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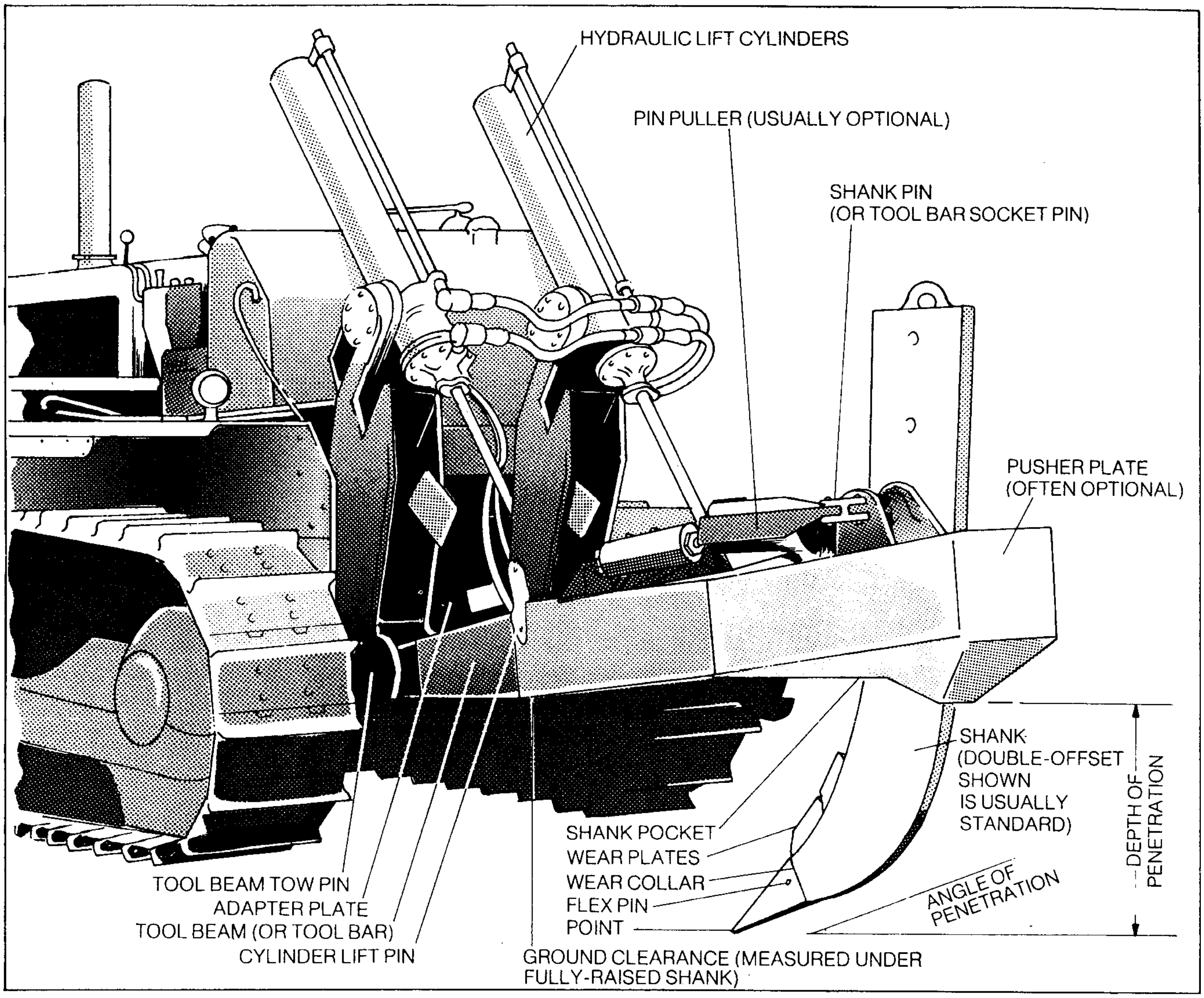
Rip Instead of Drilling and Blasting



Rip Instead of Drilling and Blasting

Rather than bringing in drilling and blasting crews to loosen difficult overburden, operators are finding tractor ripping more economical and practical.

Dan Jackson, western editor

As tractor size, weight and horsepower have steadily increased, the use of rippers has expanded dramatically in surface mining, both in their capabilities and applications. Harder materials can be ripped to greater depths at higher production rates than ever before, offering economic advantages over drilling and blasting. One company, CRC Kelley, now offers a 179-in.-long ripper shank to match the strength of the new super dozers, a major leap in ripper capability. Units are now in operation in North Dakota and Colorado.

The additional weight the new breed of giant tractors brings to bear upon the ripper tooth extends the range of materials that can be ripped. Tandem ripping, adding the weight and power of a second tractor, extends the rippability range even further. There are limits to what material can be ripped and what must be drilled and blasted, but ripping is competing more and more with drill and blast methods.

"Each new generation of big horsepower tractors seems to give greater emphasis to ripping productivity," said Rusty

More versatile rippers with larger shanks, combined with bigger, stronger tractors, are changing capabilities of overburden ripping.

Bentley, president, Kelley Products. "As costs go up and users demand higher returns in efficiency and production, I think with this current generation of tractors we have seen ripping come into its own as the most effective and economical tool in the earth moving industry."

The production rate and cost per bank cubic yard (bcy) determine the equipment and method required to get hard materials into movable form. The advantages of using the tractor-mounted ripper over other methods usually can be summarized in its ability to loosen many materials faster at the lowest cost per yard. To evaluate this advantage, it is necessary to establish cost and production on a unit basis.

Tractor-ripper owning and operating costs include the purchase price of the tractor and its equipment, plus delivery costs to the job site. Ripper tractors are usually equipped with extreme service shoes, crankcase and track roller guards. Taxes and assembly should be included.

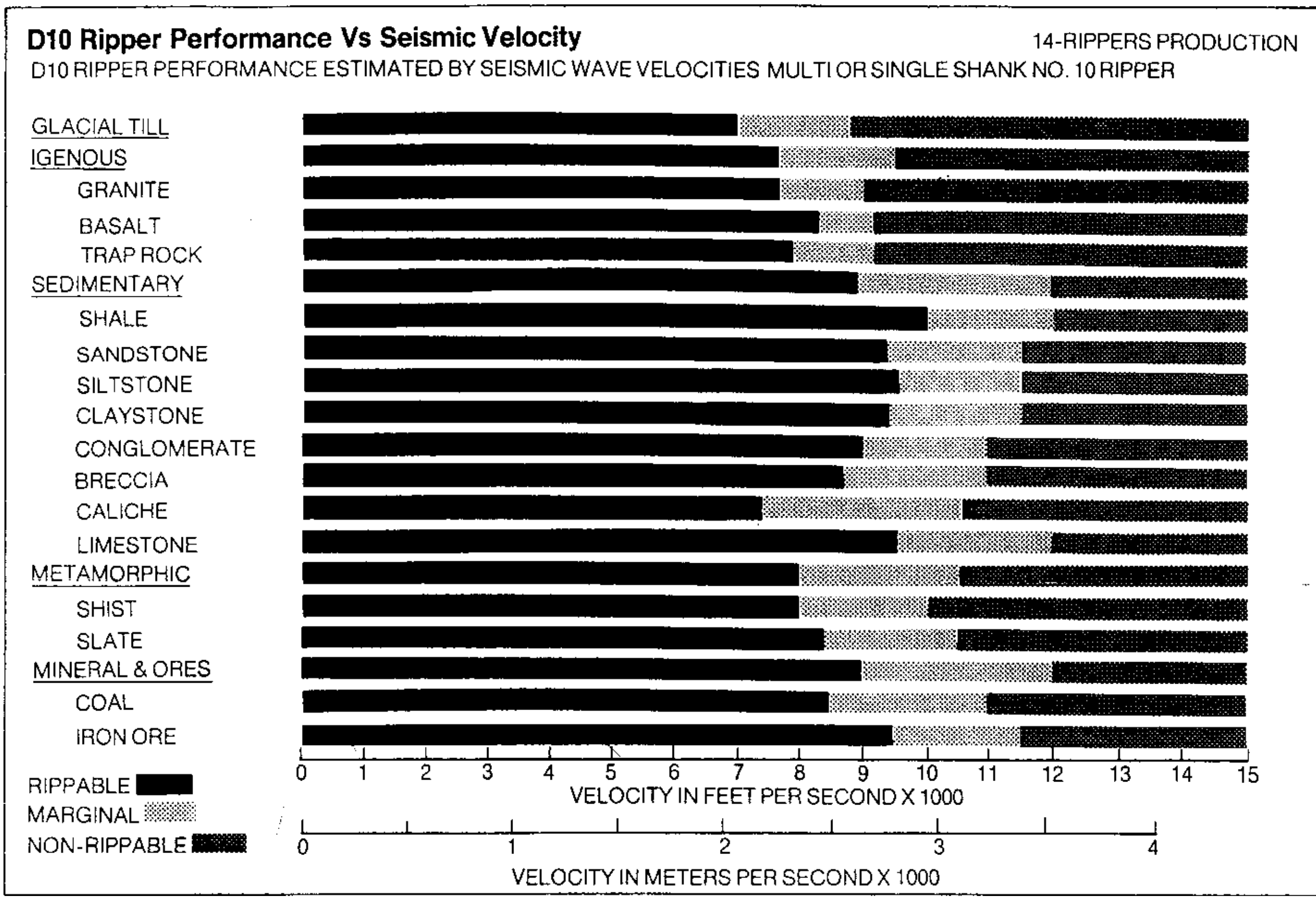
A principal difference between ripping-tractor vs. dozing-tractor cost is in the amount charged for repairs and replacement parts such as the ripper tips or dozer cutting edges. Ripper tip costs, for example, range from \$10 to \$60, depending upon size. They may last a month in light applications or only 30 minutes in severe applications. This means an expense of 5¢ to \$120 per hour. An often used tip-life estimate, under heavy one-shank conditions, is 10 hours.

Ripping and dozing hard rock are the most difficult jobs for track-type tractors, and cause the highest repair costs. Among other problems, ripping tends to wear out undercarriage components faster than pushing or dozing applications. A repair cost of 120-130% of the depreciation cost is not unusual, and even higher in extreme conditions.

A time study obtained on one job indicated that in 8.5 minutes the ripper could make two 500-ft passes at an average ripping depth of 2 ft. The spacing between passes is 3 ft. This produced the following equation:

$$\text{Production} = \frac{1{,}000\text{ ft} \times 2\text{ ft} \times 3\text{ ft} \times 60\text{ min}}{27\text{ cu ft} \times 8.5\text{ min}} = 1{,}569\text{ bcy/hr}$$

Results obtained by this method are about 15 to 30% higher than taking exact volume measurements to deter-



D10 Ripper Performance Vs Seismic Velocity

mine the actual amount of material removed. Therefore, if 20% correction is used, then production is 1,255 bcy per hour. With overall operator-machine efficiency estimated at 75%, the final production figure, according to this time study, was 1,255 x 0.75, or 941 bcy per hour. Hourly owning and operating cost of this tractor, estimated at $84.62 divided by 941 bcy per hour computes to 9¢/bcy

Tandem ripping

If some parts of rock formations prove too rough for normal ripping, there are two possibilities to be considered: using widely spaced explosives followed by rippers, or using tandem ripping tractors moving one ripper shank. A third alternative, a combination of both, may prove economical, especially if material can be scraper loaded rather than with shovels and trucks. However, accelerated wear increases hourly owning and operating costs—scrapers up one third, pushers up one half, and rippers up three quarters.

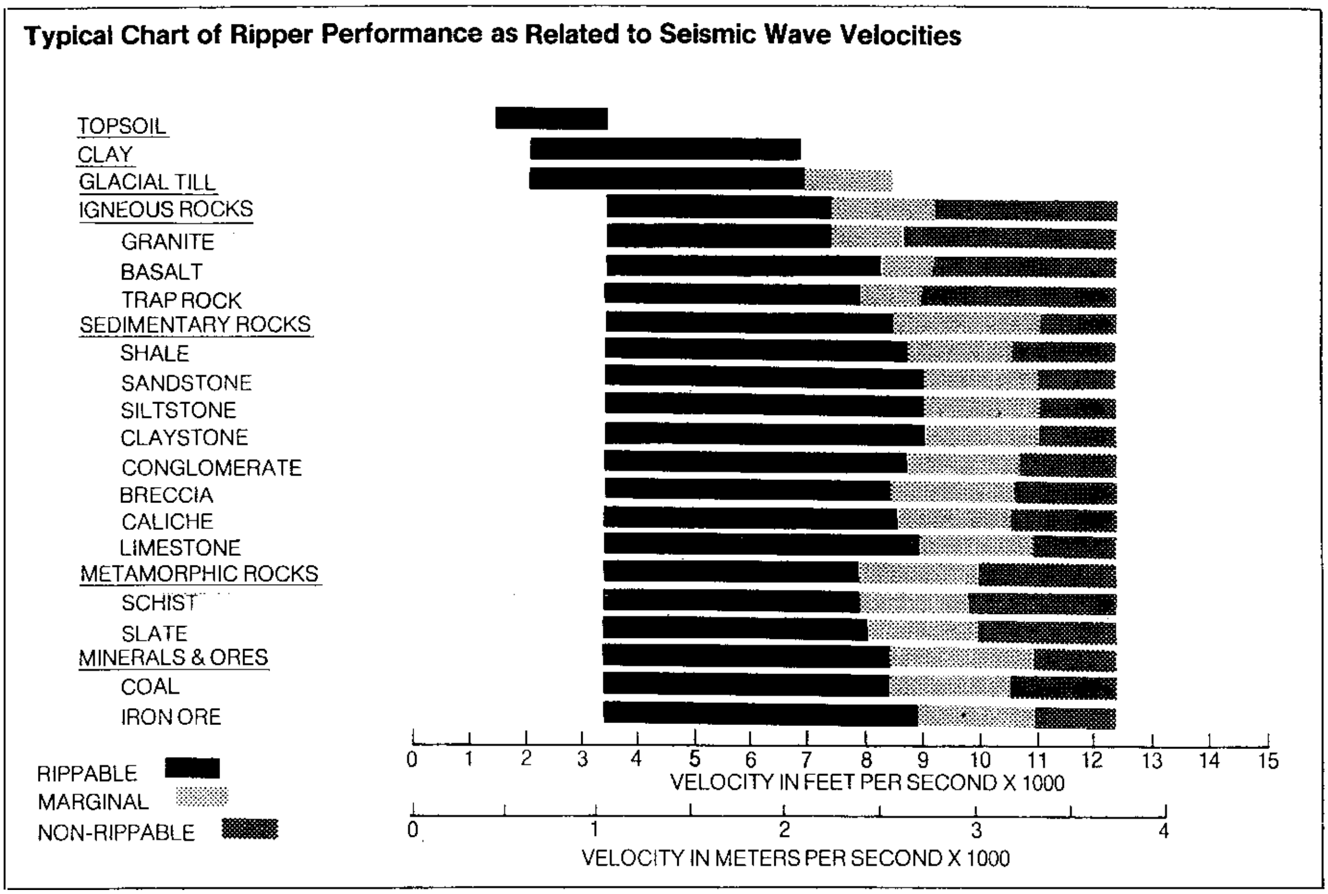
Tandem ripping to loosen difficult materials can extend the rippable range. In the situation of a 50-ft cut, for instance, where the top 15 ft can be removed by scrapers and the next 20 ft removed with a normal ripper-scraper team but where the remaining 15 ft is too difficult for normal ripping, the operator is faced with the choice of bringing in drill and blast equipment and loading units and haul trucks, or trying to tandem-rip and continue to use the scraper already on the job. If the rock can be loosened with the tandem arrangement, a substantial saving can be realized.

When single-tractor ripping, produciton falls below 150 to 200 bcy per hour, the addition of a second tractor may increase hourly production enough to be economical. While a second tractor may almost double machine costs, in a hard ripping zone it may increase production 300%. It may also enable the equipment to continue to work in a still harder ripping zone that would otherwise require drilling and blasting. The following table illustrates how adding a second tractor increases production.

	Typical Seismic, (velocity)	Production (bcy/hr)
Single tractor		
Zone A....................................	5,000	500
Zone B....................................	6,500	300
Zone C....................................	8,500	150
Tandem tractors		
Zone C....................................	8,500	450
Zone D....................................	9,500	300

Ripping vs. drilling and blasting

In a choice of whether to rip, or drill and blast, the first consideration is cost. This initial cost consideration must



then be weighed with other factors, such as using available equipment, determining the best end use of the material, and so on. Transporting and loading methods also must be considered. Optimum performance of bulldozers, scrapers, wheel loaders, trucks, shovels, elevating loaders, and conveyors require materials of varying specifications. Rippers used on a production basis can loosen material for one third to one half the cost of drilling and blasting. The costs of moving material once it is loosened is another valid cost comparison.

End use of the material also influences the decision of whether to blast or rip. Rock must be of a size that can be handled efficiently by the dozer, but modifications in the ripping operation, varying the spacing, depth, and direction of ripping passes, for instance, usually produce the desired particle size. By contrast, a desired rock fragmentation may be difficult to obtain by blasting, necessitating expensive secondary blasting. And, since ripped rock tends to be smaller than rock loosened by blasting, appreciable increases in crusher production may be realized.

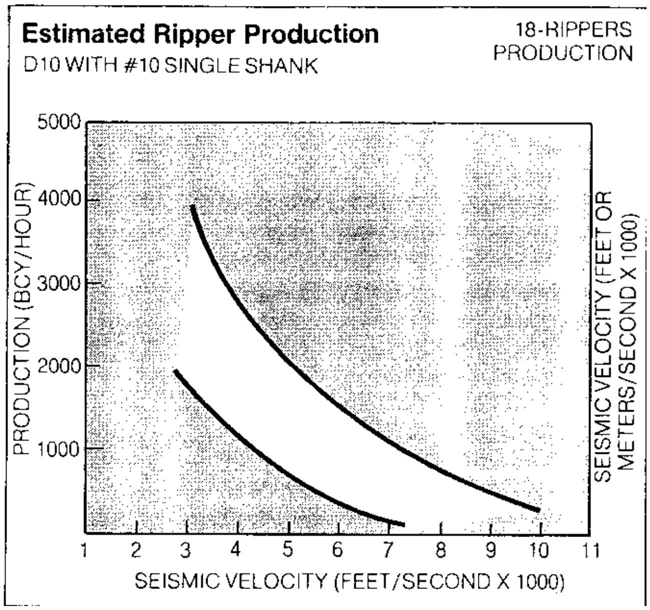
An additional comparison of blasting vs. ripping can be made in terms of how the material is to be moved. Dozed material presents few problems. However, material top loaded into haul units must be smaller than the loading bucket, and scrapers can haul only those materials that are well broken up and loosened.

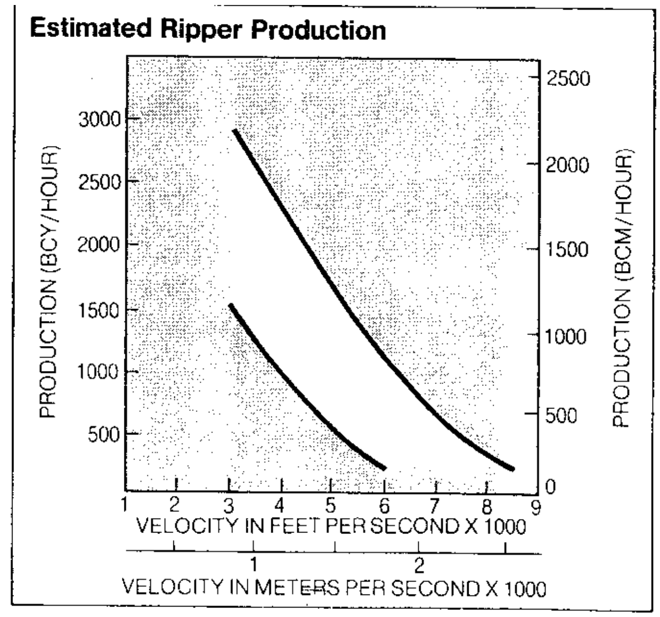
The drilling and blasting process typically averages between 40¢ and 60¢ per bank cubic yard in normal construction and mining operations. For cost per yard to be competitive by this yardstick, a large size dozer must rip about 300 to 350 bcy per hour. When production drops below this level, ripping becomes uneconomical except for small volumes of material where setup costs for blasting become a factor. And, in large operations, drilling and blasting costs can be as low as 15¢ to 30¢ per bank cubic yard. To be competitive there, a dozer would have to trip between 400 and 500 bcy per hour.

Rippability evaluation

To determine whether a particular material can be ripped, field testing and an evaluation of the geology are usually best. Physical characteristics of materials favoring ripping include the presence of fractures, faults and planes of weakness, weathering effects, brittleness or crystalline structure, stratification of lamination, large grain size, moisture permeated clay, shale and rock formations, and low compressive strength. Unfavorable conditions include massive and homogeneous formations, non-crystalline structure, absence of planes of weakness, fine-grained material with a solid cementing agent, and formations of clay origin where moisture makes the material plastic.

Assessing these criteria is largely a matter of observation.





Visible laminations, faults and fractures give a good indication of rippability. However, those conditions which are not visible also must be included in the overall evaluation. A simpler, less expensive test uses refraction a seismograph to determine rippability of materials by indicating the degree of consolidation, including such factors as rock hardness, stratification, degree of fracturing, and the amount of decomposition or weathering.

This system, in wide use for a number of years, is based upon the amount of time it takes for seismic waves to travel through different kinds of sub-surface materials. The speed in a hard, tight rock is fast—up to 20,000 fps, and as slow as 1,000 fps in a loose soil.

Velocity of the seismic waves through the layers is determined by the formula:

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}}$$

where D is the distance from sound source to receiver and T is the time lapse. Plotted points form a line for each type of material, since velocities are the same for a similar consolidation. The flatter the slope of the line, the more consolidated the material.

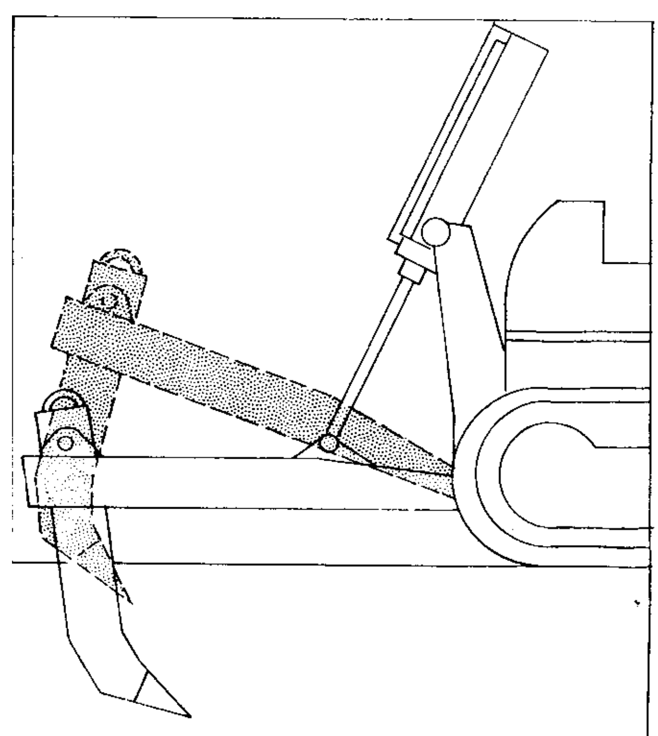
The resulting velocity information can be compared to previous tests in similar materials where the rippability was known. For most materials, a range of rippability in terms of velocities has already been established. From 10 to 20 minutes are required to run each test and to determine seismic wave velocities.

Besides degree of consolidation of rippability of each layer, seismic tests also help reveal the thickness of each layer. The depth of each consoliation change can be computed with the formula:

$$D = \frac{X}{2}\sqrt{\frac{V2 - V1}{V2 + V1}}$$

where:
D = depth
X = distance along the bottom of the graph from zero to the point of intersection
VI = the velocity wave in the upper layer
V2 = the velocity in the next lower layer

However, seismographs give accurate thickness indications only when layers get progressively harder as depth



The radial ripper beam pivots to raise and lower the shank and change the angle of the tip.

increases, as is the usual case.

Ripper equipment selection

In selecting the right equipment for a particular ripping job there are three primary factors to consider:

- Down pressure available at the tip, which determines the ripper penetration that can be achieved and maintained.
- Tractor flywheel horsepower, which determines whether the tractor can advance the tip.
- Tractor gross-weight, which determines whether the tractor will have sufficient traction to use the horsepower.

Ripper mounting brackets and hydraulic control mechanisms vary widely among manufacturers, but there are only three basic ripper designs used: radial, parallelogram and adjustable parallelogram.

The radial ripper provides a variety of angles of penetration to match differences in material. The parallelogram ripper maintains the same tip-to-ground angle regardless of tooth depth, forming a constant tooth angle and providing good penetration characteristics in most materials.

The adjustable parallelogram ripper combines benefits of both types. It has the additional benefit of being able to vary the tip angle to the optimum angle of penetration, and can be adjusted for optimum ripping angle in any material while the tractor continues to move.

Penetration depends both upon down-pressure and penetration angle. The best angle (formed by the front or top face of the ripper tip and the ground when penetration is about to begin) varies as the cut progresses, depending upon the kind and consolidation of material.

Short shank tips are used when penetration is difficult and shock is severe, and long tips are used in abrasive materials where breakage is not a primary factor. Intermediate tips are recommended for applications where abrasive material is hard enough to break the long tip.

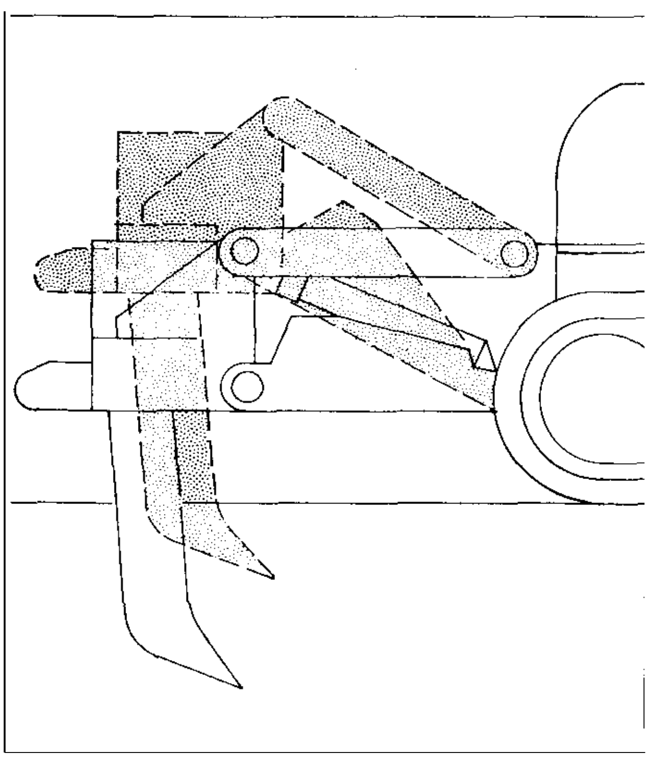
Ripping techniques

Most ripping is done in first gear because 1 to 1½ mph gives economical production, and tractor undercarriage and ripper tip wear increase rapidly with an increase in speed. When working with easily ripped materials, it is better to use two or three teeth rather than increase speed.

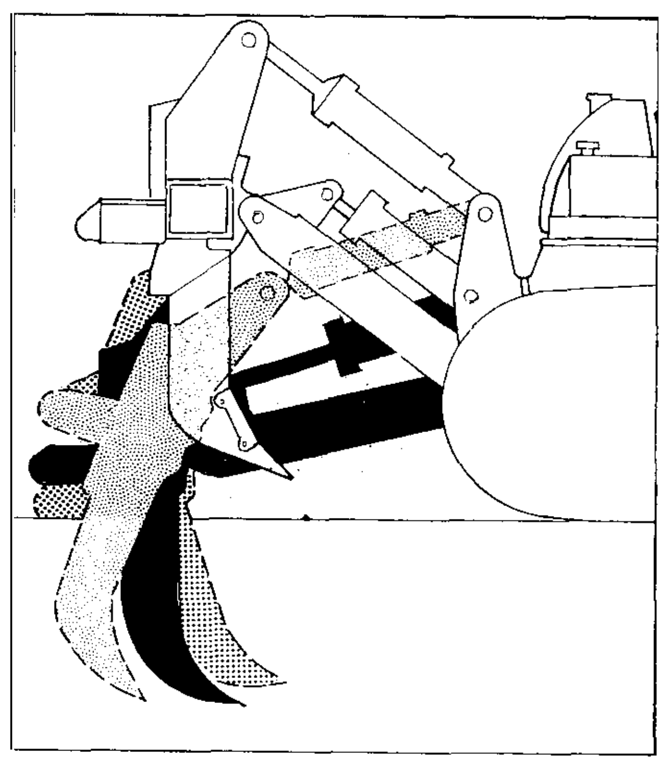
One tooth is normally used in material that breaks out in large, thick slabs. The slabs fracture or pass around the shank. Often, even though the material can be handled with two teeth, production is higher with only one tooth. One reason is there is less slippage and stalling, making it easier on machine and operator.

When using two teeth in difficult materials, one may become stalled temporarily by a hard spot, producing severe off-center loads on the ripper beam, mounting and tractor. Using only one tooth centers the load on the beam and mounting assembly and allows the tooth to exert full force.

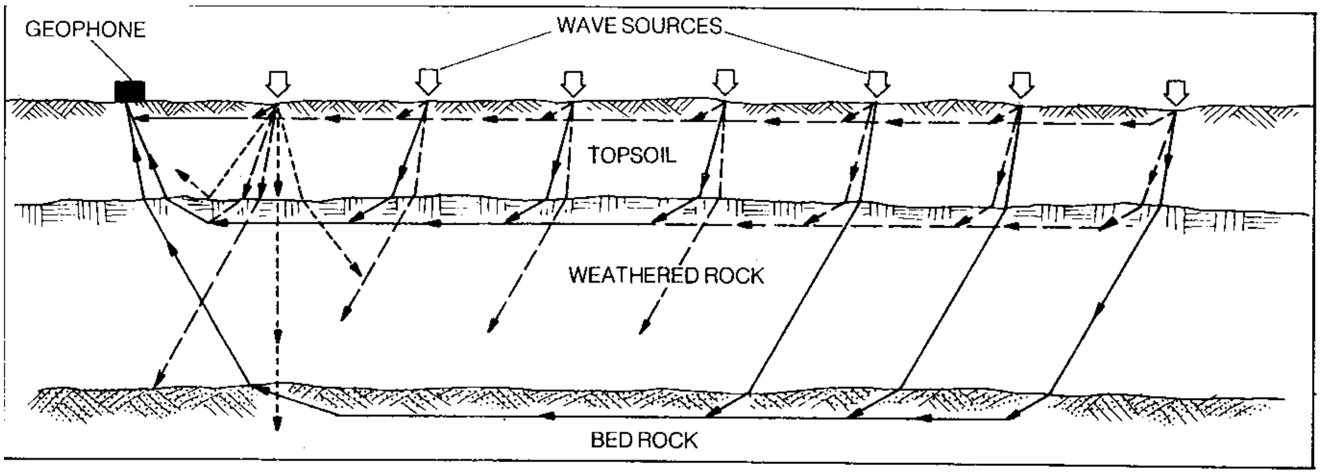
Sometimes it is practical to rip as deep as the shank will allow. However, where more stratification is encountered, it is usually preferable to rip at partial depth, removing the material in its natural layers, rather than making a full-depth pass. An initial, half-depth pass breaks the material loose. The second pass can be made at full depth with much less effort and better total fragmentation.



The parallelogram ripper maintains the same hp-to-ground angle at all depths as the shank penetrates the ground.



Adjustable parallelogram ripper combines radial and parallelogram traits, with varying tip-to-ground angle as the ripper penetrates.



In addition, if the tooth will not penetrate to full depth, the rear of the tractor will be lifted off the ground. When this occurs, traction is lost and ripping production goes down. Also the added weight to the front rollers and idlers causes undue stress and wear.

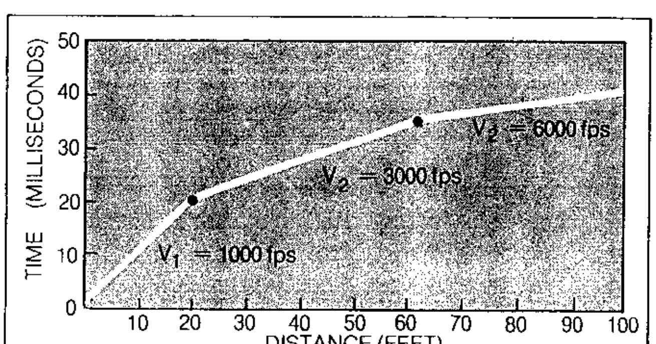
While deep ripping with a single tooth often yields higher production, many thinly laminated materials, particularly shales, denser mudstones and siltstones, frequently can be better handled by more teeth at shallower depths.

Where scrapers are used to move the material, uniform depth is important. Hard knobs of rock can force the scraper cutting edge out of the ground and damage scrapers and cutting edges. On such jobs, working depth should be determined by the depth of the most difficult part of the cut area.

Pass spacing helps determine the production rate by indicating the time required to cover the area. Costs are lowest with maximum spacing, but end-use and moving methods may necessitate closer spacing with smaller ripped chunks. Crusher acceptance, hauling and loading method tend to define pass spacing.

For scraper loading, ripping should proceed in the same direction as the scrapers. The ripper tractor then doubles as a pusher and traffic moves in the same direction. However, ripping rock formations with vertical laminations that run parallel to the cut may result in only deep channels with little breakage. When this occurs, it may be necessary to rip the material across the cut to obtain proper breakup.

Ripping downhill whenever possible, helps the tractor to use its horsepower and weight to increase production. Uphill ripping sometimes is preferred to get more down pressure from weight transfer or to get under and lift horizontal, slabby material. If the material is laminated and the plane of the laminations is inclined to the surface of the ground, it is best to rip from the shallow end (where the laminations reach the surface) toward the deep end. This helps keep the tip in the ground. Otherwise, the tip tends to slide up the laminations and may be forced out of the ground.



Cross ripping makes the pit rougher and is more severe on scrapers and other excavating tools. Its use should be restricted to material that comes out in large slabs and it will loosen material in which single pass ripping produces only deep channels. When material is extremely hard to penetrate, cross ripping will frequently separate fracture planes set up by the initial ripping pass.

Using two tractors

Adding a second tractor to push the first tractor-ripper can extend the range of materials that can be ripped. Rather than bring in drill and blast crews, it may be cheaper to add a second tractor to finish difficult portions of a ripping job. When ripping production drops to less than 150 to 200 cu yds per hour, for example, adding the second tractor almost doubles the costs, but production can be increased by three or four times in some materials.

Single-shank rippers are designed with an integral push block for tandem pushing in severe applications. Multiple shank rippers are designed for less severe ripping applications and are usually not equipped with push blocks.

A second tractor can add down-pressure on the ripper. The dozer on the push tractor should be in a float position unless additional up or down pressure is required.

Rock that is too difficult to rip often can be pre-blasted with a light charge and then ripped successfully. Experience with this ripping technique is limited and involves rather careful cost comparison. It is generally employed, and recommended, on jobs where scrapers are to be used to load and haul the materials. At relatively small cost, light blasting fractures the rock enough to permit ripper penetration. This practice has been used to reduce the cost of moving highly consolidated rock formations.