

The potential for animal power in small-scale mining in southern Africa

by

K C Taupitz

*Mining Adviser, SADCC Mining Coordinating Unit
Small-Scale Mining Subsector, c/o GTZ, Private Bag RW 37X, Lusaka, Zambia*

Abstract

The use of animal power in small-scale mining in southern Africa may be seen as an alternative to expensive mechanical equipment. However, for environmental and legal reasons, the only animals suitable for mining work are donkeys (or perhaps mules), and these animals do not have sufficient power for most mining and ore processing operations. Nor can the use of whim-type animal powered gears overcome this deficiency. These animals can, however, be efficiently used for surface haulage of ore, overburden or supplies, as load carriers in gemstone mines, as pack or riding animals, and for pulling trains of mine cars underground, and their use for this work should be promoted.

Introduction

About 80–90% of all mines in the SADCC (Southern African Development Coordination Conference) countries are small-scale mines which together produce 10–20% (by value) of each country's mining production. (In this context "small-scale" means a production level of up to 100 000 t/year in the case of open cast mining and 50 000 t/year for underground mining.) The exceptions are small-scale gemstone mines in Zambia and Lesotho, which contribute about 25 and 80% by value, respectively.

Small-scale mining provides jobs (some part-time) for 70 000–100 000 people. About one-third of all employees in the SADCC mining sector work in small mines.

Some small-scale mines rely entirely on manual labour; the miners are often local farmers who use mining to supplement their incomes in seasons when little agricultural work is being done. Other mines use mechanical equipment to greater or lesser degrees. But engines and motors, and the fuel (or electricity supply) to run them, are expensive. For these latter mines, animal power may seem to offer a cost-effective alternative. However, a closer look at the practices and power requirements of mining shows that the potential for adoption of animal traction is limited.

Choice of power animals

Unlike farmers, miners do not have a wide choice of draft animals, for various reasons:

- the environment in many mining areas is not suitable for farming or ranching (dry, barren land with very scarce animal feed resources, or widespread tsetse infestation): many animals simply cannot survive in these areas
- in many countries, larger animals cannot be kept on mining claims because farmers have sole grazing rights on communal or state lands
- some mines are located in game parks or safari reserves where domestic animals are not permitted.

Where environmental or legal conditions are favourable, farmer-miners or farmer-contractors can use their own oxen or horses. And full-time miners could hire such animals from local farmers. But for most miners, the only practical draft animal is the donkey (or perhaps the mule, but this has so far not been very popular in Zambia).

Mining practices

The power requirements of mining practices are rather high in comparison with the power that can be generated by draft animals. For example, the power needed to crush and grind ore to a size suitable for mineral extraction, or limestone to agricultural lime, is some 5–20 kWh; drilling holes requires about 0.7–1 kWh/m; and pumping 1000 litres of water up 50 m over a distance of 200 m takes 2.4 kWh. By comparison, a donkey can generate only about 0.25 kW during six to eight hours of continuous work, an ox or a mule about twice this power, and a horse only about three times this power. Clearly, the use of animal power for these operations is not an efficient alternative to mechanical equipment.

Animals could be used for hoisting, but again their power output is not sufficient. For example, in a vertical shaft, a span of two donkeys can lift a load of only 60 kg by direct pull, or 120 kg using block

and tackle; typical capacities on an incline are 85 kg at 45 degrees or 150 kg at 15 degrees. Such gross weights are too small for practical application.

Whim-type animal-powered gears and runner-wheel gears could be used to make better use of the limited power obtainable from draft animals. For example, in the past, horse whims have been used for hoisting operations in Europe and North America. A simple American design, which could be used in southern Africa, has a sweep length of more than 4 m (5–7 times the drum radius, to avoid gears). One mine donkey could therefore lift about 180–200 kg gross (150 kg net) at 0.1–0.12 m/s. Unfortunately, these capacities are not very useful, and the costs per kWh are quite unfavourable compared to a small diesel engine which has 10 times the power output (Table 1).

In general, therefore, the small amount of power obtainable from donkeys is not really interesting to the miner, bearing in mind the high energy requirements for most mining and ore processing applications.

Haulage and transport

Although donkeys cannot be used cost-efficiently for many mining operations, they can be valuable sources of power for haulage and transport work.

Surface haulage and transport

In Zimbabwe, many small mines use two-wheeled carts pulled by two oxen or five donkeys to take ore from the mine to the mill or to fetch supplies. On a good level (or slightly downhill) road up to 2 tonnes net load can be transported, although in more hilly areas (common in most mining districts), loads should be limited to about 1 tonne to avoid over-exerting the animals. Daily outputs of 12 tonne-km (6 t over a distance of 2 km) would be normal.

A tractor and trailer would, of course, have a much greater work capacity, probably at a lower cost per unit output. But for transporting small quantities of materials a tractor would be under-utilised and hopelessly uneconomical.

Small carts (0.6–0.7 t net load), pulled by two donkeys, could be used in open cast mines to haul ore to the mill or overburden to the dump. Outputs of 2.5–4 tonne-km per shift can be expected under average open cast mine conditions—equivalent to the work of three to four men using wheelbarrows. A disadvantage is that donkeys would not be able to work on gradients greater than about 5%, compared to 8–12% for motorised haulage.

Table 1: Comparison of the estimated costs of running an animal-powered gear and a diesel engine

	<i>Animal gear (US\$)</i>	<i>Diesel engine (US\$)</i>
Capital outlays		
Engine or animal gear	800	3500
Donkeys (4)	400	–
Total outlay	1200	3500
Daily operating costs		
Driver	10	–
Animal feed	6	–
Fuel	–	13
Lubricant	negligible	1
Maintenance	1	1.50
Total operating costs	17	15.50
Daily depreciation		
Engine or animal gear	0.32	2.80
Animals	0.32	–
Interest	0.29	0.84
Total depreciation	0.93	3.64
Total daily running costs	17.93	19.14
Energy produced (kWh/day)	5	50
Cost per kWh output	3.59	0.38

In the past, prospectors have used donkeys and mules as means of transport, and these animals could still be used today as pack animals, especially in mountainous areas where there are no roads for wheeled traffic. For example, for many gemstone mines, the daily output of a few kilograms of unprocessed stone could easily be carried by mule or donkey to the central processing facilities. Also, supervisors and maintenance personnel could use these animals to carry themselves and their tools from a central plant or workshop to the individual small mines and diggings.

Underground haulage

The use of horses or mules to pull trains of mine cars (tubs) has a long tradition in the USA and Europe. An American textbook from 1941 says: "For duties below 200 mineral-ton-miles per day, it has been claimed that no mechanical system can compete with animal haulage".

In southern Africa, haulage distances underground are generally short (20–200 m) and best suited for hand tramming. Only in the chrome mines of the northern sector of the Great Dyke (Zimbabwe) are adits (tunnels) of several hundred metres common. In these mines, one donkey (adits are too narrow for

two animals) could pull a train of 3 x 0.8 t (net) mine tubs at a speed of 0.7 m/s. For a 400 m adit, the productivity of one donkey could equal that of two to three hand trammers.

Other applications

In corundum mines in northern Transvaal, animal power is used for washing corundum (dissolving out softer impurities) in rotating 400–500 litre drums half filled with stone and water. The drums have a horizontal axis, the ends of which are hitched to the drag chain of a span of four oxen. The drum is then rotated by the oxen pulling it over the ground, like a roller, until the corundum is sufficiently clean.

This principle could be applied more generally: a pair of donkeys should be able to rotate a 200 litre drum, with a load of 80–100 kg stone or ore.

Conclusions and recommendations

Donkeys can be used efficiently for surface haulage of ore, overburden or supplies, as load carriers in gemstone mines, as pack or riding animals, and for pulling trains of mine cars underground, and their use for this work should be promoted. However, whims and other arrangements to convert donkey power into rotating energy cannot be recommended, because the energy requirement of even small-scale mining are too high.

Photograph opposite
Four oxen in northern Namibia pulling a sledge carrying wood