TABLE I

	MINERAL	COMPOSITION	Apparent Log Density	Average Δt	ϕ_N* (GNT)	γ-Ray Deflection (APIU)	Apparent K_2O%
SEDIMENTARY MINERALS	Calcite	$CaCO_3$	2.710	47.5	0	0	—
	Dolomite	$CaMg(CO_3)_2$	2.876	43.5	4	0	—
	Quartz	SiO_2	2.648	51.5	–4	0	—
SEDIMENTARY FORMATIONS	Limestone	(e.g., when $\phi = 10\%$)	2.540	62	10	5-10	0
	Dolomite	(e.g., when $\phi = 10\%$)	2.683	58	13.5	10-20	0
	Sandstone	(e.g., when $\phi = 10\%$)	2.485	65.3	3	10-30	0
	Shale		2.2-2.75	70-150	25-60	80-140	2-10
EVAPORITES — NON-RADIOACTIVE	Halite	$NaCl$	2.032	67	0	0	—
	Anhydrite	$CaSO_4$	2.977	50	0	0	—
	Gypsum	$CaSO_4 \cdot 2H_2O$	2.351	52.5	49	0	—
	Trona	$Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$	2.100	65	40	0	—
EVAPORITES — RADIOACTIVE	Sylvite	KCl	1.863	74	0	~500	63.0
	Carnallite	$KCl \cdot MgCl_2 \cdot 6H_2O$	1.570	78	65	200	17.0
	Langbeinite	$K_2SO_4 \cdot 2MgSO_4$	2.820	52	0	275	22.6
	Polyhalite	$K_2SO_4 \cdot MgSO_4 \cdot 2CaSO_4 \cdot 2H_2O$	2.790	57.5	15	180	15.5
	Kainite	$MgSO_4 \cdot KCl \cdot 3H_2O$	2.120	—	45	225	18.9
OTHER MINERALS	Sulfur**		2.030	122.0	45 (15.5″)	0	
	Lignite		0.7-1.5	140-170	←High→ Greater than 50%	0	
	Bituminous Coal		1.3-1.5	110-140		0	
	Anthracite Coal		1.4-1.8			0	

* ϕ_N = Apparent Limestone Porosity from a Neutron Log.
** $\phi_{SNP\ (sulfur)} = 40$.
Data from Reference 9.

NON-RADIOACTIVE EVAPORITES

Bedded evaporites are essentially nonporous and electrically nonconductive. Thus, they are characterized by extremely high readings on resistivity logs. Some evaporites are quite soluble in water-base drilling muds and lead to enlarged holes, so a caliper log is an important part of the logging program.

Since evaporite beds have little or no porosity, but do have characteristic responses on the porosity logs (Table 18-1), a single porosity log — Sonic, Density, or Neutron — will often provide identification.

When evaporite beds contain mixtures of minerals, or are intercalated in sedimentary rocks, several logs (Sonic, Gamma Ray, Neutron, Density) may be used in a solution involving linear simultaneous equations. (See Tri-Porosity method, Chapter 13.) Such computations are generally done on computers. A crossplot of two porosity logs may be used for identification of a mixture of two minerals. Fig. 18-2 is a Sonic-Neutron crossplot showing the positions of several non-radioactive minerals. (See also Fig. 13-2, Chapter 13.)

RADIOACTIVE EVAPORITES

Radioactive evaporites of commercial interest include the potash minerals. Their radioactivity comes from the potassium isotope, K^{40}, which constitutes a constant fraction of naturally occurring potassium.

For effective evaluation of potash deposits the logs must identify the potash minerals (some of which are more valuable than others) and determine the fractions if a mixture is present.

Fig. 18-3 shows how a crossplot of Gamma Ray and Density Log data can identify the various pure potash minerals. When the bed consists of a mixture of only two potash minerals the crossplot can often identify them and give the mineral fractions, because the point falls on a line joining the two mineral points.

For use in potash interpretation, the Gamma Ray reading is converted to "apparent K_2O content" by means of an empirically established relationship (Fig. 18-4). The K_2O value obtained from the Gamma Ray is used in complex lithologies to solve for potash by means of linear simultaneous equations.

SULPHUR

Sulfur usually occurs as an infilling in the pore structure of limestone, some of the pore space being water-filled. Such deposits are conveniently located by an overlay of Density and Neutron logs (Chapter 13). Where only limestone is present, the two curves coincide. Sulphur is indicated by a divergence of the curves, the Density Log indicating the higher porosity. (The SNP Neutron Log sees the sulphur as limestone, and reads only liquid-filled porosity.)

The bulk-volume fraction, S, of sulphur in a limestone matrix can be determined from the equation

$$S = \frac{\phi_D - \phi_{SNP}}{.4} \quad (\text{for } \rho_f = 1.0) \qquad (18\text{-}1)$$

If a Sonic Log is available instead of a Density Log, or if a GNT type Neutron Log is run instead of the SNP, variations of the above equation are used.[9]

A resistivity log and a Sonic or Density Log may be used for sulphur evaluation if only sulphur, limestone, and water are present, and if R_w is known. Porosity is computed from the resistivity of the water-saturated formation:

$$\phi = \sqrt{\frac{R_w}{R_o}} \qquad (18\text{-}2)$$

This value of porosity is used in Eq. 18-1 to obtain the bulk-volume fraction of sulphur.

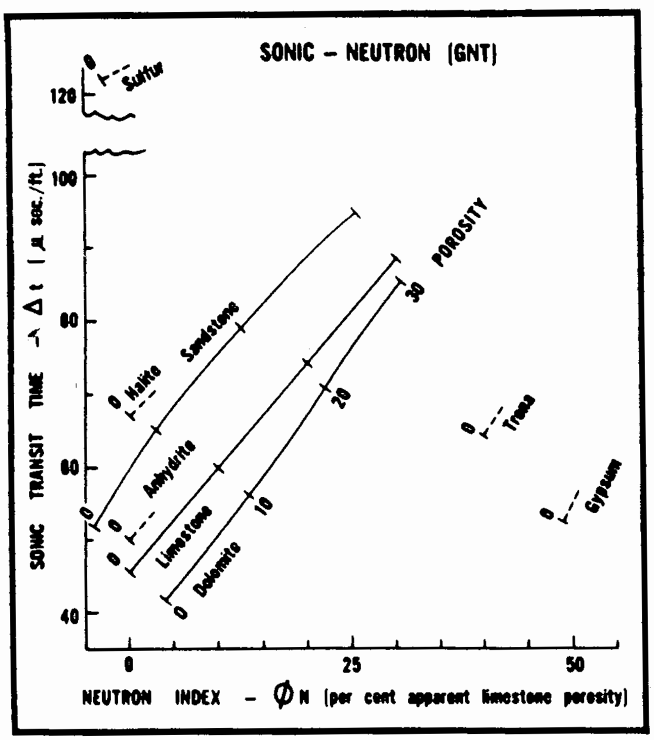

Fig. 18-2 — *Sonic-Neutron crossplot for mineral identification. (Courtesy SPWLA, Ref. 9)*

The methods of sulphur evaluation discussed above are valid only for the simple limestone-sulphur-water combination. The problem is complicated by mineral mixtures or gas saturation. For example, either gas saturation or salt can give the same log response as a rich sulphur deposit. Complex lithologies again require the use of the Tri-Porosity method (Chapter 13).

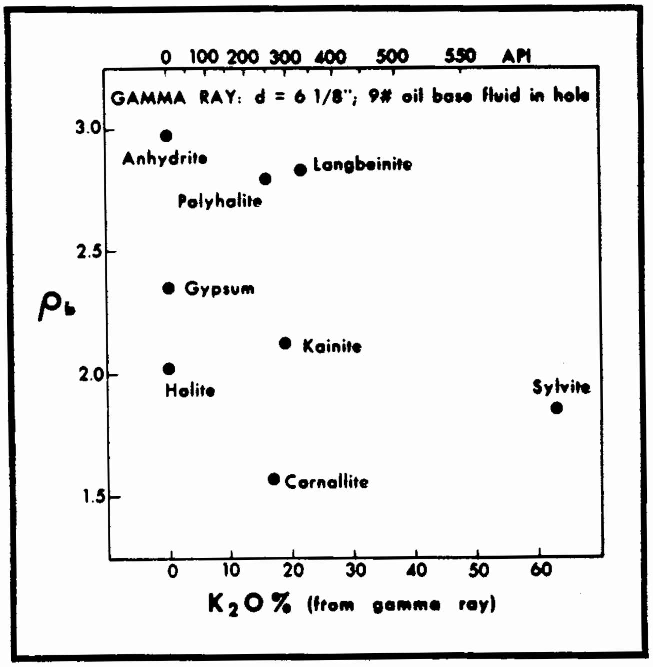

Fig. 18-3 — *Crossplot of bulk density and apparent K_2O content (from Fig. 18-4) identifies potash minerals. (Courtesy SPWLA, Ref. 9)*

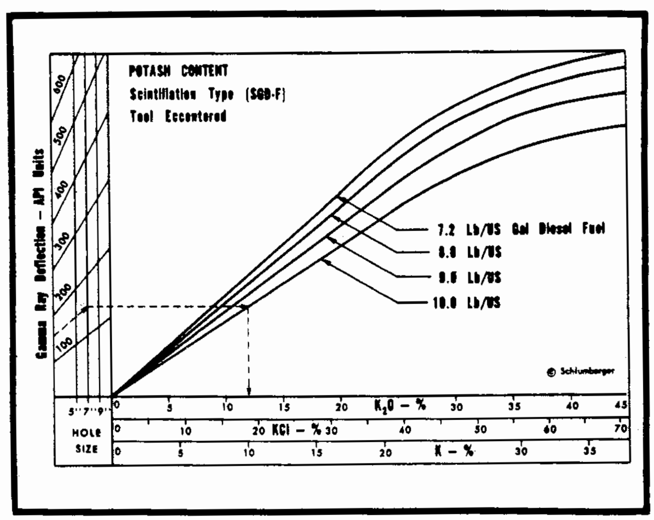

Fig. 18-4 — *Empirical chart relating Gamma Ray Log deflection and apparent potassium content. (Courtesy SPWLA, Ref. 9)*