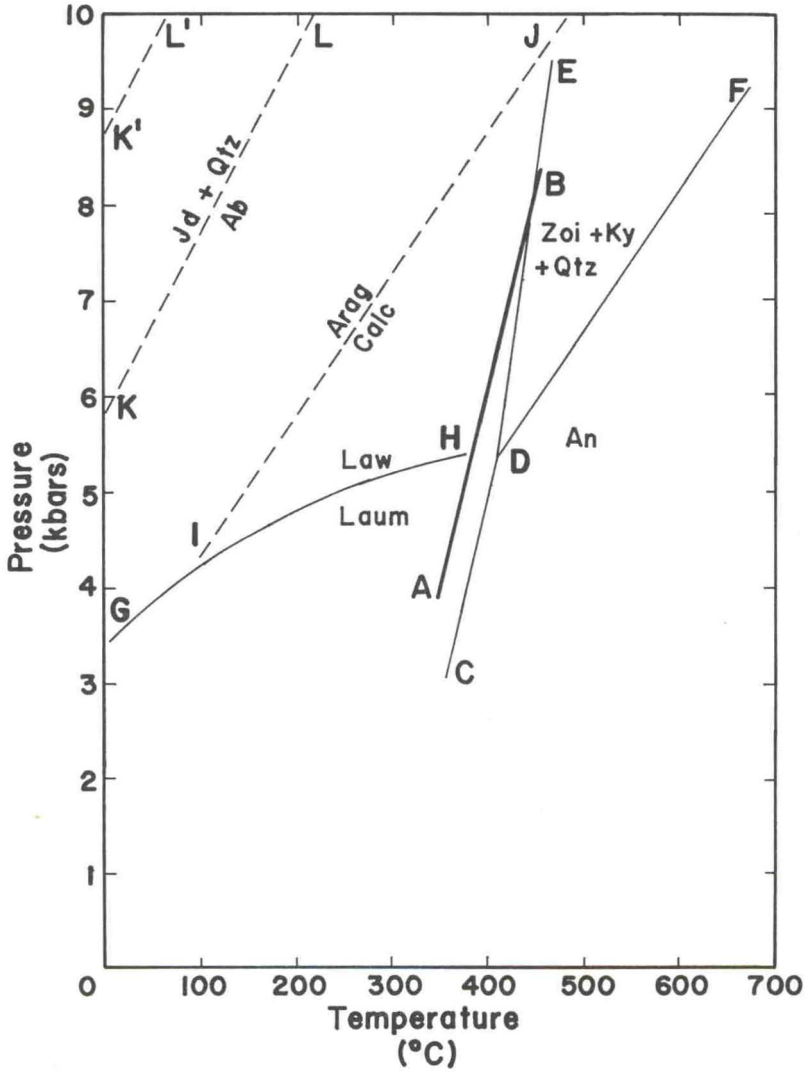

Fig. 1. Some experimentally determined and estimated boundary relations concerned with lawsonite.

A–B Lawsonite = anothite + water (Crawford and Fyfe).
C–D Lawsonite = anorthite + water (estimated, Newtown and Kennedy, 1963).
D–E Lawsonite = zoisite + kyanite + quartz + water (Newton and Kennedy, 1963).
D–F Zoisite + kyanite + quartz = anorthite + water (Newton and Kennedy, 1963).
G–H Lawsonite + quartz + water = laumontite (estimated by Fyfe).
I–J Aragonite = calcite (Clark, 1957; Crawford and Fyfe, 1964; Jamieson, 1953; and MacDonald, 1956).
K–I and K'–I' Jadeite + quartz = albite (Fyfe and Valpy, 1959).

suggest that the free energy change of the reaction:

$$\text{leonhardite} + \text{water} = 2\ \text{laumontite} \qquad (3)$$

is extremely small, a few hundred calories at the most. As the uncertainty in the free energy of leonhardite is 1400 cals, we may equate the free energies of laumontite reactions to those known for leonhardite.

From table 3 we obtain the following data for the reaction:

$$\text{leonhardite} = 2\ \text{lawsonite} + 4\ \text{quartz} + 3\ \text{water}$$

$$\Delta G^\circ = +4.4\ \text{Kcal}\ ;\ \Delta S^\circ = -16.65\ \text{e.u.}\ ;\ \Delta V^\circ = -68.85\ \text{cm}^3.$$

If we assume that ΔG° for reaction (3) is small, then for reaction (1) we obtain:

$$\Delta G^\circ = +2.2\ \text{kcal}\ ;\ \Delta S^\circ = -5\ \text{e.u.}\ ;\ \Delta V^\circ = -22.55\ \text{cm}^3.$$

The entropy of laumontite has been estimated by considering average water contributions to leonhardite. Thus the high entropy assemblage laumontite is stable at low temperature. Therefore, as temperature increases laumontite be-

TABLE 3

Thermodynamic properties of minerals, water, and carbon dioxide at 25°C and 1 atmosphere

Mineral	$S_{298.15K}^{\circ\circ}$ cal/deg mole	$\Delta G_{298.15^\circ K}^{\circ}$ kcal/mole From elements	From oxides	V cc/mole
Anorthite $CaAl_2Si_2O_8$	48.4[g] ±0.3	–	−23.8[a] ±0.6	100.73[j] ±0.15
Calcite $CaCO_3$	22.2[g] ±0.2	−269.78[k]		36.94[f] ±0.02
Carbon Dioxide CO_2	51.06[k]	−94.26[k]		
Kaolinite $Al_2Si_2O_5(OH)_4$	48.53[h] ±0.30	−888.1[b] ±0.7		99.31[h] ±0.30
Laumontite $CaAl_2Si_4O_{12} \cdot 4H_2O$	115.2[m] (est)			205.4[m]
Lawsonite $CaAl_2Si_2O_7(OH)_2 \cdot H_2O$	56.8[i] ±0.5	−1062.1[a] ±0.8	−31.7[a] ±0.6	101.33[d] ±0.15
Leonhardite $Ca_2Al_4Si_8O_{24} \cdot 7H_2O$	220.4[i] ±1.6		−67.8[a] ±1.4	416.48[e]
Quartz SiO_2	10.0[l]			22.69[j] ±0.005
Thompsonite $CaAl_2Si_2O_8 \cdot 2.4H_2O$				135.6[m]
Water (liquid) H_2O	16.716[l]			18.069[e] ±0.003

[a] Barany (1962).
[b] Barany and Kelley (1961).
[c] Coombs (1952).
[d] Davis and Pabst (1960).
[e] Gray (1957).
[f] Graf (1961).
[g] Kelley and King (1961).
[h] King and Weller (1961a).
[i] King and Weller (1961b).
[j] Larsen and Berman (1934).
[k] Latimer (1959).
[l] Rossini and others (1952).
[m] Calculated by W. S. Fyfe.