Geology. — *Determination of the pressure in gas containing strata.* By J. VERSLUYS.

(Communicated at the meeting of May 26, 1928).

The pressure in the oil bearing strata is a factor of importance in oil recovery, because from this pressure the quantity of gas dissolved in the oil can be calculated. In a porous rock containing liquid without gas the pressure can be computed from the specific gravity of the liquid and the level to which it rises in a well. The pressure in strata holding only gas may be deduced from the pressure of the gas in a closed well near the surface.

Generally it is accepted that the pressure exerted by the weight of the gas in the well may be neglected which would mean that the pressure at the bottom would be the same as the pressure at the head of the well. This however is not by any means the case, in deep wells great pressures occur. The specific gravity of the gas under a great pressure may not always be neglected. The initial pressure of the gases and fluids in the pores of the rocks as a rule does not differ much from the hydrostatic pressure of a column of water which would fill the borehole up to the surface. This was stated i.a. by J. H. GARDNER (III) in 1916, the phenomenon has since been observed in many districts and is mentioned by several authors.

According to this observation, in a sand at a depth of 1000 metres the pressure would be about 100 atmospheres. With this pressure a gas, the specific gravity of which in grams/cub. centimeter is 0.001 at atmospheric pressure, would have a specific gravity of $^1/_{10}$ of that of water. If 100 atmospheres pressure are measured at the head of a closed well the weight of the column of gas would equal that of a column of water of 100 metres, so there must be added about 10 atm. to the pressure at the head of the well and the gas pressure in the sand would be about 110 atmospheres. These figures are arbitrarily chosen, but it is clear that the pressure in the well-head can considerably differ from the pressure in the earth layer.

The correction to be applied to the measured gas pressure at the head of a well can be simply deduced. If the pressure at a height y above a certain level in the well is p atmospheres and the specific gravity of the gas γ, then the pressure exerted by the column of the gas enclosed by the levels y and $y + dy$ in units of power per unit of area is

$$p\gamma \, dy \qquad (1)$$

If the pressure of one atmosphere is equal to a units of power per unit of area, we may write :

$$p\gamma\, dy = -a\, dp \quad \ldots\ldots\ldots \quad (2)$$

or

$$dy = -\frac{a}{\gamma}\frac{dp}{p} \quad \ldots\ldots\ldots \quad (3)$$

Integrating this equation between the limits y_2 and y_1, respectively p_2 and p_1, we get :

$$y_2 - y_1 = -\frac{a}{\gamma} \log \frac{p_2}{p_1} \quad \ldots\ldots\ldots \quad (4)$$

and if y_1 and y_2 be taken for the heights of the gas-bearing stratum and the head of the well $y_2 - y_1 = D$ is the depth of the well. So

$$D = \frac{a}{\gamma} \log \frac{p_1}{p_2} \quad \ldots\ldots\ldots \quad (5)$$

or

$$p_1 = p_2\, e^{\frac{D\gamma}{a}} \quad \ldots\ldots\ldots \quad (6)$$

Hitherto p_2 and p_1 have been expressed in atmospheres ; this formula (6), however, holds if any other unit of pressure be chosen.

If D be expressed in meters, then $a = 10.33$ and then the pressure p_1 in the gas-bearing sand would be computed from the formula :

$$p_1 = p_2\, e^{\frac{D\gamma}{10.33}} \quad \ldots\ldots\ldots \quad (7)$$

in which p_2 is the pressure in the closed well, measured at the surface, γ the specific gravity of the gas in grams per cubic centimeter and D the depth of the well in meters. If the depth be expressed in feet and the specific gravity in pounds per cubic foot this formula becomes

$$p_1 = p_2\, e^{\frac{D\gamma}{2093.6}} \quad \ldots\ldots\ldots \quad (8)$$

This pressure p_1 is generally called "*rockpressure*" which term however in recent times is being replaced by the more correct expression "*reservoir pressure*" (see I page 363 and II).

If we multiply the volume of a gas pool by its average porosity and the reservoir pressure p_1, we find the amount of gas contained in the pool disregarding phenomena of adsorption.

Should gas and liquid be associated in a porous bed, the reservoir pressure cannot be calculated from the pressure at the head of the closed well, this as a rule partly being filled with liquid. W. B. HEROY (I, p. 371) states that in literature many very low figures for the reservoir pressure are encountered, these figures practically giving the pressure read at the head of the closed well (the so-called closed pressure).

In W. B. HEROY's paper two methods are described of determining the reservoir pressure in oil-bearing strata. One of these methods (see I, p. 366) is to pump gas into the well, forcing the liquid from the well into the porous rock. The gas pressure required to produce this result is the pressure p_2 in (7) and (8) and the reservoir pressure is p_1 computed with the aid of one of these formulae.

Multiplying the volume of oil in the subterranean reservoir by the absorption coefficient and the reservoir pressure, according to the HENRY law, we get the amount of gas absorbed in the oil.

LITERATURE.

I. W. B. HEROY: "Rockpressure". *Bull. Am. Ass. Petr. Geol.*, XII, pp. 355—384, 1928.

II. Communication from the "SUBCOMMITTEE TO CALIFORNIA OPERATORS GENERAL COMMITTEE ON GAS CONSERVATION", entitled: „Increase oil recovery, conserve gas", in *The Oil and Gas Journal*, May 10th 1928, pp. 38, 142 and 143.

III. J. H. GARDNER: "The Mid-Continent oil fields", *Bull. Geol. Soc. Am.*, XXVIII, pp. 700—702, 1916.