DISCUSSION.

This department has been established by the editors in order to afford to those interested in questions relating to economic geology an opportunity for informal discussion. Contributions are cordially invited either in the form of discussion of more formal papers appearing in earlier numbers or bearing upon matters not previously treated. Letters should be directed to the Editor, Sheffield Scientific School of Yale University, New Haven, Conn. The full name of the author should be attached to all communications.

THE CONGLOMERATES OF THE WITWATERSRAND.¹

Sir: I wish to thank Dr. Mellor for his splendid presentation of the characteristics of the conglomerates of the Witwatersrand, with the gold which they contain, and for his most interesting discussion of the methods which Nature may have adopted in forming these beds of conglomerates, and in placing gold in them.

The occurrence of a conformable sedimentary series five miles in thickness, like that of the Witwatersrand, is not in itself a matter for very particular comment, for such series occur in other parts of the world, especially along the flanks of important mountain ranges, and the coarseness or fineness of the sediments in them depends largely on the strengths of the currents, whether caused by winds, tides, or rivers, by which the sediments were distributed. If small particles of gold, as well as pebbles of quartzite or other similar rock, were being supplied to the moving waters at the same time, they would be distributed together, but large particles or nuggets of gold would not be

¹ This excerpt from a discussion by Mr. J. B. Tyrrell of a paper on "The Conglomerates of the Witwatersrand," by Mr. E. T. Mellor, was published in part in Bull. 139 of the Institution of Mining and Metallurgy, 1916. It is reprinted in these columns by the author because the comparison which is made with American auriferous gravels is of somewhat unusual interest to American readers.

carried by water and dropped along with small or medium-sized pebbles of quartzite, etc., for the currents that would easily carry the latter would not move the former.

In western Alberta, in a great series of conformable Mesozoic and Tertiary sediments, gold occurs in a finely divided state in the *Edmonton* sandstones at top of the Cretaceous. These beds were laid down near an old shore line, and the fossils contained in them prove that they were deposited in brackish water. No beds holding a sufficient quantity of gold to pay for mining have yet been discovered in these sandstones, but the streams which now drain the country east of the Rocky Mountains cut down into them in many places, and concentrate the gold derived from their sandstone banks into the gravel bars in the rivers, whence it is collected by simple methods of alluvial washing. The gold so obtained is in very minute particles which, under the microscope, may be seen to be well rounded like most other particles of placer gold. I believe that it is also in the form of such minute rounded particles in the *Edmonton* sandstones, from which it is derived, for no matter how near the gravel bars which now contain it may be to its probable source in the sandstone itself, the gold always presents the same rounded appearance.

Whether the gold is confined to certain definite strata in the series or not I do not know, but I have definitely determined its presence in, or in the immediate vicinity of, some of the beds of lignite which are interstratified with the sandstone.

In this particular instance the source of the gold is reasonably certain, for it was undoubtedly transported from the quartzite and granite mountain range away to the west within the confines of the province of British Columbia, and was carried a long way before it finally settled near the shore of the brackish sea. Though nowhere concentrated into rich pockets or beds the total quantity so carried from the mountains must have been large.

In a disseminated placer, in which the gold has been distributed by tidal currents over a sea floor, no "paystreak," such as is commonly found in stream placers, would be looked for, but if

actual beaches should be discovered paystreaks might reasonably be expected to occur, for the gold would have been concentrated in them by the waves. In this connection the distribution of the conglomerate in the Far East Rand described by Dr. Mellor in his paper, and illustrated by him on Fig. 4, strongly suggests the presence of such beaches formed on a gently sloping shore which was at the same time slowly and regularly sinking beneath the sea. Such a method of formation would account perfectly for the local parallelism of these bands of conglomerate.

Stream and ocean placers have some common characteristics, and it may be interesting to refer to one or two of these. In the Klondike District, where I was mining placers for a number of years, the gold-bearing gravels occur in the bottoms, or what were once the bottoms, of river valleys. They are essentially of two ages, namely, Older Pliocene gravels and Newer Recent gravels. The former occur in the bottoms of wide mature valleys with gently sloping sides on which the underlying rock has decayed to such an extent that naked cliffs and escarpments are unknown; while the latter are in the bottoms of narrow, immature, and often gorge-like valleys cut in the bottoms of the old Pliocene valleys. These newer valleys are thus cut down through the older gravels, sometimes one or two hundred feet into the underlying hard granitoid gneiss or schist, and what remains of the older gravels may lie along the top of the steep banks of the newer valleys. In both these gravel deposits, wherever gold is present, it is concentrated in a thin, but ill-defined, layer just above bedrock and in the fissures of the underlying bedrock. The total average thickness of the gold-bearing layer might be put at 3 feet, 1 foot of this being gravel and 2 feet bedrock, though this thickness varies greatly in different places. In some parts of Dominion Creek the "pay," though very rich, was confined to a few inches of gravel just above bedrock, and the underlying bedrock was barren; while on a mining claim on Hunker Creek, which yielded a large quantity of gold, there was scarcely any gold in the gravel or in the

upper foot of bedrock, for it had sunk as much as 7 or 8 feet into the cracks of this bedrock.

In the Newer Recent gravel the gold-bearing layer lies below the water level of the stream in the valley of which it occurs, and tinstone, all more or less thoroughly rounded. This "black sand" composed chiefly of small grains of magnetite and ilmenite, with some hematite and a little impure cassiterite or tinstone, all more or less thoroughly rounded. This "black sand" lies loose in the gravel or in the cracks of the bedrock, being distributed much in the same way as the gold. On some mining claims crystals of pyrites were collected in considerable quantity with the gold in the sluice boxes. The crystals were always beautifully sharp and angular; I do not remember to have seen any that were rounded or waterworn. On closer investigation these crystals were invariably found to have been broken out of the underlying bedrock, and not to have been derived from the gravel. One claim which I was operating on Hunker Creek yielded large quantities of these crystals from a bedrock of dark graphitic schist.

The gold itself, both in the gravel and in bedrock, was always in more or less rounded and waterworn nuggets and particles, known collectively as "dust." Even where originally in elongated or thread-like forms, these particles had been pounded and bruised, so that their points and angles had been rounded off. No new crystals or crystalline films of gold had been formed anywhere since this *Recent* gravel had assumed its present position.

With regard to the older *Pliocene* gravels, wherever they were well situated for examination, as on the tops of the banks of the newer valleys, they were found to contain neither magnetite nor pyrites. If either of these minerals had ever been present they had been leached out.

In these older gravels most of the contained gold was in the form of well-rounded particles similar to those in the newer gravels. But in addition to such rounded particles or grains there were many pieces which showed beautiful sharp crystalline

structure, either in moderately stout forms, or in delicate feathery shapes such as it would be difficult or almost impossible to move without crushing or destroying. In many cases this gold was in the form of thin crystalline films between layers of the schistose bedrock, while, in one instance, Mr. M'Connell, now Director of the Geological Survey of Canada, drew my attention to a very delicate film of gold adhering to the outside of a pebble in the gravel.

Such crystals had never been mechanically transported along with sand and gravel by water, but had evidently been formed just where they were found. The gold would seem to have been first dissolved, probably by the action of water on the surrounding "dust," and then to have been precipitated from the solution, but in no instance did I find any evidence that pyrites took any part in this action, or were precipitated with the gold. Possibly the gold had not been carried any appreciable distance in solution, for the beautiful fragile crystals above referred to were always found within the narrow limits of the original thin gold-bearing layer of gravel and bedrock, and not in the gravel above it or in the bedrock below it.

If the process of solution and precipitation which gave rise to these crystals were carried far enough it is quite conceivable that it might completely destroy the rounded character of the particles of gold usually found in placer deposits, and give rise to forms and characteristics similar to those found in the conglomerates of the Witwatersrand.

J. B. TYRRELL.