according to Brock [1978] blue-green (i.e. procaryotic) algae do not exist below pH 4 and pollution of water systems by acid mine drainage should eliminate any indigenous blue-green algae. In this study, no blue-green algae were found in the polluted water bodies at Rum Jungle.

In May, Chlorella was not isolated from the sediment samples. Since algae grow in the surface waters of water bodies, it is probable that the Chlorella isolated from sediments in June was transported there by sinking water.

Stratification in lakes during summer is a well known phenomenon. Temperature and dissolved oxygen gradients become established when the warmer and less dense surface layers are separated from colder and denser bottom layers which usually then become anaerobic. However, as the ambient temperature begins to drop in early winter, the surface waters cool more quickly and become denser than the underlying water and so the water 'turns over' thus re-aerating the bottom layers [Brock 1979].

There were several indications that this 'turning over' was occurring in White's opencut during June (the first month of winter). Figure 4 shows the temperature distribution with depth in the opencut and it can be seen that the surface water temperature in June is much lower than that in May. The wide range of temperature values at the surface stems from the fact that the measurements were spread over the time period 8 am to 6 pm during which the air temperature changed markedly. This effect was most noticeable in May. In May the deepest sample was the coldest, whereas in June some of the surface water was colder than that at the bottom, suggesting that further mixing probably continues during winter. Figure 3 shows that the D.O. content of the water was higher in June (since it was colder, the capacity of water to hold D.O. was increased) than in May, although the opencut still contained a sharply defined aerobic/microaerophilic interface at about 4-5 metres from the surface. The algae found in the sediments during June were probably not growing there but had either sunk, or been transported there by falling, cold surface waters. The presence of bacteria in the water column in June also indicated that there was a slight upwelling of bottom water as mixing began.

Hence the differences noted between samples taken in May 1979 and June 1978 may well be ascribed to lower ambient temperatures in June rather than to other wet/dry season differences.

5.2 Intermediate Opencut

The sediment samples differed significantly between May and June, except for total soluble solids concentration and dissolved oxygen (Table 4). The pH in June was lower than in May, and all the bacterial groups occurred in numbers 10 to 100 times higher in June than in May.

In June the physicochemical parameters of the sediments were not significantly different from those of the water column, but all bacterial groups were 100 to 1000 times higher in the sediments than in the water column.

Chlorella spp. were isolated from all samples from the opencut except sediment samples taken in May. Desulfovibrio spp. were isolated from eight out of eleven sediments in May, and from all sediments in June. Also T. denitrificans was isolated from seven sediments in May and from four out of five sediments in June.

No stratification was observed in this opencut. Figure 3 shows that, in May, the dissolved oxygen content decreases from the surface to about 20 metres depth, increases slightly and then decreases to almost zero at the deepest area (the centre of the opencut), whereas in June, D.O. decreased from the surface to about 30 metres and was relatively high again in the deepest area.

Temperature measurements (Figure 4) indicated that the surface waters were still slightly warmer than the bottom layers in June, although cooling was occurring since surface temperatures in May were much higher.

The occurrence of populations of T. ferrooxidans in the opencut was somewhat surprising because of the low concentration of soluble iron. However, the bacteria were probably utilising solid sulphidic substrates and any ferric iron was probably precipitated at the pH of the opencut.

5.3 Comparison of Intermediate and White's Opencuts

See Tables 6 and 7.

5.3.1 Acidity

The pH of White's opencut was lower by about 0.5-1.0 units than that of Intermediate, and consequently the amount of soluble iron was much higher (by about 100 to 500 times) in White's than in Intermediate .

One of the major mechanisms in the generation of acidity in the opencuts is the oxidation of sulphidic material, mainly iron pyrites, in the walls and floor exposed by mining operations. Generally in water bodies the pH of sediments is lower than the water above [Wood 1965]; this was found to be so in White's but not in Intermediate.

5.3.2 Total soluble solids and soluble copper and iron

White's opencut contained a higher concentration of total soluble solids than did Intermediate. The concentration of total soluble solids showed no variation with depth in Intermediate opencut, but in White's was found to increase from the water column to the sediments (Figure 3). It is the sulphate ion which is the greatest component of the soluble solids [Davy 1975].

The concentration of soluble copper was higher in Intermediate opencut than in White's and in Intermediate the concentration in the water column was the same as that in the sediments. The concentration of soluble iron in Intermediate opencut was less than 1 mg/L in June and less than 5 mg/L in May (except for one sample which contained 36 mg/L). White's opencut, however, contained high levels of soluble iron which was higher in the sediments than in the water column and was also higher in June (when the pH was lower) than in May.

5.3.3 Dissolved oxygen

The water column of White's opencut showed a distinct stratification into aerobic and microaerophilic zones which has been recorded previously [Davy 1975].

5.3.4 Microbial populations

Average numbers of *T. ferrooxidans* were about ten times higher in White's opencut than in Intermediate. In Intermediate the distribution of *T. ferrooxidans* in sediments was fairly uniform, whereas the southern end of White's contained populations of *T. ferrooxidans* which were lower than those in the other areas sampled (Appendices B and F). Since White's opencut is not receiving runoff or seepage from the overburden dumps it is thought that populations of *T. ferrooxidans* isolated from the sediments were not transported here but were actively growing.

No sulphur-oxidising bacteria were isolated at pH 3.5 although large populations, from both opencuts, were isolated at pH 4.8. Both sulphur oxidisers growing at pH 6.2 and acidophilic heterotrophs were more abundant in Intermediate opencut than in White's. It is interesting that this is the opposite of the pattern for the dumps [Goodman, Khalid and Ralph 1981]. As discussed previously [Goodman, Khalid and Ralph 1981] high pH sulphur-oxidising bacteria may be less tolerant to high metal concentrations than T. ferrooxidans; it is unlikely that these sulphur oxidisers could not tolerate the pH of White's opencut, since they were isolated from a low pH sediment area in Intermediate, where it was thought that seepage from the experimental leaching heap to the opencut was occurring. The scarcity of acidophilic heterotrophs in White's may have been partly caused by the low oxygen content.

Sediments generally become anaerobic, with reducing conditions occurring in finely grained sediments with coarser sediments being less reducing [Sobell and Morita 1957]. The presence of anaerobic sulphate-reducing bacteria in most of the sediment samples indicated that anaerobic, or reducing, conditions were occurring in the sediments of both opencuts. The facultative anaerobe T. denitrificans, which was isolated only from Intermediate opencut, can grow both aerobically and anaerobically by the oxidation of reduced sulphur compounds (the nitrate ion being the terminal electron acceptor under anaerobic conditions); see Schledel and Truper [1980] for possible mechanisms. At the sediment surface in Intermediate opencut, aerobic conditions may have occurred, but in White's, conditions must have been either microaerophilic or anaerobic (Appendices C,D,G,H).

The above results suggest that T. ferrooxidans was degrading pyrite in the opencut sediments anaerobically or microaerophilically, using an electron acceptor other than D.O. Similar observations were made by Baker and Wilshire [1970] on simulated pyritic coalmine drainage; anaerobic conditions did not stop the degradation of pyrite and production of ferric precipitates. This phenomenon was investigated by Babij et al. [1981] who showed that under microaerophilic conditions, with increased CO_2 concentration, T. ferrooxidans did effect metal release from White's overburden material, but did not produce acidity.

5.4 Hole R

In May 1979, a trench was cut near Intermediate opencut where seepage was thought to have been occurring towards Copper Creek (see Map 2). The results of analysis of soil samples and water seepage suggest that the soil and water were different (Table 8a and Appendix F).

The pH of the water was similar to that of the water in the opencut and about 1.0-1.5 units lower than that of the soil. The concentrations of total soluble solids were similar, but only one (out of four) soil samples contained soluble copper and none contained soluble iron, whereas both copper and iron were present in the seepage water. Although populations of pH 4.8 sulphur-oxidising bacteria were similar, numbers of pH 6.2 sulphur oxidisers were almost 1000 times higher in the seepage than in the soil. T. ferrooxidans was isolated from the soil but was not detected in the water. The seepage water was found to be depleted of oxygen since anaerobic sulphate-reducing bacteria (Desulfovibrio spp.) were isolated from it, as well as T. denitrificans. Desulfovibrio spp. reduce sulphate to sulphide which can either precipitate with metal ions or form hydrogen sulphide. If hydrogen sulphide was being formed, then this would have provided a substrate for and explain the very high numbers of high pH sulphur oxidisers (to which group T. denitrificans also belongs, see Table 1 in Goodman, Khalid and Ralph [1981]).

It is probable that the bacteria in the soil of hole R were transported there from seepage from Intermediate opencut and were not actively growing. Temperature measurements indicated no heat formation from pyritic oxidation, since temperatures within the well compacted soil were below ambient and decreased with depth (Table 8b). Also, measurements of relative humidity indicated that water activity in the soil was probably too low for bacterial growth [Brock 1975].

Soil samples were taken from one vertical face of hole R, and the 'base' sample was about 10-15 cm from the actual bottom of the hole which was not exactly level. The soil felt damp and was mostly a tightly compressed clay-type except at the bottom of the hole where it was coarser and consisted of a more rock-type material. The water sample was collected from seepage water which had accumulated in the hole about a week after the hole had been dug. The level of this water within the hole at the time of sampling was about 3-6 cm and had seeped from soil which was not sampled. The above results suggest that the soil samples came from areas above the water table and therefore do not represent the soil exposed to seepage from Intermediate opencut at a greater depth. The soil samples analysed would have accumulated salts or microorganisms from the opencut water by capillary action.

5.5 Associated Water Systems

The water systems associated with the opencuts comprise the collection ponds at the base of the experimental heap-leach pile, the old bed of the East Branch of the Finniss River and Copper Creek (see Maps 1 and 2). These areas contain less water than the opencuts and may almost dry out during the dry season. The results of analysis of water samples are contained in Table 9 and Appendices B and F.

Because the experimental heap-leach pile continues to shed acid and heavy metals [Davy 1975], samples from these areas have low pH and high concentrations of total soluble solids, soluble copper, and iron. The effect of evaporation during the dry season would explain why concentrations of soluble salts and metal ions are generally higher in June than in May.

The results from area 7 (Table 9), water in a ditch between the experimental heap-leach pile and Intermediate opencut, suggest that seepage was occurring from the heap-leach pile towards the opencut. In June, samples from the opencut areas, 78/4 and 78/6, across from the heap-leach pile, and area 7 (Appendix B and Table 9 respectively) had a similar pH of 2.7 and 2.6 respectively, each of which was lower than other areas sampled. Seepage from the heap-leach pile could have been entering Intermediate opencut in these areas (see Map 2). This corroborates earlier findings [Davy 1975, p.6.12].

6. CONCLUSIONS

Abundant populations of *T. ferrooxidans* and autotrophic sulphur-oxidising bacteria in the sediments of both Intermediate and White's opencuts indicate the occurrence of microbial degradation of sulphidic material. The isolation of *Desulfovibrio* spp. and *T. denitrificans* from the sediments, along with *T. ferrooxidans*, suggest that *T. ferrooxidans* may be solubilising mineral sulphides anaerobically, or microaerophilically, and using something other than oxygen as a terminal electron acceptor. This is also indicated by the low dissolved oxygen content of the water column below about 5 metres in White's opencut and the fact that the largest populations of *T. ferrooxidans* were isolated from sediments from White's opencut. Thus, in situations where water availability will not become a limiting factor for the growth of *T. ferrooxidans*, degradation of sulphidic minerals by these organisms will continue, even if the concentration of dissolved oxygen is less than about 1 mg/L.

Results of physicochemical measurements show that the two opencuts are behaving differently; the reasons for this are at present unknown.

The sulphide heap-leach pile is still generating large amounts of acid and soluble heavy metals. Drainage and seepage from this heap are polluting the water bodies at the mine site.

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TABLE 1

WHITE'S OPENCUT

JUNE 1978						
	Surface n=4 Col.1 $\bar{x}$	Water Column n=10 Col.2 $\bar{x}$	Water Column n=10 Col.2 s.d.	Sediments n=5 Col.3 $\bar{x}$	Probability (P) that $\bar{x}$ is same: Cols. 1&2	Probability (P) that $\bar{x}$ is same: Cols. 2&3
pH	2.53	2.42	0.2	2.14	P=0.3	P=0.03
Log Soluble Solids (ppm)	3.9	3.9	0.1	4.1	P=1	*
Log Soluble Copper (ppm)	2.0	2.0	0.1	1.9	P=0.6	*
Log Soluble Iron (ppm)	2.2	2.2	0.1	2.7	P=0.5	P=0.001
Log No.$^{\alpha}$ <u>T. ferrooxidans</u>	2.0 $(^{4}/_{4})$	1.9 $(^{10}/_{10})$	0.2	4.3 $(^{5}/_{5})$	P=0.9	*
Log No. S oxidisers pH 4.8	1.4 $(^{3}/_{4})$	1.7 $(^{9}/_{10})$	0.8	4.5 $(^{5}/_{5})$	P=0.7	P=0.001
Log No. S oxidisers pH 6.2	$(^{1}/_{4})$	0.5 $(^{2}/_{10})$	1.0	ND		
Log No. Acidophilic Heterotrophs pH 3.5	ND	ND		0.9 $(^{2}/_{5})$		
Log No. <u>Chlorella</u>	1.5 $(^{3}/_{4})$	1.4 $(^{7}/_{10})$	1.1	3.2 $(^{5}/_{5})$	P=0.8	P=0.02
	Above Interface	Below Interface		Sediments		
D.O. (ppm)	6.01	1.25		1.18	*	*

$^{\alpha}$Log no. organisms = Log organisms/mL; n = no. samples;
$\bar{x}$ = mean; s.d. = standard deviation; ND = not detected;
* = Probability, P, could not be determined (difference in variances, i.e. s.d.^{2}, too large, as determined by the F test);
$(^{p}/_{q})$ = p out of q samples positive.

TABLE 2

WHITE'S OPENCUT - SEDIMENT SAMPLES

	May 1979 n = 9		June 1978 n = 5		Probability (P) that $\bar{x}$ is same
	$\bar{x}$	s.d.	$\bar{x}$	s.d.	
pH	2.70	0.1	2.14	0.2	P = 0.001
Log Soluble Solids (ppm)	4.07	0.1	4.13	0.03	*
Log Soluble Copper (ppm)	1.75	0.04	1.92	0.03	P = 0.001
Log Soluble Iron (ppm)	2.39	0.2	2.65	0.1	P = 0.05
Log No.$^{\alpha}$ <u>T. ferrooxidans</u>	4.0 ($^9/_9$)	1.3	4.3 ($^5/_5$)	1.1	P = 0.8
Log No. S oxidisers pH 4.8	4.2 ($^9/_9$)	1.3	4.5 ($^5/_5$)	0.9	P = 0.7
Log No. S oxidisers pH 6.2	1.0 ($^3/_9$)	1.7	ND		
Log No. Acidophilic Heterotrophs pH 3.5	1.2 ($^3/_9$)	1.8	0.9 ($^2/_5$)	1.3	P = 0.8
Log No. <u>Chlorella</u>	ND		3.2 ($^5/_5$)	0.8	
D.O. (ppm)	0.38	0.18	1.18	0.52	P = 0.005

$^{\alpha}$Log no. organisms = log organisms/mL; n = no. samples;
$\bar{x}$ = mean; s.d. = standard deviation; ND = not detected;
* = P could not be determined;
($^p/_q$) = p out of q samples positive.

TABLE 3
WHITE'S OPENCUT - SURFACE SAMPLES

	May 1979 n = 6 $\bar{x}$	s.d.	June 1978 n = 4 $\bar{x}$	s.d.	Probability (P) that $\bar{x}$ is same
pH	2.82	0.04	2.53	0.1	P = 0.001
Log Soluble Solids (ppm)	3.9	0.02	3.9	0.1	*
Log Soluble Copper (ppm)	1.7	0.02	2.0	0.1	*
Log Soluble Iron (ppm)	2.1	0.05	2.2	0.1	P = 0.4
Log No.$^{\alpha}$ <u>T. ferrooxidans</u>	($^1/_6$)		2.0 ($^4/_4$)	0.4	
Log No. S oxidisers pH 4.8	ND		1.4 ($^3/_4$)	1.0	
Log No. S oxidisers pH 6.2	ND		($^1/_4$)		
Log No. Acidophilic Heterotrophs pH 3.5	ND		ND		
Log No. <u>Chlorella</u>	1.7 ($^3/_6$)	1.9	1.5 ($^3/_4$)	1.1	P = 0.9
D.O. (ppm) Above interface Surface 4M	4.43 (n=23)	0.6	6.34 (n=9)	1.0	P = 0.001

$^{\alpha}$Log no. organisms = log organisms/mL; n = no. samples;
$\bar{x}$ = mean; s.d. = standard deviation; ND = not detected;
* = P could not be determined;
($^p/q$) = p out of q samples positive.

TABLE 4

INTERMEDIATE OPENCUT - SEDIMENT SAMPLES

	May 1979 n = 12 $\bar{x}$	s.d.	June 1978 n = 5 $\bar{x}$	s.d.	Probability (P) that $\bar{x}$ is same
pH	3.36	0.1	3.10	0.3	P = 0.001
Log Soluble Solids (ppm)	3.7	0.03	3.7	0.08	P = 0.3
Log Soluble Copper (ppm)	1.8	0.03	2.1	0.1	*
Log Soluble Iron (ppm)	0.2	0.5	ND		
Log No.[α] *T.ferrooxidans*	1.9 ($^{12}/_{12}$)	0.2	3.4 ($^{5}/_{5}$)	0.3	P = 0.001
Log No. S oxidisers pH 4.8	1.8 ($^{6}/_{12}$)	1.9	3.9 ($^{5}/_{5}$)	1.2	P = 0.05
Log No. S oxidisers pH 6.2	1.5 ($^{6}/_{12}$)	1.6	3.5 ($^{5}/_{5}$)	1.3	P = 0.025
Log No. Acidophilic Heterotrophs pH 3.5	1.5 ($^{7}/_{12}$)	1.5	3.8 ($^{5}/_{5}$)	1.2	P = 0.01
Log No. *Chlorella*	ND		2.3	0.9	
D.O. (ppm)	4.8	2.2	4.2	1.8	P = 0.7

[α] Log no. organisms = log organisms/mL; n = no. samples;
$\bar{x}$ = mean; s.d. = standard deviation; ND = not detected;
* = P could not be determined;
($^{p}/q$) = p out of q samples positive.

TABLE 5
INTERMEDIATE OPENCUT

	JUNE 1978				
	Water Column $n = 14$		Sediments $n = 5$		Probability (P) that $\bar{x}$ is same
	$\bar{x}$	s.d.	$\bar{x}$	s.d.	
pH	3.05	0.2	3.10	0.3	P = 0.7
Log Soluble Solids (ppm)	3.7	0.07	3.7	0.08	P = 0.7
Log Soluble Copper (ppm)	2.1	0.05	2.1	0.1	P = 0.6
Log Soluble Iron (ppm)	ND		ND		
Log No.$^{\alpha}$ <u>T.ferrooxidans</u>	1.1 ($^{14}/_{14}$)	0.4	3.4 ($^{5}/_{5}$)	0.3	P = 0.001
Log No. S oxidisers pH 4.8	1.2 ($^{7}/_{14}$)	1.5	3.9 ($^{5}/_{5}$)	1.2	P = 0.005
Log No. S oxidisers pH 6.2	0.3 ($^{3}/_{14}$)	0.6	3.5 ($^{5}/_{5}$)	1.3	P = 0.001
Log No. Acidophilic Heterotrophs pH 3.5	0.4 ($^{3}/_{11}$)	1.0	3.8 ($^{5}/_{5}$)	1.2	P = 0.001
Log No. <u>Chlorella</u>	1.5	1.5	2.3	0.9	P = 0.2
D.O. (ppm)	5.7	1.6	4.2	1.8	P = 0.2

$^{\alpha}$Log no. organisms = log organisms/mL; n = no. samples;
$\bar{x}$ = mean; s.d. = standard deviation; ND = not detected;
($^{p}/q$) = p out of q samples positive.

TABLE 6

COMPARISON OF INTERMEDIATE AND WHITE'S OPENCUTS

WATER COLUMN JUNE 1978

	Intermediate n = 14 $\bar{x}$	White's n = 14 $\bar{x}$		Probability (P) that $\bar{x}$ is same
pH	3.05	2.45		P = 0.001
Log Soluble Solids (ppm)	3.7	3.9		P = 0.001
Log Soluble Copper (ppm)	2.1	2.0		P = 0.005
Log Soluble Iron (ppm)	ND	2.2		
Log No.[α] *T. ferrooxidans*	1.1	1.9		P = 0.001
Log No. S oxidisers pH 4.8	1.2	1.7		P = 0.3
Log No. S oxidisers pH 6.2	0.3	0.4		P = 0.7
Log No. Acidophilic Heterotrophs pH 3.5	0.4	ND		
Log No. *Chlorella*	1.5	1.4		P = 0.9
		Interface		
		Above	Below	
D.O. (ppm)	5.74	6.01	1.25	*

[α]Log no. organisms = log organisms/mL; n = no. samples;
$\bar{x}$ = mean; ND = not detected;
* = P could not be determined.

TABLE 7

COMPARISON OF INTERMEDIATE AND WHITE'S OPENCUTS - SEDIMENTS

	Intermediate		White's		Probability (P) that $\bar{x}$ is same	
	May 1979 n = 12 Col. 1 $\bar{x}$	June 1978 n = 5 Col. 2 $\bar{x}$	May 1979 n = 9 Col. 3 $\bar{x}$	June 1978 n = 5 Col. 4 $\bar{x}$	May Cols. 1&3	June Cols. 2&4
pH	3.36	3.10	2.70	2.14	P=0.001	P=0.001
Log Soluble Solids (ppm)	3.7		4.1		p=0.001	
Log Soluble Copper (ppm)	1.81	2.05	1.75	1.92	P=0.001	P=0.03
Log Soluble Iron (ppm)	0.24	ND	2.39	2.65	P=0.001	
Log No.[α] *T. ferrooxidans*	1.9	3.4	4.1		*	*
Log No. S-oxidisers pH 4.8	1.8	3.9	4.3		P=0.001	P=0.5
Log No. S oxidisers pH 6.2	1.5	3.5	1.0	ND	P=0.6	
Log No. Acidophilic Heterotrophs pH 3.5	1.5	3.8	1.0		P=0.5	P=0.005
Log No. *Chlorella*	ND	1.4	ND	3.2		P=0.1
D.O. (ppm)	4.58		0.57	1.22	*	*

[α] Log no. organisms = log organisms/mL; n = no. samples;
$\bar{x}$ = mean; ND = not detected;
* = P could not be determined.

TABLE 8A

HOLE DUG NEAR INTERMEDIATE OPENCUT, BETWEEN IT AND COPPER CREEK

	HOLE R MAY 1979		
	Soil n=4		Seepage n=1
	$\bar{x}$	s.d.	
Moisture %	9.0	3.9	W
pH	4.63	0.26	3.30
Log Soluble Solids (ppm)	3.3	0.1	3.2
Log Soluble Copper (ppm)	1.3 ($^1/_4$)		1.0
Log Soluble Iron (ppm)	ND		1.7
Log No.$^{\alpha}$ _T.ferrooxidans_	3.2 ($^3/_4$)	0.2	ND
Log No. S oxidisers pH 4.8	2.7 ($^3/_4$)	0.9	2.4
Log No. S oxidisers pH 6.2	3.0	0.6	5.9
Log No. Acidophilic Heterotrophs	ND		ND
Desulfovibrio spp.	ND		+
T.denitrificans	ND		+

$^{\alpha}$Log no. organisms = log organisms/g dry weight or /mL;
n = no. samples; $\bar{x}$ = mean; s.d. = standard deviation;
($^p/q$) = p out of q samples positive; ND = not detected;
+ = positive growth in selective liquid medium.

TABLE 8B

HOLE R

Distance from Surface (m)	Temperature °C	Relative Humidity %
0	33 (ambient)	72 (ambient)
0.5	32	88
1.0	31.6	80
1.5	30.5	95
2.0	30	90

TABLE 9
ASSOCIATED WATER SYSTEMS

n=1

	Area 1 M	Area 1 J	Area 2 M	Area 2 J	Area 3 M	Area 3 J	Area 4 M	Area 4 J	Area 5 M	Area 5 J	Area 6 J	Area 7 J
pH	2.6	2.8	2.5	2.7	2.5	2.6	2.4	2.6	2.7	3.0	3.0	2.9
Log Soluble Solids (ppm)	3.5	3.6	3.8	3.9	4.2	5.0	3.6	4.0	3.7	3.9	3.9	4.3
Log Soluble Copper (ppm)	2.5	2.6	2.7	2.9	3.0	4.4	2.5	2.8	2.2	2.3	2.2	3.1
Log Soluble Iron (ppm)	1.8	2.0	1.9	2.6	2.6	3.9	2.0	2.5	1.6	1.4	1.7	2.5
Log No.$^{\alpha}$ <u>T.ferrooxidans</u>	2.2	1.3	1.6	2.8	ND	4.9	ND	1.3	ND	1.7	1.5	3.7
Log No. S oxidisers pH 4.8	ND	ND	ND	2.6	ND	3.6	1.3	2.9	ND	ND	3.9	ND
Log No. S oxidisers pH 6.2	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND	ND
Log No. Acidophilic Heterotrophs pH 3.5	1.5	ND	ND	ND	ND	3.1	ND		ND	2.6	ND	2.0

See Map 2
Area 1 = Barren liquor pond; Area 2 = oxide, or main pregnant liquor, pond;
Area 3 = Sulphide, or secondary pregnant liquor, pond;
Area 4 = Acid liquor pond;
Area 5 = Copper Creek, old bed of East Finniss, receiving drainage from above 4 ponds;
Area 6 = Copper Creek further west than area 5;
Area 7 = Ditch between sulphide heap and Intermediate opencut;
M = May 1979; J = June 1978;
α Log no. organisms = log organisms/mL; n = no. samples; ND = not detected.

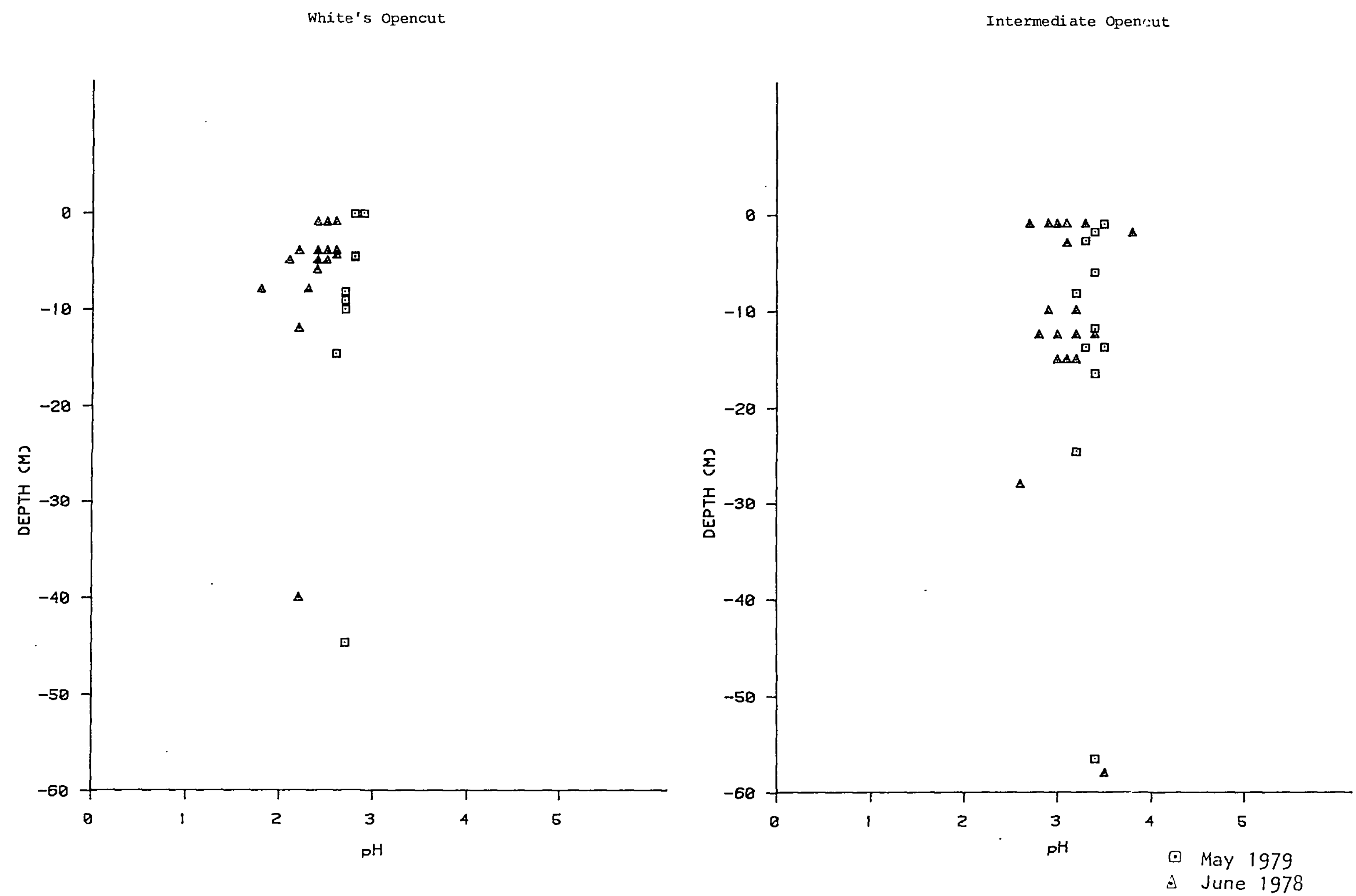


FIGURE 1. pH OF OPENCUTS

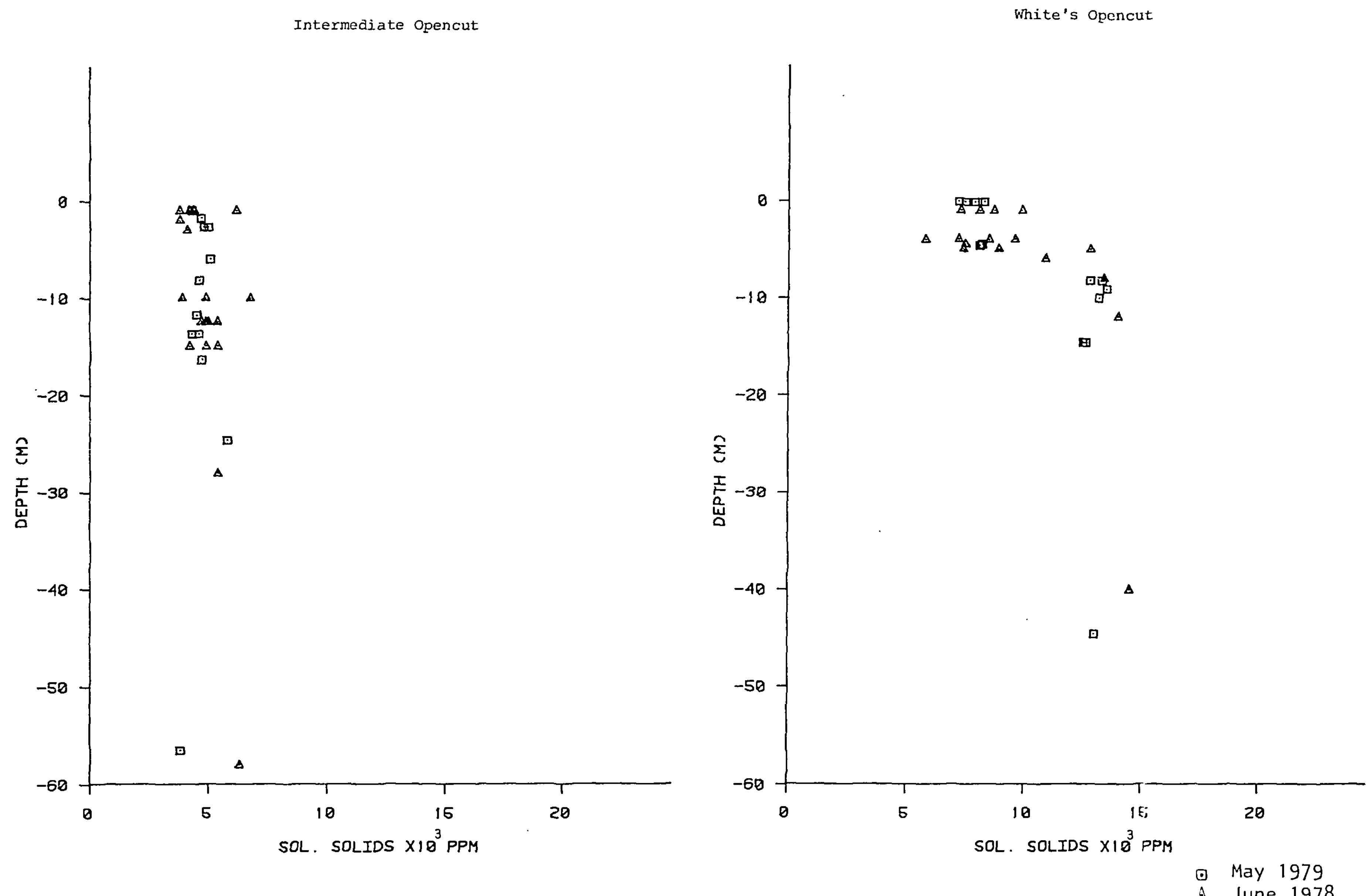


FIGURE 2. CONCENTRATIONS OF TOTAL SOLUBLE SOLIDS IN OPENCUTS

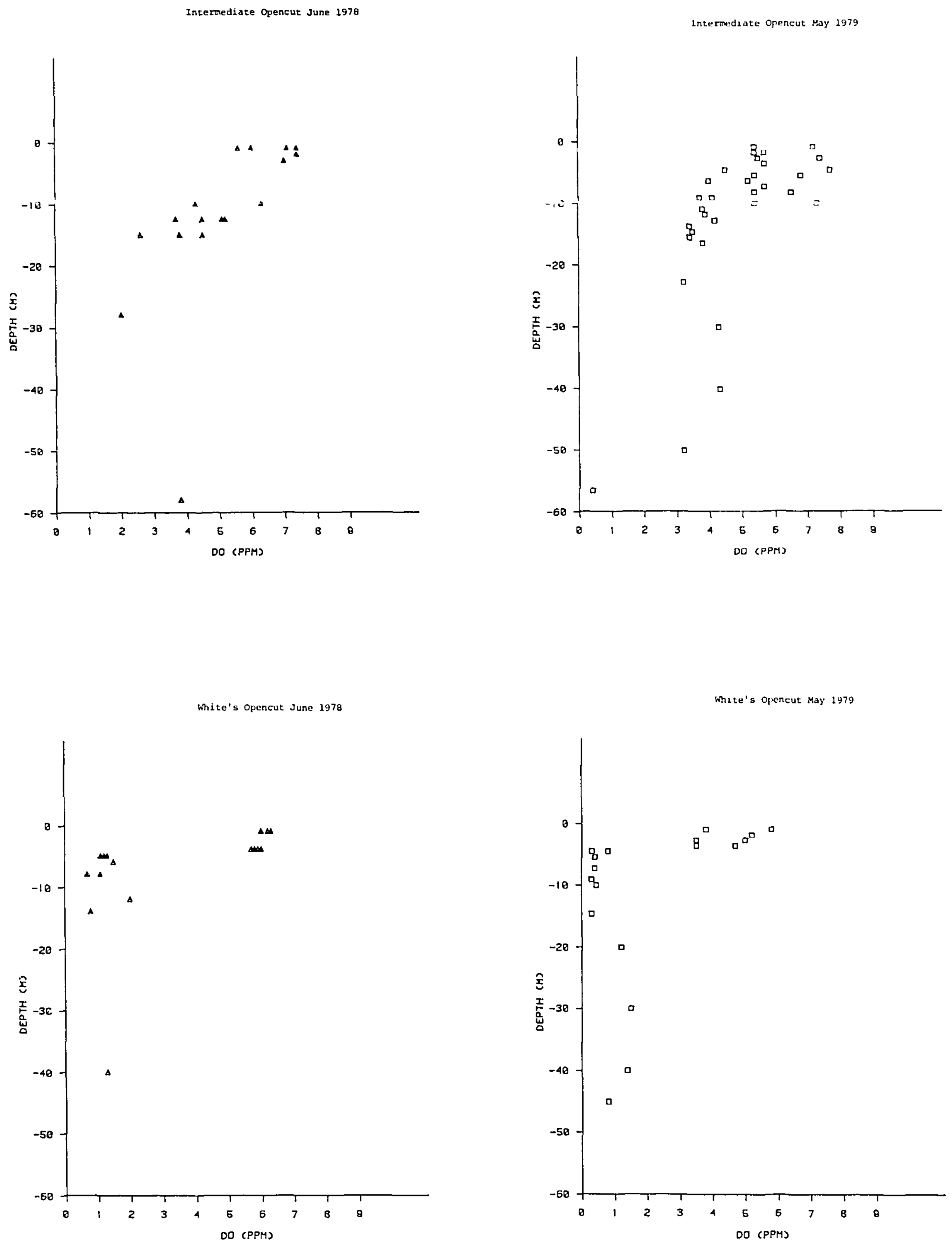


FIGURE 3. CONCENTRATIONS OF DISSOLVED OXYGEN IN OPENCUTS

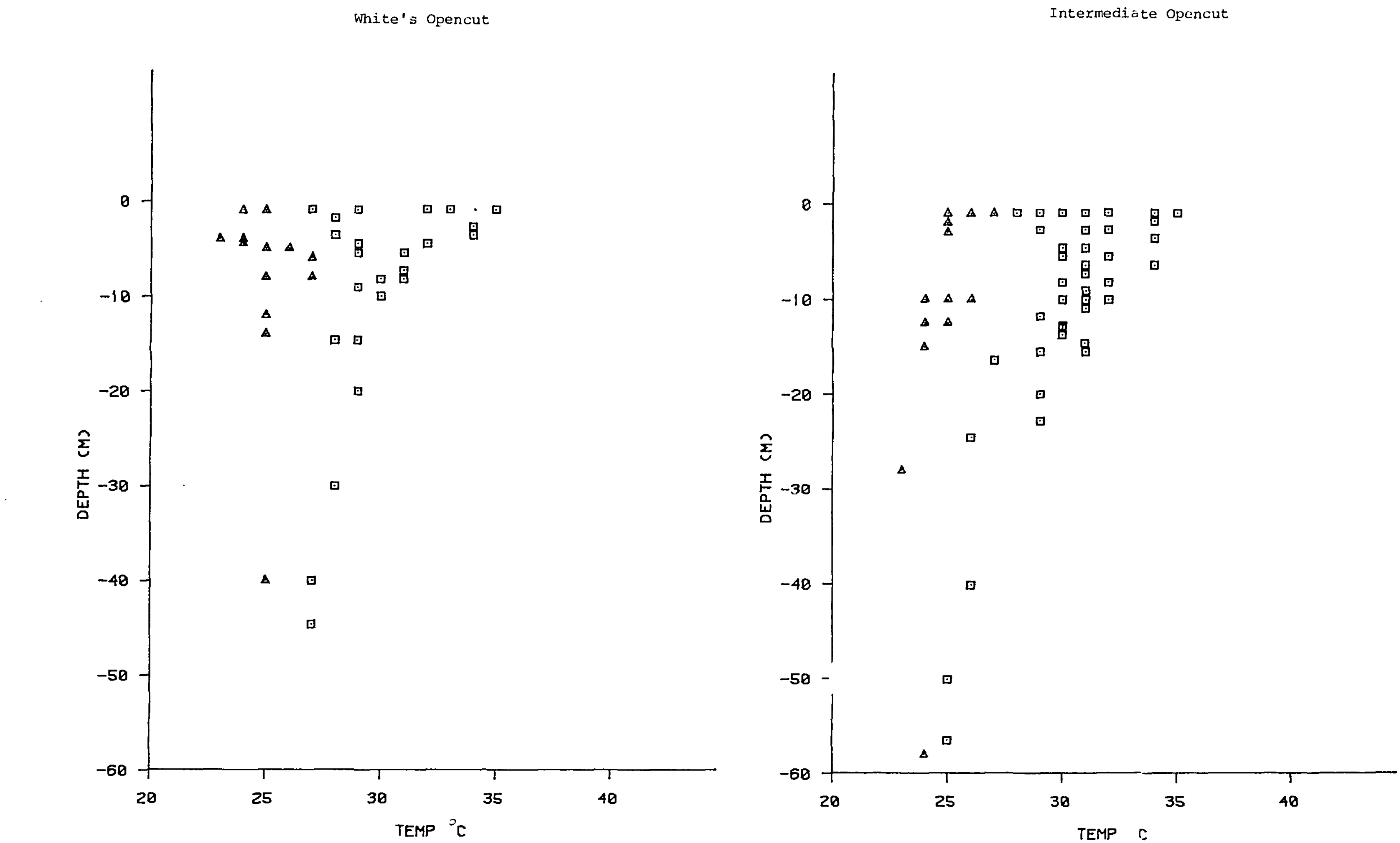
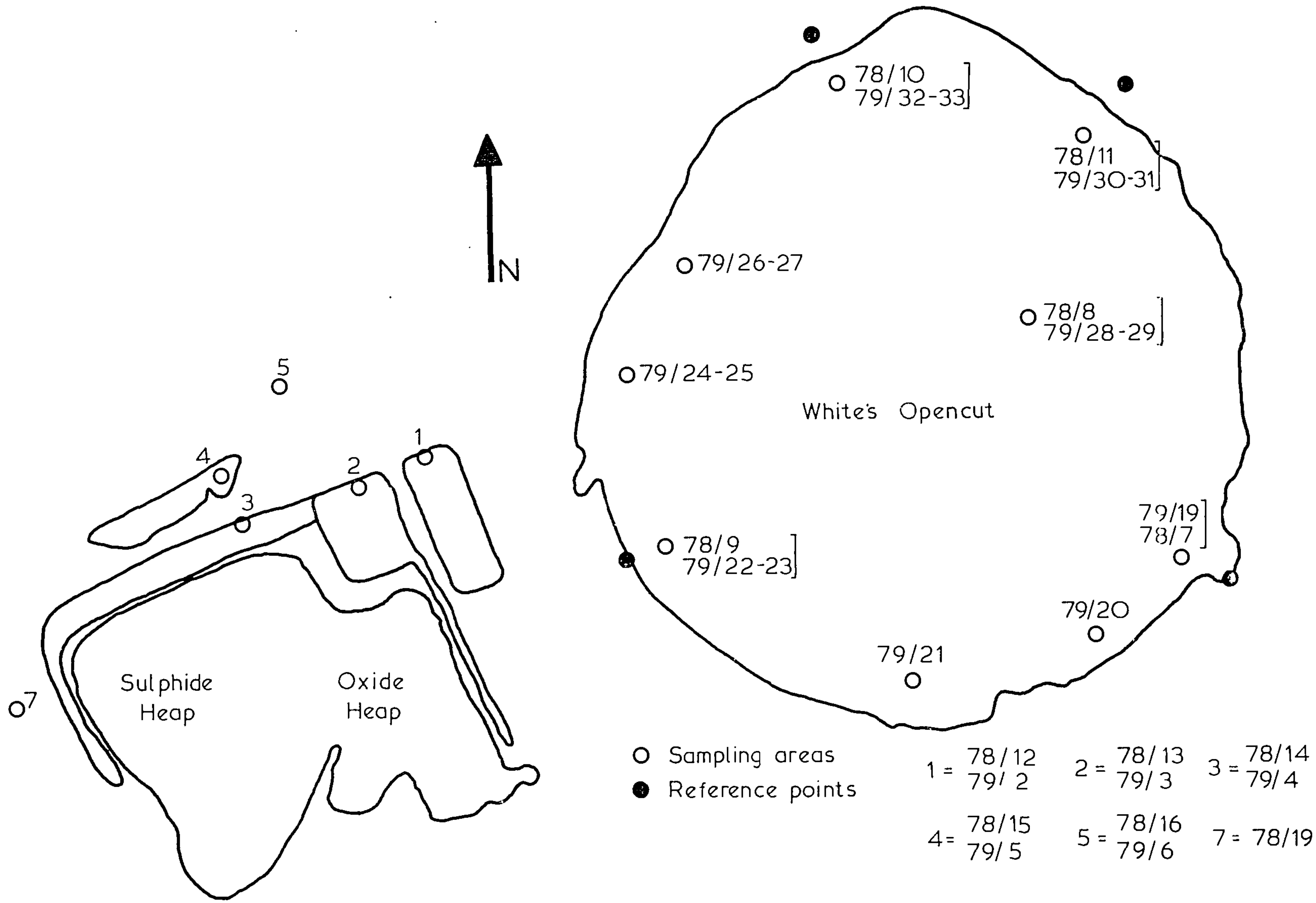
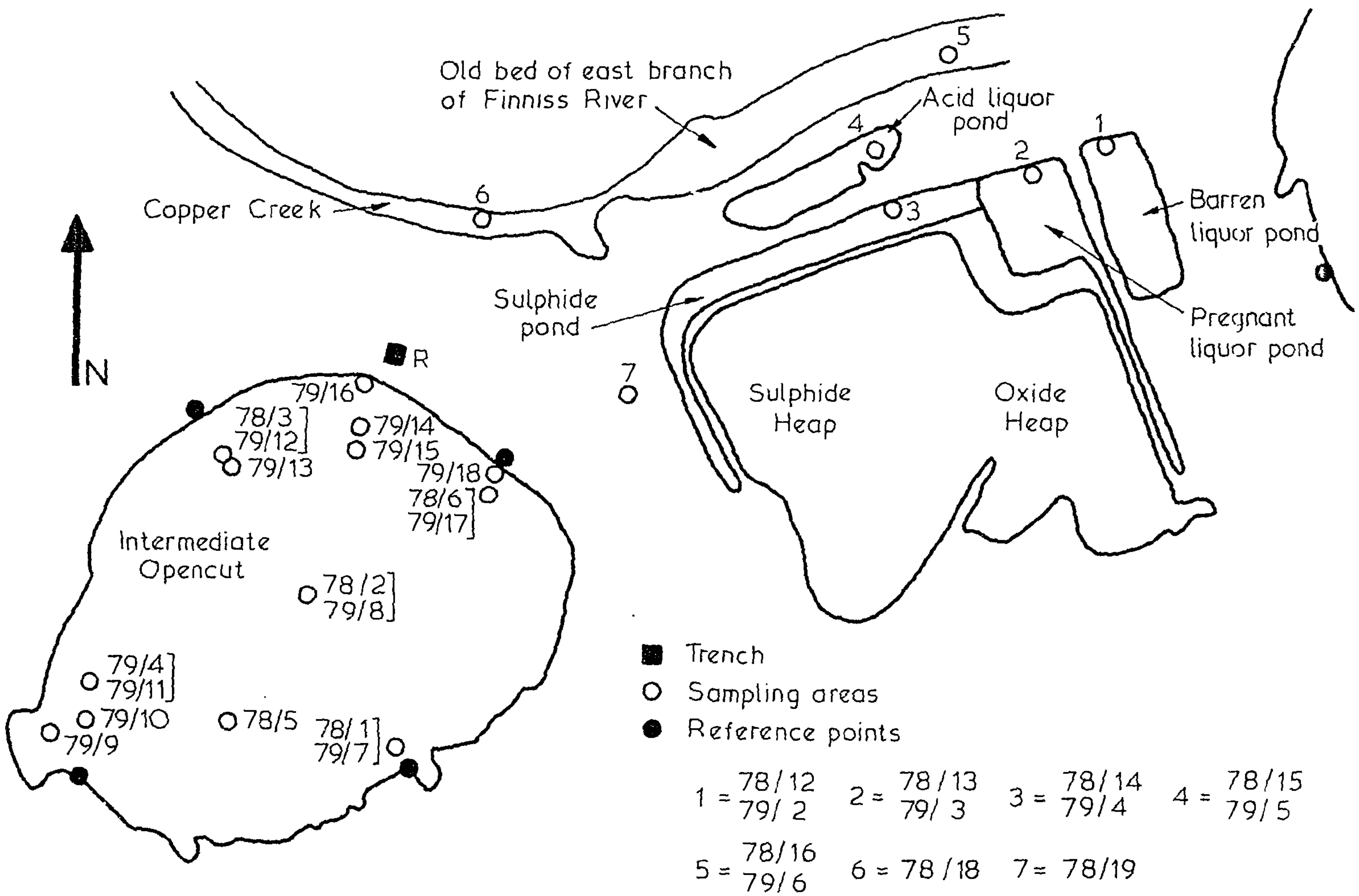


FIGURE 4. TEMPERATURE DISTRIBUTIONS OF OPENCUTS

□ May 1979
△ June 1978



MAP 1. WHITE'S OPENCUT AND COPPER LEACH PILE SHOWING LOCATIONS OF SAMPLING AREAS



MAP 2. INTERMEDIATE OPENCUT AND COPPER LEACH PILE SHOWING LOCATIONS OF SAMPLING AREAS

APPENDIX A

DETAILS OF LOCATIONS FROM WHICH SAMPLES WERE TAKEN - JUNE 1978

Code: RJ no.	Coordinates of sample location *	Description, Field Observations
		INTERMEDIATE OPENCUT
78/1	008-444	Sampling area 10.6 metres from shore.
1		Water sample collected at a depth of 1 metre.
10		Water sample collected at a depth of 10 metres.
12.5		Water sample collected at a depth of 12.5 metres.
15		Water and sediment sample collected from the bottom at a depth of 15 metres.
78/2	004-452	Sampling area in centre of opencut.
1		Water sample collected at a depth of 1 metre.
10		Water sample collected at a depth of 10 metres.
12.5		Water sample collected at a depth of 12.5 metres.
58		Water and sediment sample collected from the bottom at a depth of 58 metres.
78/3	999-459	Sampling area 24 metres from shore.
1		Water sample collected at a depth of 1 metre.
2		Water sample collected at a depth of 2 metres.
3		Water and sediment sample collected from the bottom at a depth of 3 metres.
78/4	992-447	Sampling area 20 metres from shore.
1		Water sample collected at a depth of 1 metre.
10		Water sample collected at a depth of 10 metres.
12.5		Water sample collected at a depth of 12.5 metres.
15		Water and sediment sample collected from the bottom at a depth of 15 metres.
78/6	014-457	Sampling area 17.5 metres from shore.
1		Water sample collected at a depth of 1 metre.
12.5		Water sample collected at a depth of 12.5 metres.
15		Water sample collected at a depth of 15 metres.
28		Water and sediment sample collected from the bottom at a depth of 28 metres.

* Coordinates refer to Map 2.4 in AAEC/E365

(Continued)

Code: RJ no.	Coordinates of sample location	Description, Field Observations
		WHITE'S OPENCUT
78/7	090-469	Sampling area 16 metres from shore.
1		Water sample collected at a depth of 1 metre.
4		Water sample collected at a depth of 4 metres.
5		Water sample collected at a depth of 5 metres.
8		Water and sediment sample collected from the bottom at a depth of 8 metres.
78/8	082-484	Sampling area in centre of opencut.
1		Water sample collected at a depth of 1 metre.
4.5		Water sample collected at a depth of 4.5 metres.
6		Water sample collected at a depth of 6 metres.
40		Water and sediment sample collected from the bottom at a depth of 40 metres.
78/9	059-472	Sampling area 21 metres from shore.
1		Water sample collected at a depth of 1 metre.
4		Water sample collected at a depth of 4 metres.
5		Water sample collected at a depth of 5 metres.
8		Water and sediment sample collected from the bottom at a depth of 8 metres.
78/10	072-498	Sampling area 30 metres from shore.
1		Water sample collected at a depth of 1 metre.
4		Water sample collected at a depth of 4 metres.
5		Water sample collected at a depth of 5 metres.
12		Water and sediment sample collected from the bottom at a depth of 12 metres.
78/11	086-496	Sampling area 17.5 metres from shore.
4		Water sample collected at a depth of 4 metres.
5		Water sample collected at a depth of 5 metres.
14		Water and sediment sample collected from the bottom at a depth of 14 metres.

(Continued)

Code: RJ no.	Coordinates of sample location	Description, Field Observations
		RUM JUNGLE AREA
78/12	046-478	Water sample from barren pond.
78/13	042-476	Water sample from oxide pond.
78/14	037-475	Water sample from sulphide pond, directly at base of sulphide heap.
78/15	035-478	Water sample from acid pond.
78/16	039-483	Water sample from Copper Creek, receiving drainage from all four ponds.
78/17		Water samples from Rum Jungle Creek South opencut.
78/18	013-472	Water sample from 'cut' between Copper Creek and Intermediate opencut.
78/19	022-463	Water sample from deep trench between sulphide heap and Intermediate opencut.
78/20		Radioactive water sample from Radon Spring, Jabiru.

APPENDIX B

PHYSICOCHEMICAL AND MICROBIOLOGICAL DATA - JUNE 1978 SAMPLES

LOCATION: INTERMEDIATE OPENCUT

Sample no.		78/1 1	78/1 10	78/1 12.5	78/1 15		78/2 1	78/2 10	78/2 12.5	78/2 58	
Distance from Basement (cm)		1400	500	250	0		5700	4800	4550	0	
Moisture Content (%)		W	W	W	W		W	W	W	W	
Water solubles ($x10^3$ p p m)		6.2	6.8	4.7	5.4		4.4	4.9	5.4	6.3	
pH		3.1	3.2	3.2	3.1		3.3	3.2	3.4	3.5	
Soluble Metal Content (p p m)	Fe	1	1	1	n		1	1	1	n	
	Cu	145	125	100	165		120	113	120	95	
	Zn	6	4	5	6		6	6	6	7	
T.ferrooxidans ($x10^3$)	pH2.5	0.05	0.01	0.01	5.4		0.02	0.03	0.04	1.3	
Low pH S oxidisers ($x10^3$)	pH3.5	NG	NG	NG	NG		NG	NG	NG	NG	
Intermediate pH S oxidisers ($x10^3$)	pH4.8	15	NG	0.07	0.41		0.64	0.01	3.5	500	
High pH S oxidisers ($x10^3$)	pH6.2	0.02	NG	NG	0.2		NG	NG	0.02	500	
Acidophilic Heterotrophs ($x10^3$)	pH3.5	2.2	NG	NG	0.6		NG	NG	NG	500	
Nutrient Agar ($x10^3$)	pH7	NG	NG	NG	NG		NG	NG	NG	NG	
Desulfovibrio					+					+	
T.denitrificans					+					+	
Chlorella ($x10^3$)	pH3.5	0.72	NG	1.2	1.2		0.86	0.03	8.0	NG	

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p p m) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

(Continued)

LOCATION: INTERMEDIATE OPENCUT (Contd.)

Sample no.		78/3 1	78/3 2	78/3 3		78/4 1	78/4 10	78/4 12.5	78/4 15		
Distance from Basement (cm)		200	100	0		1400	500	250	0		
Moisture Content (%)		W	W	W		W	W	W	W		
Water solubles ($x10^3$ p p m)		4.4	3.8	4.1		3.8	3.9	4.9	4.2		
pH		3.0	3.0	3.1		2.7	2.9	3.0	3.2		
Soluble Metal Content (p p m)	Fe	1	1	1		1	1	1	n		
	Cu	125	125	125		110	95	105	105		
	Zn	7	7	6		6	6	6	7		
<u>T.ferrooxidans</u> ($x10^3$) pH2.5		NG	0.01	4.2		0.02	0.01	0.01	2.0		
Low pH S oxidisers ($x10^3$) pH3.5		NG	NG	NG		NG	NG	NG	NG		
Intermediate pH S oxidisers ($x10^3$) pH4.8		NG	NG	1.2		NG	NG	0.57	10		
High pH S oxidisers ($x10^3$) pH6.2		NG	NG	0.43		NG	NG	0.04	5.6		
Acidophilic Heterotrophs ($x10^3$) pH3.5		NG	NG	0.42		NG	NG	0.21	11		
Nutrient Agar ($x10^3$) pH7		NG	NG	NG		NG	NG	NG	NG		
<u>Desulfovibrio</u>				+					+		
<u>T.denitrificans</u>				NG					+		
<u>Chlorella</u> ($x10^3$) pH3.5		0.1	NG			NG	NG	2.2	0.27		

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p p m) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

(Continued)

LOCATION: INTERMEDIATE OPENCUT (Contd.)

Sample no.		78/6 1	78/6 12.5	78/6 15	78/6 28						
Distance from Basement (cm)		2700	1550	1300	0						
Moisture Content (%)		W	W	W	W						
Water solubles ($x10^3$ p p m)		4.2	5.0	4.9	5.4						
pH		2.9	2.8	3.0	2.6						
Soluble Metal Content (p p m)	Fe	1	1	1	1						
	Cu	125	113	113	85						
	Zn	6	6	7	7						
T.ferrooxidans ($x10^3$) pH2.5		0.01	0.02	0.01	2.4						
Low pH S oxidisers ($x10^3$) pH3.5		NG	NG	NG	NG						
Intermediate pH S oxidisers ($x10^3$) pH4.8		NG	0.01	NG	8.5						
High pH S oxidisers ($x10^3$) pH6.2		NG	NG	NG	2.0						
Acidophilic Heterotrophs ($x10^3$) pH3.5		NG	NG	NG	5.5						
Nutrient Agar ($x10^3$) pH7		NG	NG	NG	0.05						
Desulfovibrio					+						
T.denitrificans					+						
Chlorella ($x10^3$) pH3.5		NG	0.01	NG	NG						

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p.p.m.) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

(Continued)

LOCATION: WHITE'S OPENCUT

Sample no.		78/7 1	78/7 4	78/7 5	78/7 8		78/8 1	78/8 4.5	78/8 6	78/8 40	
Distance from Basement (cm)		700	400	300	0		3900	3550	3400	0	
Moisture Content (%)		W	W	W	W		W	W	W	W	
Water solubles ($x10^3$ p p m)		9.9	9.6	13	13		8.7	7.5	11	15	
pH		2.4	2.2	2.1	1.8		2.5	2.6	2.4	2.2	
Soluble Metal Content (p p m)	Fe	125	125	225	325		125	125	250	525	
	Cu	75	85	115	80		103	100		80	
	Zn	5	6	6	6		6	6		6	
T.ferrooxidans ($x10^3$) pH2.5		0.04	0.05	0.05	1.7		0.05	0.16	0.6	2.3	
Low pH S oxidisers ($x10^3$) pH3.5		NG	NG	NG	NG		NG	NG	NG	NG	
Intermediate pH S oxidisers ($x10^3$) pH4.8		0.12	0.16	1.2	79		0.12	0.02	0.52	25	
High pH S oxidisers ($x10^3$) pH6.2		NG	NG	NG	NG		NG	NG	NG	NG	
Acidophilic Heterotrophs ($x10^3$) pH3.5		NG	NG	NG	0.12		0.03	NG	NG	NG	
Nutrient Agar ($x10^3$) pH7		NG	NG	NG	NG		NG	NG	NG	0.1	
Desulfovibrio					+					+	
T.denitrificans					NG					NG	
Chlorella ($x10^3$) pH3.5		0.24	0.38	0.38	8.1		0.24	0.02	0.22	0.16	

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p.p.m.) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

(Continued)

LOCATION: WHITE'S OPENCUT (Contd.)

Sample no.		78/9 1	78/9 4	78/9 5	78/9 8		78/10 1	78/10 4	78/10 5	78/10 12	
Distance from Basement (cm)		700	400	300	0		1100	800	700	0	
Moisture Content (%)		W	W	W	W		W	W	W	W	
Water solubles ($x10^3$ p p m)		8.1	8.5	7.4	13		7.3	7.2	8.9	14	
pH		2.6	2.5	2.5	2.3		2.6	2.6	2.4	2.2	
Soluble Metal Content (p p m)	Fe	200	150	100	400		125	150	200	500	
	Cu	120	100	135	75		70	138	80	90	
	Zn	5	6	6	6		6	6	6	6	
<u>T.ferrooxidans</u> ($x10^3$) pH2.5		0.16	0.12	0.08	815		0.2	0.05	0.08	20	
Low pH S oxidisers ($x10^3$) pH3.5		NG	NG	NG	NG		NG	NG	NG	NG	
Intermediate pH S oxidisers ($x10^3$) pH4.8		0.03	0.04	0.12	500		NG	0.07	0.07	10	
High pH S oxidisers ($x10^3$) pH6.2		0.02	NG	1.0	NG		NG	0.04	NG	NG	
Acidophilic Heterotrophs ($x10^3$) pH3.5		NG	NG	NG	0.37		NG	NG	NG	NG	
Nutrient Agar ($x10^3$) pH7		NG	NG	NG	NG		NG	NG	NG	NG	
<u>Desulfovibrio</u>					+					NG	
<u>T.denitrificans</u>					NG					NG	
<u>Chlorella</u> ($x10^3$) pH3.5		0.02	0.02	NG	2.5		NG	0.04	0.08	1.0	

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p.p.m.) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

(Continued)

LOCATION: WHITE'S OPENCUT (Contd.)

Sample no.		78/11 4	78/11 5	78/11 14							
Distance from Basement (cm)		800	900	0							
Moisture Content (%)		W	W	W							
Water solubles ($x10^3$ p p m)		5.8	7.4	12							
pH		2.5	2.4	2.2							
Soluble Metal Content (p p m)	Fe	125	225	500							
	Cu	80	80	90							
	Zn	6	6	6							
<u>T.ferrooxidans</u> ($x10^3$) pH2.5		0.07	0.22	33							
Low pH S oxidisers ($x10^3$) pH3.5		NG	NG	NG							
Intermediate pH S oxidisers ($x10^3$) pH4.8		NG	0.1	2.0							
High pH S oxidisers ($x10^3$) pH6.2		NG	NG	NG							
Acidophilic Heterotrophs ($x10^3$) pH3.5		NG	NG	NG							
Nutrient Agar ($x10^3$) pH7		NG	NG	NG							
<u>Desulfovibrio</u>				+							
<u>T.denitrificans</u>				NG							
<u>Chlorella</u> ($x10^3$) pH3.5		NG	NG	0.25							

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p.p.m.) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

(Continued)

LOCATION: SEDIMENT SAMPLES FROM OPENCUTS INTERMEDIATE : WHITE'S

Sample no.		78/1	78/2	78/3	78/4	78/6	78/7	78/8	78/9	78/10	78/11
Distance from Basement (cm)		15	58	3	15	28	8	40	8	12	14
Moisture Content (%)		W	W	W	W	W	W	W	W	W	W
Water solubles ($\times10^3$ p p m)		5.4	6.3	4.1	4.2	5.4	13	15	13	14	12
pH		3.1	3.5	3.1	3.2	2.6	1.8	2.2	2.3	2.2	2.2
Soluble Metal Content (p p m)	Fe	n	n	1	n	1	325	525	400	500	500
	Cu	165	95	125	105	85	80	80	75	90	90
	Zn	6	7	6	7	7	6	6	6	6	6
T.ferrooxidans ($\times10^3$)	pH2.5	5.4	1.3	4.2	2.0	2.4	1.7	2.3	815	20	33
Low pH S oxidisers ($\times10^3$)	pH3.5	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
Intermediate pH S oxidisers ($\times10^3$)	pH4.8	0.41	500	1.2	10	NG	79	25	500	10	2.0
High pH S oxidisers ($\times10^3$)	pH6.2	0.2	500	0.43	5.6	2.0	NG	NG	NG	NG	NG
Acidophilic Heterotrophs ($\times10^3$)	pH3.5	0.6	500	0.42	11	5.5	0.12	NG	0.37	NG	NG
Nutrient Agar ($\times10^3$)	pH7	NG	NG	NG	NG	0.05	NG	0.1	0.05	NG	NG
Desulfovibrio		+	+	+	+	+	+	+	+	NG	+
T.denitrificans		+	+	NG	+	+	NG	NG	NG	NG	NG
Chlorella ($\times10^3$)	pH3.5	1.2	NG	0.02	0.27	NG	8.1	0.16	2.5	1.0	0.25

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p.p.m.) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

(Continued)

LOCATION: RUM JUNGLE AREA | JABIRU

Sample no.		78/12	78/13	78/14	78/15	78/16	78/17	78/18	78/19		78/20
Distance from Basement (cm)											
Moisture Content (%)		W	W	W	W	W	W	W	W		W
Water solubles ($x10^3$ p p m)		4.3	7.9	107	9.5	7.6	5.8	7.5	22		n
pH		2.8	2.7	2.6	2.6	3.0	7.1	3.0	2.9		4.3
Soluble Metal Content (p p m)	Fe	100	400	8250	300	25	n	52	300		n
	Cu	425	750	25000	700	205	n	171	1170		25
	Zn	3	5	30	5	5	n	6	13		n
<u>T.ferrooxidans</u> ($x10^3$)	pH2.5	0.02	0.6	75	0.02	0.05	NG	0.03	5.5		NG
Low pH S oxidisers ($x10^3$)	pH3.5	NG	NG	NG	NG	NG	NG	NG	NG		NG
Intermediate pH S oxidisers ($x10^3$)	pH4.8	NG	0.37	3.6	0.81	NG	NG	7.5	NG		0.33
High pH S oxidisers ($x10^3$)	pH6.2	NG	NG	NG	NG	NG	NG	NG	NG		0.21
Acidophilic Heterotrophs ($x10^3$)	pH3.5	NG	NG	1.2	NG	0.4	NG	NG	0.09		NG
Nutrient Agar ($x10^3$)	pH7	NG	NG	NG	NG	NG	NG	NG	NG		NG
<u>Desulfovibrio</u>											
<u>T.denitrificans</u>											
<u>Chlorella</u> ($x10^3$)	pH3.5	NG	NG	NG	NG	0.6	NG	NG	0.04		NG

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p.p.m.) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

APPENDIX C

TEMPERATURE, DISSOLVED OXYGEN AND pH DATA - INTERMEDIATE OPENCUT WATER SAMPLES, JUNE 1978

Sample No.	Depth (m)	pH	D.O. (ppm)	°C
78/1	1	3.1	7.4	26.8
	10	3.2	8.0	25.9
	12.5	3.2	5.2	25
	15 Bottom	3.1	3.8	24
78/2	1	3.25	7.4	25.5
	10	3.2	4.3	24
	12.5	3.4	3.7	24
	58 Bottom	3.5	3.8	23.5
78/3	1	3.0	7.1	25.2
	2	3.0	7.4	25.2
	3 Bottom	3.1	7.0	25.1
78/4	1	2.7	6.0	25.3
	10	2.9	6.3	25.2
	12.5	3.0	4.5	24
	15 Bottom	3.2	4.5	24
78/6	1	2.9	5.4	25.2
	12.5	2.8	5.1	24.5
	15	3.0	2.6	23.5
	28 Bottom	2.6	2.0	23.2

APPENDIX D

TEMPERATURE, DISSOLVED OXYGEN AND pH DATA - WHITE'S OPENCUT WATER SAMPLES, JUNE 1978

Sample No.	Depth (m)	pH	D.O. (ppm)	^{o}C
78/7	1	2.4	6.2	23.5
	4	2.2	6.0	23.5
	5	2.1	1.25	25.5
	8 Bottom	1.8	0.7	27
78/8	1	2.5	6.3	24
	4.5	2.6	6.2	23.5
	6	2.4	1.5	26.5
	40 Bottom	2.2	1.3	25
78/9	1	2.6	6.0	24
	4	2.5	5.8	23.2
	5	2.5	1.2	25
	8 Bottom	2.3	1.1	25.2
78/10	1	2.6	6.0	24.8
	4	2.6	5.9	23.3
	5	2.4	1.1	24.8
	12 Bottom	2.2	2.0	25
78/11	4	2.5	5.7	23.3
	5	2.4	1.2	24.8
	14 Bottom	2.2	0.8	25

APPENDIX E

DETAILS OF LOCATIONS FROM WHICH SAMPLES WERE TAKEN - MAY 1978

Code: RJ no.	Coordinates of sample location	Description, Field Observations
		INTERMEDIATE OPENCUT
79/7	As 78/1 008-441	Sampling area 11 metres from shore. Sediment sample, depth 13.7 metres.
79/8	As 78/2 004-452	Sampling area in centre of opencut, 95 m from shore. Sediment sample, depth 56.5 m.
79/9	991-443	Sampling area 19 from shore. Sediment sample, depth 11.8 m.
79/10	992-444	Sampling area 36 m from shore. Sediment sample, lot of gravel, depth 16.4 m.
79/11	As 78/4 992-447	Sampling area 19.5 m from shore. Sediment sample, depth 13.7 m.
79/12	As 78/3 999-459	Sampling area 24 m from shore. Sediment sample, depth 2.7 m.
79/13	000-458	Sampling area 29 m from shore. Sediment sample, depth 6.0 m.
79/14	007-461	Sampling area 27 m from shore. Sediment sample, depth 1.8 m.
79/15	007-459	Sampling area 38 m from shore. Sediment sample, depth 8.2 m.
79/16	007-463	Sampling area 3 m from shore, at end of boat. Sediment sample, 1 m deep.
79/17	As 78/6 014-457	Sampling area 18 m from shore. Sediment sample, depth 24.6 m.
79/18	014-458	Sampling area 3 m from shore, at end of boat. Sediment sample, depth 2.7 m, gas driven out.

(Continued)

Code: RJ no.	Coordinates of sample location	Description, Field Observations
		WHITE'S OPENCUT
79/19	As 78/7 090-469	Sampling area 16 metres from shore. Sediment sample, depth 4.5 m.
79/20	084-465	Sampling area 21 m from shore. Sediment sample, depth 4.6 m.
79/21	073-463	Sampling area 25 m from shore. Sediment sample, depth 9.1 m.
79/22	As 78/9 059-472	Sampling area 21 m from shore. Sediment sample, depth 8.2 m.
79/23		Water sample taken at surface.
79/24	057-483	Water sample taken at surface. Sampling area 22 m from shore.
79/25		Sediment sample, depth 10 m.
79/26	061-488	Sampling area 23 m from shore. Water sample taken at surface.
79/27		Sediment sample, depth 8.2 m.
79/28	As 78/8 082-484	Sampling area in centre of opencut. Water sample taken at surface.
79/29		Sediment sample, depth 44.6 m.
79/30	As 78/11 086-496	Sampling area 17.5 m from shore. Water sample taken at surface.
79/31		Sediment sample, depth 14.6 m.
79/32	As 78/10 072-498	Sampling area 26 m from shore. Water sample taken at surface.
79/33		Sediment sample, depth 14.6 m.

(Continued)

Code: RJ no.	Coordinates of sample location	Description, Field Observations
		RUM JUNGLE AREA
79/1	528-025	Water sample from pond in old quarry at end of tailings dam; water level below top of slime dam, separated by embankment.
79/2	046-478	Water sample, edge of barren pond.
79/3	042-476	Water sample, edge of oxide pond.
79/4	037-475	Water sample, edge of sulphide pond.
79/5	035-478	Water sample, edge of acid pond.
79/6	039-483	Water sample, edge of Copper Creek.
79/34	098-464	Water sample, edge of pond at culvert of White's heap.
RJCS		Sediment sample from edge of Rum Jungle Creek South.
	009-464	R HOLE Hole dug where it was thought there was seepage between Intermediate opencut and Copper Creek.
408		Soil sample 0.5 m from top of hole; slightly damp, red-brown.
409		Soil sample 1.0 m from top of hole; damper with zone of gravel deposit.
410		Soil sample 1.5 m from top of hole; tightly compressed, yellow-brown clay.
411		Soil sample 2.0 m from top of hole, about 10 cm from the base. Grey, rocky material, damp.
437		Water sample collected a few days later from seepage into the hole, pH 3.3.

APPENDIX F

PHYSICOCHEMICAL AND MICROBIOLOGICAL DATA - MAY 1979 SAMPLES

LOCATION: INTERMEDIATE OPENCUT

Sample no.		79/7 13.7	79/8 56.5	79/9 11.8	79/10 16.4	79/11 13.7	79/12 2.7	79/13 6.0	79/14 1.8	79/15 8.2	79/16 1.0
Distance from Basement (cm)											
Moisture Content (%)		W	W	W	W	W	W	W	W	W	W
Water solubles ($x10^3$ p p m)		4.3	3.8	4.5	4.7	4.6	5.0	5.1	4.7	4.6	4.3
pH		3.3	3.4	3.4	3.4	3.5	3.3	3.4	3.4	3.2	3.5
Soluble Metal Content (p p m)	Fe	5	2	n	2	n	n	n	n	n	n
	Cu	62	55	65	63	64	68	66	67	67	64
	Zn	7	7	7	7	7	7	6	7	7	6
<u>T.ferrooxidans</u> ($x10^3$) pH2.5		0.11	0.13	0.11	0.07	0.07	0.14	0.04	0.04	0.06	0.09
Low pH S oxidisers ($x10^3$) pH3.5		NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
Intermediate pH S oxidisers ($x10^3$) pH4.8		0.08	4.9	16	18	9.6	NG	NG	NG	NG	NG
High pH S oxidisers ($x10^3$) pH6.2		0.14	0.14	0.81	1.8	1.3	NG	NG	NG	NG	NG
Acidophilic Heterotrophs ($x10^3$) pH3.5		0.05	0.31	0.2	0.15	NG	NG	NG	NG	0.2	0.35
Nutrient Agar ($x10^3$) pH7		NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
<u>Desulfovibrio</u>		+	+	NG	NG	+	NG	+	+	+	+
<u>T.denitrificans</u>		NG	+	+	+	+	NG	+	NG	NG	+
<u>Chlorella</u> ($x10^3$) pH3.5		NG	NG	NG	NG	NG	NG	NG	NG	NG	NG

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p.p.m.) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

(Continued)

LOCATION: INTERMEDIATE OPENCUT (Contd.)

Sample no.		79/17 24.6	79/18 2.7								
Distance from Basement (cm)											
Moisture Content (%)		W	W								
Water solubles ($x10^3$ p p m)		5.8	4.8								
pH		3.2	3.3								
Soluble Metal Content (p p m)	Fe	36	n								
	Cu	59	69								
	Zn	7	7								
T.ferrooxidans ($x10^3$) pH2.5		0.11	0.08								
Low pH S oxidisers ($x10^3$) pH3.5		NG	NG								
Intermediate pH S oxidisers ($x10^3$) pH4.8		1.3	NG								
High pH S oxidisers ($x10^3$) pH6.2		12	NG								
Acidophilic Heterotrophs ($x10^3$) pH3.5		21	NG								
Nutrient Agar ($x10^3$) pH7		NG	NG								
Desulfovibrio		+	NG								
T.denitrificans		+	NG								
Chlorella ($x10^3$) pH3.5		NG	NG								

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p.p.m.) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

(Continued)

LOCATION: WHITE'S OPENCUT

Sample no.		79/19 4.5	79/20 4.6	79/21 9.1	79/22 8.2	79/23 0	79/24 0	79/25 10	79/26 0	79/27 8.2	79/28 0
Distance from Basement (cm)						820	100		820		4460
Moisture Content (%)		W	W	W	W	W	W	W	W	W	W
Water solubles ($x10^3$ p p m)		8.2	8.1	14	13	7.9	8.3	13	7.2	13	7.5
pH		2.8	2.8	2.7	2.7	2.8	2.8	2.7	2.9	2.7	2.8
Soluble Metal Content (p p m)	Fe	100	105	305	325	120	145	300	150	295	120
	Cu	45	55	58	53	53	55	60	55	55	55
	Zn	n	n	n	n	n	n	n	n	n	n
<u>T.ferrooxidans</u> ($x10^3$) pH2.5		12	2.0	0.6	0.3	NG	NG	26	0.15	9.5	NG
Low pH S oxidisers ($x10^3$) pH3.5		NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
Intermediate pH S oxidisers ($x10^3$) pH4.8		488	15	0.1	23	NG	NG	187	NG	34	NG
High pH S oxidisers ($x10^3$) pH6.2		54	0.3	NG	0.1	NG	NG	NG	NG	NG	NG
Acidophilic Heterotrophs ($x10^3$) pH3.5		8.5	0.8	NG	NG	NG	10	NG	36	4.0	NG
Nutrient Agar ($x10^3$) pH7		NG	NG	NG	NG	NG	5.4	NG	NG	NG	NG
<u>Desulfovibrio</u>		+	NG	NG	NG	NG	NG	NG	NG	+	NG
<u>T.denitrificans</u>		NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
<u>Chlorella</u> ($x10^3$) pH3.5		NG	NG	NG	NG	2.3	NG	NG	2.3	NG	5.0

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p.p.m.) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

(Continued)

LOCATION: WHITE'S OPENCUT (Contd.)

Sample no.		79/29 44.6	79/30 0	79/31 14.6	79/32 0	79/33 14.6					
Distance from Basement (cm)			146		146						
Moisture Content (%)		W	W	W	W	W					
Water solubles ($x10^3$ p p m)		13	7.9	13	7.2	13					
pH		2.7	2.8	2.6	2.8	2.6					
Soluble Metal Content (p p m)	Fe	330	125	330	120	325					
	Cu	58	50	60	55	60					
	Zn	n	n	n	n	n					
<u>T.ferrooxidans</u> ($x10^3$) pH2.5		2206	NG	511	NG	1.0					
Low pH S oxidisers ($x10^3$) pH3.5		NG	NG	NG	NG	NG					
Intermediate pH S oxidisers ($x10^3$) pH4.8		80	NG	32	NG	0.1					
High pH S oxidisers ($x10^3$) pH6.2		NG	NG	NG	NG	NG					
Acidophilic Heterotrophs ($x10^3$) pH3.5		NG	NG	NG	NG	NG					
Nutrient Agar ($x10^3$) pH7		NG	NG	NG	NG	NG					
<u>Desulfovibrio</u>		+	NG	NG	NG	NG					
<u>T.denitrificans</u>		NG	NG	NG	NG	NG					
<u>Chlorella</u> ($x10^3$) pH3.5		NG	NG	NG	NG	NG					

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p.p.m.) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

(Continued)

LOCATION: RUM JUNGLE AREA

Sample no.		79/1	79/2	79/3	79/4	79/5	79/6	79/34	RJCS		
Distance from Basement (cm)											
Moisture Content (%)		W	W	W	W	W	W	W	W		
Water solubles ($x10^3$ p p m)		0.7	3.3	6.0	15	4.4	5.1	8.0	0.5		
pH		5.3	2.6	2.5	2.5	2.4	2.7	3.3	6.2		
Soluble Metal Content (p.p m)	Fe	n	65	85	440	95	40	65	n		
	Cu	n	300	525	1050	300	145	33	n		
	Zn	n	2	4	6	2	5	n	n		
<u>T.ferrooxidans</u> ($x10^3$)	pH2.5	NG	0.17	0.04	NG	NG	NG	NG	NG		
Low pH S oxidisers ($x10^3$)	pH3.5	NG	NG	NG	NG	NG	NG	NG	NG		
Intermediate pH S oxidisers ($x10^3$)	pH4.8	NG	NG	NG	NG	0.02	NG	NG	NG		
High pH S oxidisers ($x10^3$)	pH6.2	5.0	NG	NG	NG	NG	NG	NG	1.0		
Acidophilic Heterotrophs ($x10^3$)	pH3.5	NG	0.03	NG	NG	NG	NG	NG	NG		
Nutrient Agar ($x10^3$)	pH7	NG	NG	NG	NG	NG	NG	NG	NG		
<u>Desulfovibrio</u>		NG	NG	NG	NG	NG	NG	NG	+		
<u>T.denitrificans</u>									NG		
<u>Chlorella</u> ($x10^3$)	pH3.5	NG	NG	NG	NG	NG	NG	NG	NG		

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p.p.m.) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

(Continued)

LOCATION: HOLE R

Sample no.		408	409	410	411	437					
Distance from Surface (cm)		50	100	150	200	210					
Moisture Content (%)		4.7	9.7	13.9	7.5	W					
Water solubles ($x10^3$ p p m)		3.1	2.0	1.6	1.7	1.6					
pH		5.0	4.4	4.5	4.6	3.3					
Soluble Metal Content (p p m)	Fe	n	n	n	n	10					
	Cu	n	n	19	n	50					
	Zn	n	n	n	n	n					
<u>T.ferrooxidans</u> ($x10^3$) pH2.5		2.2	1.8	1.0	NG	NG					
Low pH S oxidisers ($x10^3$) pH3.5		NG	NG	NG	NG	NG					
Intermediate pH S oxidisers ($x10^3$) pH4.8		0.08	0.41	NG	4.2	0.25					
High pH S oxidisers ($x10^3$) pH6.2		0.21	1.0	0.57	5.4	749					
Acidophilic Heterotrophs ($x10^3$) pH3.5		NG	NG	NG	NG	NG					
Nutrient Agar ($x10^3$) pH7		NG	0.09	NG	NG	NG					
<u>Desulfovibrio</u>					NG	+					

Enumeration of organisms as no. per ml or gram dry weight
n = negligible (less than 1 p.p.m.) NG = No Growth W = Water Sample
Blank space indicates sample was not tested.

APPENDIX G

TEMPERATURE, DISSOLVED OXYGEN AND pH DATA - INTERMEDIATE OPENCUT WATER SAMPLES, MAY 1979

Sample No.	Depth (m)	pH	D.O. (ppm)	^oC
79/7	0.9	3.25	5.5	31.5
	2.7		5.5	31.5
	4.6		4.5	31
	6.4		4.0	31
	9.1		4.1	31
	10.9		3.75	31
	13.7 sed.		3.5	29.5
79/8	0.9	3.4	7.15	30
	4.6		5.5	30
	9.1		3.7	30.5
	14.6		3.5	30.5
	22.8		3.2	29
	30.1		3.5	26
	40.1		4.3	25.5
	50.1		3.2	25
	56.5 sed.		0.44	24.5
79/9	0.9	3.4	5.4	28
	2.7		5.6	29
	5.5		5.4	29.5
	8.2		5.4	30
	10.9		4.7	30
	11.8 sed.		3.9	29
79/10	0.9	3.4	5.7	29
	5.5		5.7	30
	10.0		5.5	30
	13.7		3.3	30
	15.5		3.4	29
	16.4 sed.		3.8	27
79/11	0.9	3.45	5.7	30
	4.6		5.6	30
	7.3		5.7	31
	10.0		5.4	31
	12.8		4.2	30
	13.7 sed.		3.4	29

(Continued)

Sample No.	Depth (m)	pH	D.O (ppm)	^{o}C
79/12	0.9	3.3	5.4	35
	1.8		5.7	34
	2.7 sed.		5.95	33
79/13	0.9	3.35	6.9	31
	2.7		7.4	31
	4.6		7.7	31
	6.0 sed.		6.5	31
79/14	0.9	3.35	5.3	34
	1.8 sed.		5.4	34
79/15	0.9	3.2	5.4	34
	3.6		5.7	34
	6.4		5.2	33.5
	8.2 sed.		6.5	32
79/16	1.0 sed.	3.5		
79/17	0.9	3.2	6.4	32
	5.5		6.8	31.5
	10.0		7.3	31.5
	15.5		7.1	31
	20.0		8.4	29
	24.6 sed.		8.2	26
79/18	2.7 sed.	3.25		

APPENDIX H

TEMPERATURE, DISSOLVED OXYGEN AND pH DATA - WHITE'S OPENCUT WATER SAMPLES, MAY 1979

Sample No.	Depth (m)	pH	D.O. (ppm)	°C
79/19	0.9	2.8		28
	1.8			29
	2.7			29
	3.6			29.5
	4.5 sed.			29.5
79/20	0.9	2.75	5.8	26.5
	1.8		5.2	27
	2.7		4.9	28
	3.6		1.3	28
	4.6 sed.		0.32	29
79/21	0.9	2.7	3.8	29
	2.7		3.5	29
	3.6		3.5	29.5
	4.6		0.4	29
	5.5		0.29	29
	9.1 sed.		0.29	29
79/22	0.9	2.7	3.9	35
	2.7		4.0	33.5
	3.6		4.1	33.5
	4.6		0.75	31.5
	5.5		0.45	31
	8.2 sed.		0.32	30
79/23	surface	2.8		
79/24	surface	2.8		
79/25	0.9	2.65	5.0	31.5
	2.7		5.0	31
	3.6		0.3	31
	4.6		0.26	30
	10.0		0.3	29.5

(Continued)

Sample No.	Depth (m)	pH	D.O. (ppm)	^{o}C
79/26	surface	2.85		
79/27	0.9	2.7	4.4	33
	2.7		4.5	32.5
	3.6		4.3	32
	4.6		0.6	31.5
	8.2 sed.		0.45	30.5
79/28	surface	2.8		
79/29	0.9	2.7	3.9	32
	2.7		3.9	32
	3.6		4.0	31.5
	4.6		0.32	31.5
	10.0		0.6	29.5
	20.0		1.2	28.5
	30.1		1.5	27.5
	40.1		1.4	27
	44.6 sed.		0.8	27
79/30	surface	2.8		
79/31	0.9	2.6	4.5	33
	2.7		4.4	32
	3.6		4.6	29.5
	4.6		0.5	32
	7.3		0.4	31
	14.6 sed.		0.3	29
79/32	surface	2.75		
79/33	0.9	2.6	5.2	27
	2.7		4.8	28.5
	3.6		4.7	28.5
	4.5		0.35	29
	14.6 sed.		0.26	28