

The harder limestones and dolomites come next in order and owing to the wide variations in qualities which are characteristic of the sedimentary rocks it would be wrong to say that all limestones make good road material. While as a class they are unsuitable for any but the lightest traffic the better varieties rival trap in excellence. The great majority of limestones are of good cementing qualities, consequently a tough, hard limestone can usually be depended on to give good service. This is especially true of flinty limestones.

The granites, like the limestones, as a class are not satisfactory. They usually lack in binding material or when this is present, owing to the granular structure, they disintegrate quickly. There are, however, some varieties that furnish first-class material and in Great Britain granite has been used with satisfaction in some limited localities.

Gneiss, which is the metamorphic form of granite, possesses much the same qualities. It is hard, has good wearing qualities, but in most cases a low binding power.

The remaining rocks of the metamorphic series need not be taken up individually as they are practically of no value except for the foundation of the road. Schist, marble, and quartzite are all suitable in some respects, but lack one or more of the necessary qualities. Slate possesses no properties that would justify its use and it is consequently valueless as road metal.

Field stone is used in some localities with success. As it contains boulders of both igneous and sedimentary rocks and may have some of the metamorphic rocks present, the author dealt with it separately, and explained that, owing to peculiar physical treatment in ages past some kinds are excellent material.

Where the boulders have lain for a long time exposed to the elements, decay sometimes penetrates them to such an extent that they are unsuitable. In using field-stone, therefore, it is advisable to separate those which have been penetrated by decay from the sound ones and confine them to the bottom of the road.

The extent to which decay has rendered the stone unsuitable may easily be determined in the field. After a little experience a person may, by the aid of a small sledge hammer, distinguish between those which are suitable and those which are not. If they ring sharply to the blow of the hammer they are sound. If, on the other hand, they pulverize under successive blows and when broken show evident traces of decay, as by iron stains penetrating the mass, they should be condemned.

Sound field stone, when crushed to commercial sizes, forms a remarkably good material and, even when of inferior value, it may be used for the bottom course and a better grade of stone applied to the top of the road.

**Properties Necessary in Broken Stone.**—The necessary properties that make a rock suitable for the top section of a waterbound macadam road are briefly as follows: Toughness to resist the shocks from traffic; hardness to resist the grinding action of traffic, and, good cementing properties to resist the tendency of the traffic to dislodge the stones; it should break with a clean, angular fracture in order to compact solidly in the road bed; it should be non-absorptive in order to resist the action of frost. Owing to the wide variation in the degree in which the above qualities are possessed by the rocks found throughout the province and the difference in the traffic conditions on roads within adjacent localities, care should be taken that

the material selected should meet conditions. It is a waste of money to build a road of soft limestone where there is heavy traffic of both horse-drawn vehicles and motor cars and trucks simply because the material is easily procured and the original cost kept low. The amount spent on maintenance will, in a case like this, soon exceed the cost of the use of a superior material which would need a very small amount of repairs. It is, in many instances, more economical in the end to build the foundation of local stone and import a higher grade of limestone or even a good trap rock for the top section of the road. On the other hand, where light farm traffic is to be provided for, a lower grade of stone will usually give quite as satisfactory service as a better and more expensive material.

The choice of a suitable road metal is just as important. The author described the characteristic formation and source of each. He detailed its physical features, and its degree of suitability in road making. The advantages of pebbles of all sizes were shown by lantern slides. Pit gravel usually contains an excess of earthy material and can be improved by screening. River gravel is still being deposited in drifts and bars by streams and while it resembles pit gravel it has, as a rule, not as much clay, and is one of the best sources of road material. Lake gravel varies a great deal in character. It is usually free from earth and clay and contains sufficient sand to pack well, but it has a tendency to be slaty, which is undesirable.

In accepting these statements the great variation in qualities possessed by gravels even of the same class must be remembered and before deciding on a material all the available deposits should be visited and a thorough inspection made of the material in each.

A gravel that possesses suitable binding qualities will stand vertically in the pit and require considerable force, if not blasting, to remove it. If it comes from the pit face in large boulders of cemented material resembling conglomerate rock it may be said to contain suitable binding qualities.

The sizes and shapes of the pebbles as well as the materials of which they are composed has a vital effect on the service that the gravel will give. These qualities can be roughly determined by observation. Sharp, angular pebbles are preferable to round, flat, or disc-shaped ones for the reason that they will compact into a denser mass and afford greater opportunity for the binding material to hold them in place. The advantage of having pebbles of all sizes has been shown.

The determination of the materials composing the pebbles is more difficult, but by breaking some of the larger ones and identifying them as igneous or sedimentary rocks, the smaller ones can be picked out and properly classified. As trap rock is superior in hardness and toughness to the other rocks, a gravel that contains a fair percentage of trap pebbles can usually be relied upon to give good service. Hard limestone pebbles also form good gravel, but a large percentage of sandstone and shale will quickly cause the road to go to pieces.

The sizes, shape and material of the pebbles having been determined a small amount of the gravel should be weighed and screened on a  $\frac{1}{4}$ -inch screen, and the amount retained should be weighed. It should be from 75 to 80 per cent. of the total weight. Of the material passing through the screen about half may be considered to be clay or other binding material.

(To be continued.)