Reclamation of Strip-Pit-Coal Mining-Spoil by Mineral Recovery and Geochemical Treatment

A. C. SHEAD, Department of Chemistry

University of Oklahoma, Norman[1]

Utilization or disposal of the refuse from coal mining is a national problem. The refuse or "spoil" from the strip-pit mining of coal is of especial concern to the State of Oklahoma because of the large area, estimated (I) at from 12000-18000 acres, that is involved. Most proposals for reclamation depend on revegetation and contemplate restoration of the spoil to some sort of land use. Garner[2], especially, favors this solution of the problem. This is, perhaps, the ultimate disposal of the problem in all cases. However, there are some intermediate or alternate steps that can be taken in the mean time. These remedies depend and are based on the two radically different types of spoil that are found in the field. These may be classified as the low mineral type and the high mineral type. The first will respond readily to the revegetation treatment and ultimate restoration to land use with utilization as brick clay as a possible alternative choice.

The high mineral type of spoil involve the solution of an entirely different sort of problem because of its special properties based on those of the minerals in it. The outstanding feature of this high mineral type is its barren appearance and this characteristic is due to something more than a mere lack of fertility which is typical of both kinds of spoil. The situation is evident at a glance. Also, without treatment, the condition is generally permanent. It has been correctly traced to high sulfuric acidity or low pH resulting from the decomposition of iron sulfides in the spoil, by the combined action of air and water. This continuing reaction is so slow and the quantities of iron sulfides so large, that, left to natural recovery alone, the poisonous action due to acidity of the spoil is, practic-

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[2]Garner, Robert V. Revegetation of Strip-Mined Areas in Oklahoma. Proc. Okla. Acad. Sciences 34. 203.

ally permanent. Treatment is necessary for recovery from this condition. One remedy proposed (II) is the addition of lime at the rate of four or five tons per acre to neutralize the acidity.

Another is to add the low grade rock phosphate, available in the area and allow the spoil acid to convert the insoluble phosphate to soluble fertilizer, in place, right on the ground. Both of these proposed treatments involve the leveling and/or spreading of the spoil which could prove a costly operation. If the included iron sulfides are not too finely divided, and prove to be in sufficient quantity, they might, if recovered and sold, pay for the levelling and spreading of the spoil. A potential market for the sulfide exists in a nearby sulfuric acid plant which already utilizes the roasting of sulfides in the manufacture of its product. In turn, more acid could be used in treating the high grade phosphate which exists in the state. The two operations mutually support each other. There are other well-known uses for iron sulfides in substantial quantities besides in acid-making.

Highly mineralized spoils may be detected by at least four different methods: The first and most obvious means is direct observation of evident sterility. The second, is the test for acidity of water either in the spoil itself or in ponds receiving drainage from the spoil. A third, is leaching a weighed amount of spoil with distilled water and calculating from a chemical analysis of this, the exact amount of sulfuric acid in the spoil. A fourth consist of determining the amount of iron sulfides or other minerals in a given, known amount of spoil by screening them out or washing them out with a gold pan and weighing what is recovered. One or another of these criteria or a combination were used to determine the highly mineralized spoils. The locations of such of these as are available from the published literature are collected in the accompanying table. A fifth method has been implied or suggested, that spoil associated with coals high in sulfur are themselves high in percentage of iron sulfides. This rests on the assumption that iron sulfides infiltrate into both the clays-shales and associated coals after the later were deposited and in place, since the mineralization generally occurs in fissures, along bedding planes and in pockets of the primary deposits. The validity of the assumption seems to be corroborated by direct observation. This fifth criterion has been adopted and the spoils, so indicated, have also been incorporated in the table of locations. Checks obtained by different methods tend to establish proof of fact.

Since the percentages of the iron sulfides, marcasite and pyrite are roughly twice the percentages of sulfur found by analysis, the approximate percentages of the sulfides in a coal and the clay-shales in contact with it, above and below it on both sides can be calculated by multiplying the percentage of sulfur in the coal by the factor, 2. How closely such calculations will apply depends on the ratio of spoil to coal.

TABLE OF LOCATIONS

County	Location	Acidity, pH	Percent S in Associated Coal	Assoc. Coal	Over-Burden	
Craig						
1.	Welch, 6 mi. W. of. Strip-pit. Hill Seam.	—	6.1 % S	Hill	10'-14'	*III*
2.	Welch, 4 mi. W. of. Sec. 28-T28N-R20E.	—	5.76% S	—	—	*IV*
3.	Estella, 1 mi. E. of. Sec. 33-T26N-R19E.	—	6.02% S	Blue Jacket	—	*IV*
4.	Sec. 27-T26N-R19E.	pH, 2.0	—	Blue Jacket	15 feet	*I*
5.	Secs. 32 and 29-T26N-R19E.	pH, 3.5	High S.	—	10'-12'	*I*
6.	SW¼ 13 and SE¼ 14-T26N-R19E.	—	—	—	5 feet	*I*
7.	White Oak, 17 mi. N. of. Croweburg Coal.	—	—	Croweburg	18'-20'	*III*
8.	White Oak, 8 mi. N. of. Croweburg-Pawpaw Coal.	—	—	C.-P.	30 feet	*III*
9.	White Oak, 7 mi. N. of. Croweburg-Pawpaw Coal.	—	—	C.-P.	12'-19'	*III*
10.	Vinita, 10 mi. NW of. Sec. 13-T26N-R19E.	—	6.55% S	—	—	*IV*
11.	Vinita, 16 mi. W. and 1 mi. N. of. Lightening Creek Coal.	—	—	—	10 feet	*III*
12.	Vinita, 17 mi. W of. Lightening Creek Coal.	—	—	—	10'-12'	*III*
Rogers						
13.	Chelsea, 4 mi. SW of. Sequoyah Coal.	—	—	Sequoyah	25'-45'	*III*

TABLE OF LOCATIONS

County	Location	Acidity, pH	Percent S in Associated Coal	Assoc. Coal	Over-Burden	
Wagoner						
14.	Porter, 4 mi. NE of. Off Highway 51.	—	—	Secor	22 feet	*III*
15.	Redbird, 1¼ mi. NE of.	—	6.53% S	—	—	*IV*
Muskogee						
16.	Briartown, 2⅓ mi. W. of. Briartown Coal.	—	—	—	15 feet	*III*
Okmulgee						
17.	Henryetta, 1¼ mi. E. of.	pH 3.75-4.2	S present	—	50′-60′ 80A	*II*
18.	Sec. 8-T13N-R14E.		S present	Morris	—	*I*
McIntosh						
19.	Checotah, 6 mi. E. and 1 mi. N. of.		High%S	Secor	—	*III*
20.	Secs. 29,31,32-T12N-R18E.	pH 3.2-4.0	High S%	Secor	—	*I*

Note: Counties are not in strict alphabetical order. Roman numerals refer to listings in the Bibliography. Italicized Arabic numerals refer to items in the above table. Arabic numerals, not italicized are page numbers in the publications referred to by Roman numerals.

ANNOTATED REFERENCES

I. Doerr, Arthur H. Coal Mining and Landscaping Modification. Okla. Geol. Survey Circular 54(1961).

4 p 38. Considerable amount of ferruginous material in the form of ironstone nodules present in the overburden, 15 feet. The associated Blue Jacket coal is high in sulfur.

5 p 38. High Sulfur content of (associated) coal is reflected in a strong acid reaction, pH, 3.5 of the water in the pits. Barren of vegetation.

6 p 38. Poisoned areas devoid of vegetation.

18 p 43. Ironstone nodules are present.

20 p 43. Ironstone is present in the spoil from Secor coal. There is an abundance of pyritized fossils. Water in pits varies from pH 3.2 to pH 4.0.

II. Maloney, Sister M. Marion. Revegetation of Coal Stripped Land Near Henryetta, Oklahoma. Proc. Okla. Acad. Sci. *XXII,* 123(1941)

17 pp 126,128. High acidity, pH, 3.75 is correlated with the presence of iron sulfides, low fertility and the estimated need of four to five tons of lime per acre to neutralize the sulfuric acid formed by the decomposition of the iron sulfides. The lack of phosphorus is remarkable. The shale contains a great quantity of iron sulfide.

III. Malloy, Jno. M. Fifty Fourth Annual Report of Mines and Mining in Oklahoma. Department of (Oklahoma) Chief Mine Inspector (1962). *1* pp 30,44: *7* p 43: *8* p 43: 9 p 43: *11* p 45: *12* p 44: *13* p 45: *14* p 46: *16* p 45:

19 pp 25,46. The Associated Secor coals are high in percentages of Sulfur, 3.6%, 4.0%, 4.2%, 4.3% (p 25). The spoil from these coals might be expected to be high in iron sulfides.

IV. Shead, A. C. Chemical Analyses of Oklahoma Mineral Raw Materials, Okla. Geol. Survey Bul. 14 (1928). *2* p 35 No. 486: *3* p 35 No. 482: *10* p 35 No. 485: *15* p 35 No. 484.

General Statements.

With few exceptions, it is generally true that: Spoil associated with high sulfur coals in the Boggy Formation, the Bluejacket and Secor Coals are highly mineralized; spoil associated with low sulfur coal in the McAlester Formation, e.g. the Stigler Coal is not highly mineralized; Croweburg Coals (Broken Arrow, Henryetta), though not excessively high in Sulfur (Av. 2.0%) yield Spoil that is mineralized to a harmful extent; Weir-Pittsburgh, Lower Senora Formation is pyritic and would be expected to yield harmful spoil.