Secondary minerals. The principal secondary mineral is goethite or limonite, formed as a result of the oxidation of the pyrites. At the Clay mine a considerable quantity of limonite has been mined. It is reported that it was shipped to Mine La Motte, where it was used as a flux.

The pyrites exposed on the dumps becomes coated with sulphur yellow copiapite, a mineral already described in Chapter IV, and with a white efflorescence which was thought to be melanterite or szomolnokite but which X-ray analysis has shown to be a new mineral, which the writer wishes to call starkeyite, after the mine where it was discovered.

Starkeyite [$FeSO_4.4H_2O$], *a new mineral.* A dull, white, powdery efflorescence was observed on some altered pyrites which had been removed from a shallow shaft at the Starkey mine. An X-ray diffraction pattern obtained from the mineral showed it to be identical with a ferrous sulphate studied by Hanawalt, Rinn and Frevel[17] and listed by them as $FeSO_4.3H_2O$. Upon being questioned by the writer[18], Dr. Hanawalt[19] had a new analysis made of his material and reported that the results showed the composition to be $FeSO_4.4H_2O$ instead of $FeSO_4.3H_2O$. The X-ray data upon which the identity of the white efflorescence at the Starkey mine is based were obtained with an iron-target X-ray tube and are given in Table XXI. Since a mineral with the composition $FeSO_4.4H_2O$ has not been reported previously, the writer has taken the liberty to call it a new mineral.

The material obtained by the writer is too earthy to yield good optical data. The grains are white in reflected light but transparent in transmitted light. They are anisotropic and have one refractive index of 1.496. The microscopic examination of the mineral revealed the presence of tiny crystals of selenite and rhombohedral calcite as well as some black, earthy pyrites. The fact that the mineral was obtained from a pile of waste exposed to the air for a long time indicates that starkeyite is a stable hydrate under ordinary atmospheric conditions. Dr. Hanawalt reported that a sample of his material gave the same X-ray diffraction pattern even after being exposed to air for over one year.

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[17]Hanawalt, J. D., Rinn, H. W., and Frevel, L. K., Chemical Analysis by X-ray Diffraction: Ind. and Eng. Chem., Analytical Edition, vol. 10, p. 489, 1938.

[18]Grawe, O. R., Letter to J. D. Hanawalt, Aug. 22, 1939.

[19]Hanawalt, J. D., Letter to O. R. Grawe, Sept. 8, 1939.

TABLE XXI

X-RAY DIFFRACTION PATTERN OF STARKEYITE

(d = interplanar spacings in Angstrom units
I = relative intensity of diffraction line)

$FeSO_4 \cdot 4H_2O$		Starkeyite	
Hanawalt, Rinn and Frevel*		Starkey Mine	
		Madison Co., Missouri	
I	d	I	d
38	6.9	5	6.9
100	5.5	8	5.4
100	4.49	10	4.43
75	3.99	8	3.94
3	3.60	1—	3.59
50	3.40	7	3.40
50	3.24	7	3.22
75	2.97	9	2.94
20	2.75	6	2.70
38	2.58	4	2.56
38	2.43	6	2.42
38	2.36	1	2.34
38	2.27	3	2.27
3	2.18	3	2.21
8	2.11	1	2.13
3	2.04	1	2.05
38	1.97	2	1.969
.....	.....	1	1.917
20	1.89	2	1.876
18	1.80	4	1.803
8	1.76	1—	1.757
10	1.72	1	1.718
10	1.67	1	1.664
8	1.63	6	1.633
3	1.59	1	1.596
3	1.57	1	1.563
3	1.55	1—	1.534
10	1.51	4	1.509
3	1.488	1—	1.470
18	1.452	4	1.447
10	1.398	1—	1.398
10	1.370	1—	1.375
15	1.288	1	1.285
3	1.230	1	1.212
5	1.201	1	1.196
.....	.....	1	1.181
.....	.....	1	1.156
3	1.140	1	1.137
.....	.....	1—	1.109
.....	.....	1—	1.071
.....	.....	1	1.057
.....	.....	1	1.048

*Hanawalt, J., Rinn, and Frevel, op. cit., p. 489, 1938.