CORRESPONDENCE

THE ORIGIN OF RED SANDSTONES AND CONGLOMERATES

SIR,—Mr. J. B. Scrivenor's paper on the New Red Sandstone of South Devonshire, in the *Geological Magazine* for December, 1948, was of particular interest to me because, while I have examined the rocks in question only casually, I have had many opportunities to study red beds in other regions, particularly in western United States. To this may be added years of observation of the deposits now being made in arid and semi-arid regions, both temperate and sub-tropical.

From the descriptions and photographs in Mr. Scrivenor's article, I should infer with confidence that most of his conglomeratic beds were deposited as alluvial fans. Those which are distinctly but complexly stratified suggest the work of intermittent streams—muddy, but seldom loaded to full capacity. The unstratified or obscurely stratified deposits, containing angular debris and even boulders mixed together, strongly suggest mudflows, or in some cases deposits made by transient floods fully loaded with debris. Both kinds of deposits are typical of semi-arid regions such as parts of Utah and Nevada. Alluvial fans made by floods descending short steep ravines in desert regions may leave deposits consisting almost entirely of poorly sorted angular debris. Longer streams, having an opportunity to carry fragments farther, and hence to abrade them notably, have sub-angular or even well-rounded pebbles. The typical mudflow is entirely unsorted, unstratified, and may contain boulders of large size.

The colour of these red deposits varies with the proportion of clay, sand, and gravel. As the red iron oxide exists in a very fine state of division, the deposits containing little but clay are generally of a dark red or even chocolate colour, while those with but little clay may be only pink or tawny.

While there is good evidence that some red beds have been deposited in lakes, such an environment is generally unfavourable, unless the lakes are shallow and intermittent. In permanent lakes of any considerable depth, the bottom waters are ordinarily in a reducing condition, owing to the presence of decaying organic matter. Such deposits are normally some shade of grey or black, even where the inflowing streams bring in brown or red mud. This does not rule out the probability of deposition of red mud in small temporary shallow lakes incidental to the building of a river flood plain.

A dilemma is posed by the fact that red soils, which are probably the source of most red continental deposits, are characteristic of well-drained hilly regions, subject to a hot climate with generous rainfall, and the further fact that red beds commonly bear evidence of having been deposited under semi-arid or even arid conditions. Both requirements may be satisfied in regions where streams rising in a moist tropical region flow out into an arid plain, as along the north-west side of the Deccan Plateau, in India. Any other combination of conditions that would permit red soils to be produced by chemical weathering and yet would protect them from chemical reduction after transport and deposition would also meet the requirements of the case.

Mr. Scrivenor is troubled by the dimensions that seem to be required for the supposed alluvial fans in the case of the New Red Sandstone. It may be pointed out that in western United States and other regions alluvial fans of more than ten miles radius are rather common, and much larger ones are known. The very large fans generally have gradients of less than one degree, whereas small torrential fans of less than one mile radius may range from four to six degrees or, in the case of mudflow fans, as high as fifteen degrees.

ELIOT BLACKWELDER.

STANFORD UNIVERSITY,
CALIFORNIA.