THE USE OF TEMPERATURE PROFILES TO ESTIMATE THE
PYRITIC OXIDATION RATE IN A WASTE ROCK DUMP FROM
AN OPENCUT MINE

J. R. HARRIES and A. I. M. RITCHIE
Environmental Science Division,
Australian Atomic Energy Commission Research Establishment,
Private Mailbag, Sutherland, New South Wales 2232, Australia

(Received 25 September, 1980)

Abstract. Temperature distributions were measured in a dump of waste rock from an old opencut U mining
operation in the Northern Territory of Australia. The 20 yr old dump contained pyritic material, averaging
about 3% S, which is known to be oxidising. The temperatures were in the range 32 to 37°C for most of
the dump, but ranged up to 56°C in one region. The temperature distributions were used to evaluate the
heat source distributions which identify oxidation sites and are a direct measure of rates of oxidation within
the dump.

Oxidation occurred in the top 5 m of the dump and, at some sites, down to 15 m from the surface.
Oxidation rates at the deep sites did not change over the 8 mo period from the end of one wet season to
the beginning of the next.

1. Introduction

High acidity and heavy metal pollution in run-off and seepage water from waste rock
dumps and tailings dams containing pyritic material is a problem common to many
mining operations throughout the world (Raicevic, 1979; Hore-Lacy, 1979; Olson
et al., 1979). Although acid mine drainage has presented an operational problem, over
the years, due to increased corrosion rates of some mine equipment, there is increasing
concern about the impact that polluted waters have on the environs of the mine. The
problem can be controlled while the mine is in operation by directing leachate from
the offending areas into the processing plant where it is treated along with process
water. However, acid generation from oxidation of pyritic material and consequent
acid leaching can continue long after the mine has ceased operation to become one
of the major detrimental environmental effects of disused mine sites.

It is clear that mine managements, faced with the task of meeting water quality
standards, or local authorities faced with the need to rehabilitate abandoned mine
workings, require the measures to be cost effective. This, in turn, requires an under-
standing of the pyritic oxidation mechanism and an appreciation of the rate controlling
steps in that mechanism in a given situation. A necessary prerequisite of such an
understanding is an ability to determine where and at what rate pyritic oxidation
proceeds in a particular dump or tailings dam. However, it would seem necessary to
have some means of ascertaining rapidly and unambiguously that steps taken to
prevent or to eliminate pyritic oxidation have indeed led to a reduction in the oxidation
rate.
Levels of acid and heavy metals in leachate from a waste dump or tailings dam, or the viability of vegetation on the surface of such areas, are obvious indicators of pyritic oxidation. However, neither are good indicators of where the oxidation sites are in the material, or of the oxidation rate, as a number of poorly understood physical and chemical processes are involved in transporting acid and soluble metal salts from the oxidation sites to the surface of the deposited material or to deep drainage. Oxidation of pyrite releases heat and, as soil is a poor conductor of heat, the oxidation process should result in a temperature rise in the region of the oxidation site. The temperature distribution in a mass of material undergoing pyritic oxidation therefore can be used to determine the distribution of pyritic oxidation sites and the rate of oxidation at these sites.

Temperatures can be measured comparatively easily and accurately in the field with simple instrumentation. Furthermore, temperatures are a measure of the average heat production over many cubic metres of material and reflect the behavior of a large volume of the leaching system in the region where the measurements are being made. Such averaging is a distinct advantage in measurements in overburden dumps which are notoriously heterogeneous and where measurements of macroscopic rather than microscopic processes are required. The temperature of the material will also respond quickly (within a few weeks) to changes in heat production and hence to changes in oxidation rates. Other parameters, such as change in leachate concentration, are unlikely to respond so rapidly or so unambiguously to changes in oxidation rate because other factors, such as water flow rates through the material, determine leachate concentrations.

In this paper we describe measurements of the temperature distribution within a waste rock dump which is known to be undergoing pyritic oxidation and feeding water, polluted by heavy metals, into the local river system. Temperatures were monitored over a period of some 3 yr in a set of six probe holes, drilled through the full depth of the dump, to determine where heat was produced. A more detailed set of temperature measurements, carried out over a period of 8 mo, was used to evaluate the heat source distribution. The same probe holes were used to determine the soil matrix density and the water density in the region of the probe holes using neutron and gamma scattering techniques. These determinations will be reported separately.

2. Description of Field Conditions

The waste rock dump studied was the dump of overburden material from opencut mining of White’s U ore body at Rum Jungle in the Northern Territory of Australia. Mining started in 1953 and the site was abandoned in 1971 leaving three overburden dumps, an experimental heap leach pile, a tailings dam and three opencuts which are now flooded. White’s overburden dump, which was completed in 1958, is the largest dump with an area of some $2.7 \times 10^5$ m$^2$, a volume of $4.0 \times 10^6$ m$^3$ and a mass of some $6.9 \times 10^6$ tonne. It is also the largest single source of heavy metal pollution to the East Finniss River which flows through the mine site (Davy, 1975).