(French, ms, p. 65-68; 1970, p. 17-19). These compounds could be detected by the distinctive odor produced on opening the reaction vessels and sample tube after synthesis, and their complex character was qualitatively identified by a cursory mass-spectrometric analysis kindly performed by Dr. T. C. Hoering of the Carnegie Institution of Washington Geophysical Laboratory.

The production of such organic compounds appears to be an integral part of the formation of siderite by this method. Such formation is probably promoted by: (1) the reducing character of the gases produced by decomposition of $FeC_2O_4 . 2H_2O$ (see French and Eugster, 1965; French, 1966); (2) the low f_{O_2} established by the hydrothermal vessel (approximately the Ni–NiO buffer, or log $f_{O_2} \cong -30$ at 400°C; Eugster and Wones, 1962); (3) catalysis promoted by the iron-bearing solid phases or the pressure vessel.

Similar inorganic reactions may also have produced the organic compounds now found in meteorites (for detailed references, see French, 1970). These results also suggest that formation of organic compounds can occur at elevated temperatures and high gas pressures which correspond to moderate depths in a planetary crust, where the existence of a reduced gas phase may be favored by low f_{O_2} values controlled by equilibrium between graphite or other minerals (French, 1966, 1970). Organic compounds formed during hydrothermal activity at moderate depth could then be released to the surface, providing material for biological development even in cases where such synthetic reactions were not possible in the planetary atmospheres or oceans themselves.

EXPERIMENTAL RESULTS

The equilibrium: siderite + hematite + magnetite + gas (SHMG). —The univariant equilibrium: siderite + hematite + magnetite + gas (SHMG) is the intersection of three divariant surfaces in P_F–f_{O_2}–T space; the surface, siderite + hematite + gas (SHG); the surface, siderite + magnetite + gas (SMG); and the degenerate buffer surface, hematite + magnetite + gas (HM). The location of the SHMG curve was determined at 500 and 1000 bars P_F by reversing reactions in samples of siderite surrounded by hematite–magnetite buffers (table 2; fig. 3). The values obtained are:

P_F	T(±10°C)	$-\log f_{O_2}$ (±0.8)
500	363	24.7
1000	365	24.6

The greatest difficulty in determining equilibrium temperatures along the hematite–magnetite buffer was caused by the slight amount of reaction in both directions, under 5 percent. Determination of phases was made necessarily by optical study and by the detection of color changes and magnetism in the sample.

Limits on the equilibrium temperature of the isobaric invariant point SHMG at 500 bars are fixed by runs 108 (354°C) and 93 (372°C).

TABLE 2

Experimental data for determination of the equilibrium: siderite + hematite + magnetite + gas (SHMG) along the hematite–magnetite buffer

Run no.	Sample	T°C	$-\log f_{O_2}$ (bars)	Time (hrs)	Products Sample	Products Buffer
$P_F = P_{CO_2} + P_{CO} = 2000$ bars						
25	S	203	37.5	185	S	H + M + S
29	S	230	34.8	328	S	H + M + S
33	S	249	33.0	501	S	H + M + S
30	S	270	31.2	329	S	H + M
34	S	274	30.8	506	S	H + M + S
42	S	276	30.7	473	S + H + M	H + M + S
38	S	283	30.1	354	S + H + M	H + M + (S)
43	S	289	29.6	473	S	H + M
54	S	290	29.5	710	S + H + M	H + M + (S)
39	S	291	29.5	355	S	H + M
53	S	292	29.4	432	S	H + M
18	S	301	28.8	91	S + H + m	H + M + (S)
26	S	302	28.7	185	S + H + M	H + M
131	S	302	28.7	335	S + H + m	H + M + (S*)
52	S	318	27.5	415	S	H + M + (S)
55	S	320	27.4	710	S + H + M	H + M
132	HM	254	32.6	335	H + M + (S)	H + M + (S)
133	HM	306	28.4	331	H + M + (S)	H + M
$P_F = P_{CO_2} + P_{CO} = 1000$ bars						
44	S	241	33.9	238	S	H + M + S
45	S	280	30.5	190	S	H + M + S
58	S	294	29.4	356	S	H + M + S
70	S	303	28.6	356	S	H + M + S
71	S	325	27.1	356	S	H + M + (S)
79	S	348	25.6	567	S	H + M + S
49	S	360	24.8	531	S	H + M + S
120	S	360	24.8	372	S + h + M	H + M + S
65	S	370	24.2	373	S + H + M	H + M + (S)
124	S	380	23.6	385	S + h + (M)	H + M + (S)
121	S	389	23.1	371	S + H + M	H + M + (S)
59	S	400	22.5	356	S + h + M	H + M + (S)
125	S	418	21.5	291	S + H + M	H + M + (S*)
126	HM	349	25.5	387	H + M + (S)	H + M + (S)
127	HM	410	>22.0	289	M	M
$P_F = P_{CO_2} + P_{CO} = 500$ bars						
66	S	297	29.3	453	S + (M)	H + M + S
73	S	342	26.1	356	S	H + M
108	S	354	25.3	369	S	H + M + S
93	S	372	24.2	373	S + H + M	H + M + S
109	S	379	23.8	369	S + h + M	H + M + S
115	S	390	23.1	329	S + H + M	H + M
105	S	404	22.4	257	S + H + M	H + M + (S)
99	S	419	21.5	330	S + H + M	M
116	HM	365	24.6	327	H + M + (S)	H + M + (S)
117	HM	407	22.2	325	H + M	H + M + (S)