experimental conditions equal molar amounts of CO_2 and H_2O are initially produced [5]. However, because CO_2 is insoluble in the melt [6], while H_2O is soluble, CO_2 enters the fluid phase entirely, and H_2O is partitioned between fluid and melt. The $X_{H_2O}^{fl}$ is therefore less than 0.5, and, correspondingly, $f_{H_2O}^{fl}$ $(= f_{H_2O}^m)$ decreases. By this procedure, the solubility of H_2O in the melt may be controlled, because H_2O solubility is a function of pressure, temperature, and $f_{H_2O}^m$ [7]. H_2O fugacity may be calculated from thermodynamic data [7] and the mode of a run. Experimental details will be discussed elsewhere [8]. Oxygen fugacity was controlled by fixing P_{H_2} with a hydrogen membrane [9] to give a f_{O_2}, calculated from the $f_{H_2O}^m$, equal to that of the QFM buffer for the temperature and total pressure of the run.

Runs were made on andesite FP-16-52 from Paricutin Volcano, Mexico. Analyses of the andesite and of two experimentally-produced amphiboles are given in table 1. A few runs were made on a sample of 1921 Kilauea tholeiite, described in [3].

4. Results

Melting relations for the Paricutin andesite under H_2O-saturated conditions (summarized in fig. 1) have been previously described [8]. Amphibole in this rock composition is a near-liquidus phase only above 6 kb under H_2O-saturated conditions. Its stability has been

Table 1
Analyses of Paricutin andesite (FP-16-52) used in study and of two amphiboles from experimental runs. All analyses by electron microprobe; rock analysis on a hydrothermal run held above liquidus, calculated H_2O-free.

	FP-16-52	Amph.	Amph.
Temp (°C)		930	900
Pressure (kb)		5.8	5.5
Wt % H_2O in melt		4.7	10.3
SiO_2	60.5	40.7	45.0
TiO_2	0.91	2.94	1.61
Al_2O_3	17.3	12.9	9.6
FeO	4.3	13.6	10.3
MgO	3.8	13.1	16.1
CaO	6.3	10.8	11.7
Na_2O	4.3	2.58	2.46
K_2O	1.69	0.57	0.54
	99.10	97.19	97.31
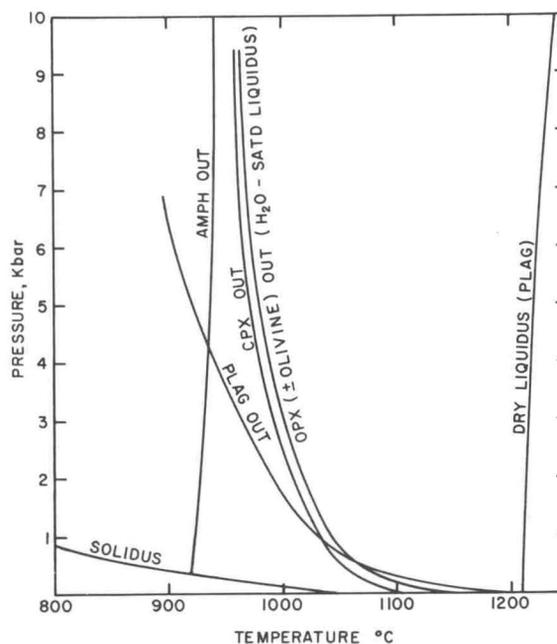
Fig. 1. Melting relations in Paricutin andesite FP-16-52. Curves refer to H_2O-saturated conditions, except for the dry liquidus at right.

closely examined at 5.5 kb in both H_2O-saturated and undersaturated runs (fig. 2). Although the upper stability limit of amphibole at H_2O-saturated conditions was determined precisely only at 2 kb, its amphibole-out temperature can be drawn with some confidence because at 2 kb this amphibole breaks down at 930 $\pm$ 5°, precisely the same as in a Mt. Hood andesite, which has a well-determined H_2O-saturated amphibole-out curve [10, 11].

In fig. 2 runs to delimit amphibole stability have been labeled with that weight percent H_2O which was calculated to be present in melt of the run. At 5–6 kb runs with 10–11 percent H_2O in melt represent H_2O-saturated conditions; runs containing 4.7 percent H_2O had $X_{H_2O}^{fl} = 0.43$. The runs containing 4.7 percent H_2O indicate that lowering $X_{H_2O}^{fl}$ from 1.0 to 0.5 changed the upper stability limit of amphibole very little up to 6 kb. The amphibole-out curve for $X_{H_2O}^{fl} = 0.5$ probably lies near or up to 15° above the H_2O-saturated amphibole-out curve at 5.5 kb. This condition agrees with results from basalt composition experiments (see below). However, when $X_{H_2O}^{fl}$ was
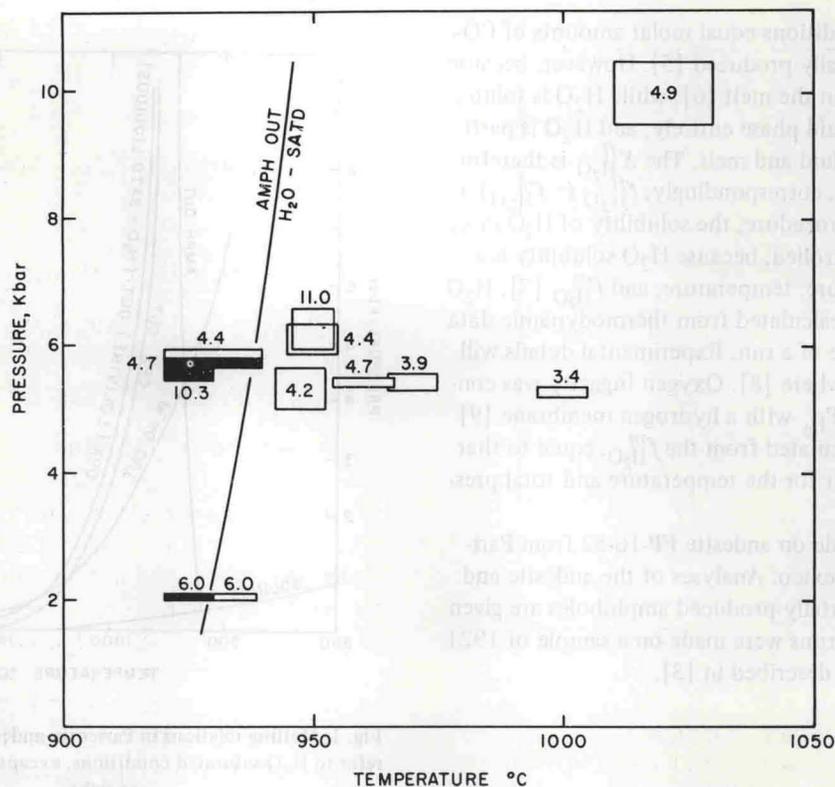
Fig. 2. Results of runs on amphibole stability in Paricutin andesite. Solid brackets indicate amphibole present; open brackets indicate amphibole absent. Size of brackets represents estimated errors in measured pressure and temperature. Numbers are weight percent H_2O in melt.

lowered from 0.5 to 0.43 (weight percent H_2O in melt lowered from 4.7 to 4.4), the upper stability limit of amphibole was *lowered*. Two runs at 5.8 kb, 930°C clearly show this effect, because for 4.7 percent H_2O the limit must lie above, and for 4.4 percent H_2O below, 930°. These capsules were run side-by-side at exactly the same experimental conditions, except for amount of oxalic acid added to the capsule. It is anticipated that further lowering of $X^{fl}_{H_2O}$ would further decrease amphibole stability. Unfortunately, experimentation in the lower temperature-lower water content range is difficult because of problems in attaining equilibrium, in determining percent glass of the run, and in having confidence in the ideal mixing assumption for H_2O-CO_2 fluids.

These results on andesite may be compared to experiments on basalt. Hill and Boettcher [12] demonstrated that above 13 kb the upper stability of amphibole in 1921 Kilauea tholeiite was raised 50–120°C

when $X^{fl}_{H_2O}$ was decreased from 1.0 to 0.5. New experiments on 1921 tholeiite at 2 kb, when combined with data of Holloway and Burnham (fig. 3), indicate that at low pressure the change in stability limit is much less, 0–15°C.

Basalt differs from andesite in that amphibole stability is about 60°C higher, and more modal amphibole is present in basalt runs, because of the greater normative amphibole content of basalt. However, amphibole compositions are similar in runs of both compositions.

5. Discussion

Holloway [3] suggested the instability of amphibole in 1921 tholeiite at 5 kb was a melting reaction:

$$100 \text{ amph} = 23 \text{ cpx} + 77 \text{ liquid} \qquad (1)$$