HILT'S LAW AND THE VOLATILE CONTENTS OF COAL SEAMS

SIR,—From Prof. O. T. Jones's article in the last two numbers of the *Geological Magazine*, on the volatile content of coal seams, in which my name figures so frequently, it may well appear to the majority of your readers that I am a believer in the so-called "law" of Hilt, and that I have devised a formula which supports it. This impression is created by a series of substitutions, of which one may be taken by way of example. The formula $V^2 \propto y$ with V representing the volatiles of the coal seam and y a *depth* below a given datum, is attributed to me, whereas the formula given in my original paper (*Q.J.G.S.*, civ, 404–5) is $V^2 \propto d$, with V representing *twice* the volatile matter and d representing a *distance* measured at right-angles from a particular plane of shear or stress. My South Wales formula has nothing to do with Hilt's "law", but the substitute is one of Prof. Jones's many experimental variants of the "law".

Your readers will be disappointed to find in this article unintelligible numerals and symbols substituted for the real values of the volatiles of coal seams. If a formula warrants testing and the results of the test are thought to be worth publishing, the calculated results should be given side by side with the actual known results. By this means, the reader may assess the value of the formula himself, and if he so pleases, he can amuse himself with differences, sums of differences, the square of the sums of differences, or any other variations of simple arithmetical exercises: but the reader should be given real values, not symbolic substitutes. The value of Prof. Jones's own arithmetical exercises may be assessed from the following quotation, which purports to elucidate one of his symbolic tables. "It may appear strange that given data, representing volatiles and depths, can conform in varying degrees of approximation to such diverse laws [*sic*] as $V \propto y^2$ and $V^2 \propto y$." Since $V \propto y^2$ is the same as $V^2 \propto y^4$ then if we let y equal 2,000 feet (the depth mentioned in Prof. Jones's next sentence) with one "law" $V^2 \propto$ 2,000 feet depth, and with the other "law" the same $V^2 \propto 2{,}000^4$ feet, or in round figures 3,000 million miles depth! By most people, this will be regarded as more than strange!

Many of your readers will wonder why Prof. Jones's attempt at an isovol map of the South Wales coalfield, based as it is on Strahan and Pollard's miscellaneous collection of old analyses (many are about a century old) of samples that cannot be located more accurately than to the nearest pit-mouth or shaft, has been published, instead of the recent official isovol map issued by Fuel Research, which is founded on their numerous modern and standardized determinations of coal samples, all of which are accurately located. That in places there is a certain broad similarity between the inaccurate and the accurate is surely no excuse for publishing the former at this late date.

Hicks has shown that in South Wales if a simple and linear rate be assumed for the decrease of volatiles of coal seams with depth, then the rate varies greatly from place to place. Dines has shown that one simple rate cannot apply in the small Kent coalfield, and Millott and Berry have shown that it requires four different simple rates to satisfy one vertical sequence in North Staffordshire. Briefly, in these three coalfields it has been shown that the rate of decrease varies between ·035 volatiles per hundred feet to 1·40 volatiles per hundred feet, a ratio between the highest and the lowest of about 40 : 1. By bringing together in one article the results of these authors, Prof. Jones himself deals Hilt's "law" an almost fatal blow. It but remains to give examples of rates of volatile *increase with depth* and the "law" receives its *coup de grâce.*

Curiously enough, the most important sequence wherein the coal seam volatiles can be shown to *increase with depth* is the boring on which Prof. Jones places so much reliance for his estimations of isobaths. It is the Notown boring, New Zealand. Prof. Jones, working on the highly improbable *assumption* that the surface peat there has a volatile percentage of 80 to 90 per cent, calculates that coals of 40 per cent volatiles would be formed under a cover of 8,600 feet to 9,200 feet, and a figure of this order is included in all of the South Wales isobath " calculations ".

Here are the data, as supplied by Wellman to me in a letter dated 8th April, 1949.

Notown Bore, New Zealand

	Volatiles. %	*Fixed Carbon.* %	*Ash.* %	*Moisture.* %
Peat, at the surface nearby	**23**	9·0	32·0	36
	26·0	22·0	25·3	26·7
Coal sample, at 3,000 feet depth	**30·0**	38·5	8·5	23·0
Coal samples, at 6,893 feet depth	**45·2**	44·5	6·2	4·1
	45·3	42·5	10·0	3·2
	46·6	43·1	6·8	4·5

It will be noted that, whereas the moisture decreases, *the volatiles increase with depth.*

The Hilt's " law " devotees will probably reject the analyses of the Pliocene peat at the surface as not being in strict vertical sequence with the coals of the boring, but if we confine our attention to the 4,000 feet of the bore that is in strict vertical sequence, we have here the greatest proved sequence of coal-bearing rocks of which analyses have been made. As the table shows, there is *an increase of volatiles with depth* of about 15 per cent per 4,000 feet, or of about 8 per cent calculated on a dry ash-free basis. That the actual figures of volatiles make nonsense of Prof. Jones's assumed volatile figure of 80 per cent to 90 per cent for the surface peat, and wildly fanciful nonsense of all of his isobath " calculations " are of relatively small importance. The important point is that here we have in the longest vertical sequence of analysed coal-bearing rocks an example of *Hilt's " law " in reverse.* An English example of the same phenomenon is found in the Spital Boring. Here, the *increase of volatiles (d.a.f.) with depth* is 1 per cent volatile per *circa* 220 feet of strata over a vertical sequence of 800 feet. Other examples could be given.

The superstructure of assumptions, " conclusions ", and " calculations ", erected by Prof. Jones, on his version of Hilt's " law ", go with the collapse of the " law "—the quasi-mathematical symbolism, the isobaths, the grossly inflated geo-syncline, almost completely air-borne over South Wales, all are " gone with the wind ".

MANCHESTER. F. M. TROTTER.
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SIR,—The weight of Dr. Trotter's contribution to the above topic may be judged by the fact that he regards the relation $v \propto y^2$ as being the same as $v^2 \propto y^4$ whence he derived the triumphant *reductio ad absurdum* which followed. This is much the same as maintaining that 2 is the same thing as 2^2. But is the relation which he derides so absurd ? Let us apply to it the test of which he approves to judge of the validity of a formula and used repeatedly in his paper in the *Quart. Journ. Geol. Soc.* (civ, 410–412). He there compares the average of the calculated volatiles with the average of the experimentally determined volatiles which latter are known to be subject to a possible error of $\pm 0 \cdot 3$ per cent. If the two averages agree within 0·6 per cent (and some of them do not) he claims the agreement as satisfactory. In other words he assumes that both the calculated and the observed figures are subject to the same error but acting in one direction in the one case and in the opposite direction in the other. This contingency is most unlikely and the argument is hardly distinguishable from wishful thinking.

However, let us apply this test to the equation which embodies the above relationship, viz. :—

$$V_2^2 = V_1^2 - \frac{y^4}{t}$$

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where v_1 is the volatile content of the top seam in a sequence, v_2 that of a lower seam in that sequence, y is the vertical depth between the two seams, and t is a constant.

It is only necessary to deal with three sequences to illustrate the use of the formula. Those chosen are those used by Dr. Trotter to find the constant in his own formula. These are Newbridge and Crumlyn (N 35), Blaengarw (B 26·5), and Resolven (R 16). The figures within the brackets are the recorded volatile percentages of the top seam in each sequence.

The calculated volatile percentages of the lower seams in each sequence denoted by the same symbols as were used by Dr. Trotter and their averages, are as follows :—

N. 35			B. 26·5			R. 16		
	obs.	calc.		obs.	calc.		obs.	calc.
2d	34	34	*4g*	22·5	23·8	*7e*	14	14·9
2c	26	28·9	*4f*	24	23·7	*7d*	8	9·7
2b	28	27	*4e*	24	23·5	*7c*	8·5	9·0
2a	25	24·1	*4d*	19	21·3	*7b*	8·5	7·5
			4c	18·5	19·8	*7a*	8	6·8
			4b	17	18·2			
			4a	17	14·3			
	113	114		142	144·6		47	47·9
Av.	28·2	28·5		20·3	20·7		9·4	9·6
Dr. Trotter's average		27			19·8			9·2

Judged by this test the expression which is held up to ridicule gives a closer correspondence between the calculated and observed volatile contents than Dr. Trotter's own formula ; in the first example the improvement is considerable.

It could, of course, be foreseen that this result would follow from any analysis of various types of relationship given in my recent paper. That led to the conclusion that almost any type of curve would give about the same degree of correspondence between the calculated and observed values and that none of them gave as good agreement as Hilt's law. There is, therefore, no justification whatever for assuming that the devolatilization of coal seams proceeds according to Dr. Trotter's or any other comparable relation. It is to be observed further that none of the expressions which I examined took account of the distance between any one of the seams and a main thrust below the coalfield which is, of course, a pure fiction.

It may be added that it is not the experimental error which determines the amount of departure of individual seams from any given relationship, but the inherent variations in the composition of the seams the volatile contents of which are usually quoted on bulk samples. Since each seam contains variable amounts of certain constituents each with markedly different volatile contents, that of the bulk sample is controlled by the relative amounts of these constituents in the seam. Until some method can be devised which will record the effect of metamorphic changes in coal seams better than the examination of bulk samples, it is idle to look for abstruse mathematical relationships between the volatile contents of various seams. So far as is known at present, Hilt's law is an adequate expression and better than any other.

O. T. Jones.

73 Barton Road,
Cambridge.
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