PETROGRAPHIC AND CHEMICAL STUDIES OF CARBONACEOUS ROCKS AROUND MUSH VALLEY NEAR DEBRE BERHAN, ETHIOPIA

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ABSTRACT

The petrography and chemistry of the fifteen (15) samples collected from the Mush Valley, 40 kms north of Debre Berhan has been described in this paper. On the basis of petrography, the bulk of the coals fall under the category of carbargillites and carbonaceous shales. Only the samples from the lower part of the section (MS—5, 5a, 5b, 5c) fall under the category of sub-bituminous coals and the samples (MS—5i, 5i$_2$) under the category of lignites with a parting. The coals of the lower part are characterized by reflectance vitrinoids (V_3 and V_4) ; while the lignites by xylinoids (less than 0.3% reflectance). The lower portion coal samples gave a calorific value of 3600 calories/gram and the samples from the middle part of the section gave a value of 2300 calories/gram.

Of the fifteen samples only (MS—5a, 5b, 5c and 5i) have fixed carbon content (34%, 32%, 58%, 48% and 41%) and volatile content of (36%, 43%, 14%, 33% and 34%) respectively. The sulphur content of the coals is remarkably high and samples (MS—5g, 5h, 5i, 23, 24, 25, 26 and 28) have a high ash content and moisture.

Owing to the high ash content, low carbon content and calorific value and inacessibility of the area, the coals are not amenable for large scale commercial exploitation. As the content of carbon is low, it is suggested that the coals may be gasified at the spot and used.

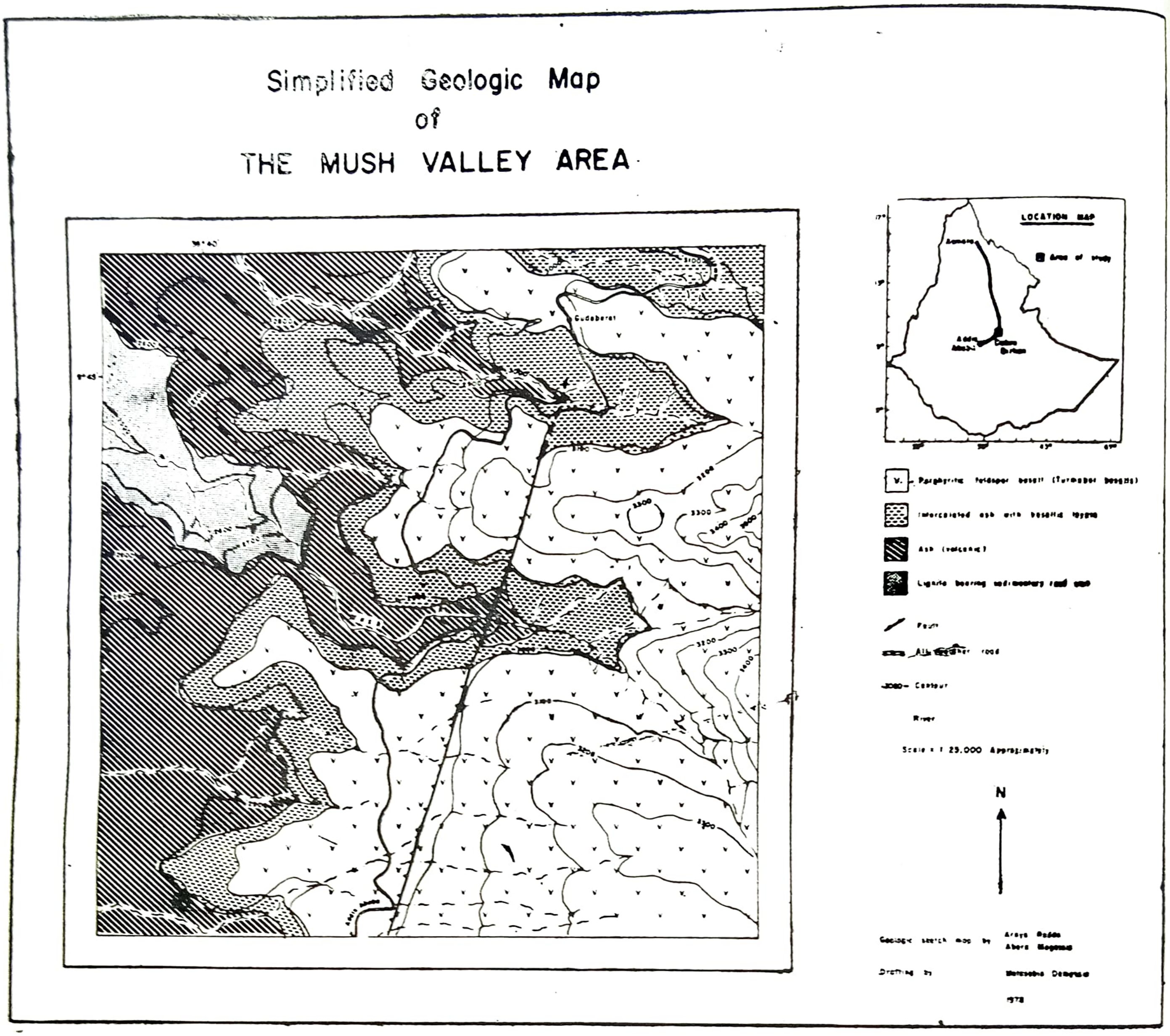
INTRODUCTION

The paper presents the petrography and chemical studies of the carbonaceous deposits intercalated with the sediments exposed at the Mush Valley, situated 40 kms from Debre Berhan between the coordinates 9° 45′ 49″ N and 39° 40′ 7″ E. The area occupied by the sediments along with the carbonaceous deposits comprise roughly five square kilometers. The coals from the Mush Valley has been reported by JELENC (1966). The study was undertaken to explore the possibilities of finding an economic potential for the exploitation of the intercalated low rank coals.

GEOLOGICAL SETTING

The lignite bearing sedimentary succession of Mush Valley area lie upon the Mio-Pliocene volcanic rocks of rhyolitic composition (JUSTIN VISENTINE *et al.*, 1974). The contact is not exposed. The sequence, which is tectonically undisturbed, consists of an association of sandstones, siltstones and shales irregularly alternating with carbonaceous shales strata showing thin lignite seams. These rocks are as thick as 384 meters, and are overlain by 134 meters of tuff that is occasionally interbedded with basalt and palaeosols.

This volcanic clastic sedimentary rocks crop out in the valleys of Mush river and its tributaries. The exposures were examined carefully and eleven sections were measured to compute the stratigraphic thickness and to study lateral and vertical variation (BABU *et al.*, 1979).



Map 1. Map showing area of study and geological distribution of the Mio-Pliocene rock nnits of the Mush Valley area, Ethiopia.

Five principle terrigenous rock types occur within the studied sections : Silts and siltstones (60% of the total sequence) ; Sands and sandstones (20%) ; Conglomeritic siltstones and gravelly silt (9%) ; Shales and mudstones (6%) and Carbonaceous shales and shales (5%).

METHODS OF INVESTIGATION

Systematic sampling of the coals as well as the associated sediments was undertaken and in all 15 coal samples were taken for the purpose of petrographic as well as proximate chemical analysis. The position of the coal samples is shown in Map-1. The samples were crushed to pass through 20 mesh sieve, and every care was taken to avoid superfines. The crushed —20 mesh sieve fraction was coned and quartered to get a representative sample of two grams, mixed with an epoxy resin and made into a pellet with a Millan mounting press under a pressure varying between 10000-150000 PSI. The pellets were polished and the macerals were estimated under the reflected light using an oil immersion lense. The coal powders were also subjected to proximate analysis using literature procedures (FAIRMAN, 1964, WELCHER, 1963 and open space). The chemical parameters pertains to moisture, volatiles, ash, sulphur and nitrogen. The reflectance was measured on the vitrinoids of selected maccrals by using Berek's micro-slit photometer using glass standards. The calorific values of the bulk compositae samples of the sub-bituminous and lignitic coals were also determined by using Baum-Calorimeter.

The variation of petrography and chemistry in the various samples is shown and presented in Figure-1 and Table-1.

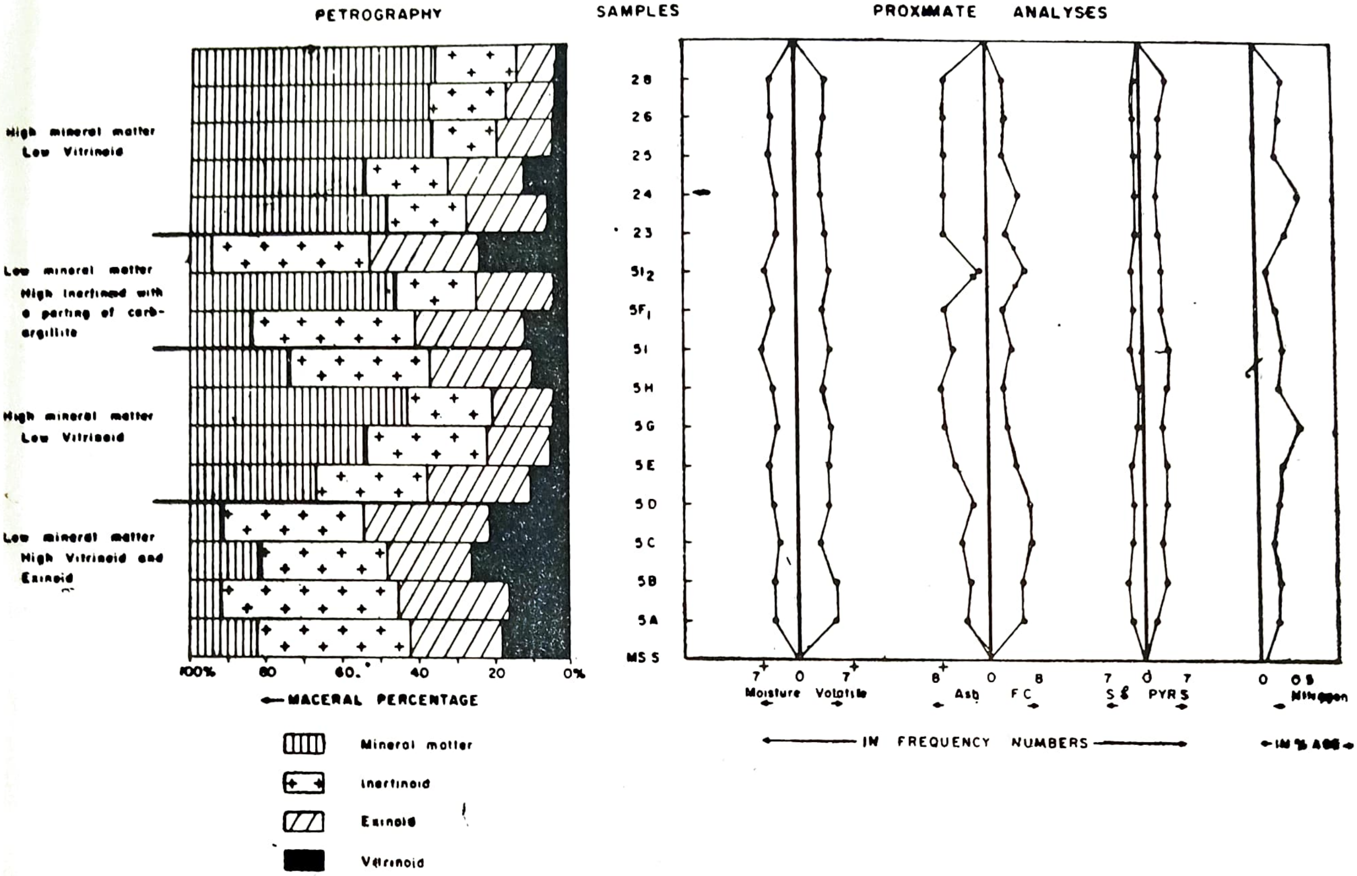


Fig. 1. Petrochemical variations in coal samples from Mush Valley, Ethiopia.

PETROGRAPHY

The vitrinoids are very low in these coals and only in the lower part of the section (MS—5, 5a, 5b, 5c) seems to possess a relatively higher percentage of vitrinoids as compared to the middle and upper parts. Vitrinoids are the bright components with and without structure. The vitrinoids with structure are frequently filled in by granular mineral matter, possibly clay minerals. Occasionally fine-grained micrinite is found associated in the cell cavities of vitrinoids. The reflectivity determined on these vitrinoids gave the value ranging between 0.20—0.40 falling in between xylinoids and vitrinoids.

The exinoids comprise chiefly sporinoids, resinoids. The sporinoids were distinguished into two groups on the basis of size namely microsporinoids and megasporinoids. Resinoids occur as globular bodies and rodlets. The sporinoids show a better preservation than resinoids. The lower portion (MS—5, 5a, 5b, 5c) are more abundant in exinoids than the other samples.

The inertinoids represented by fusinoids, micrinoids, semi-fusinoids and sclerotinoids are very much abundant in samples (MS—5i, $5i_1$, $5i_2$). The fusinoids are found

Table 1—Petrographic composition of coals from Mush Valley Area

Sample Nos.	Vitrinoids	Exinoids	Inetinoids	M.M.	Fusinoids	Micrinoids	Sclerotinoids	Semi-Fusinoids
MS-5	18.3	24.7	40.8	16.2	16.4	23.2	0.6	0.6
MS-5A	16.0	29.4	47.0	7.6	21.8	24.5	0.4	0.3
MS-5B	26.2	22.8	33.6	17.4	16.4	15.3	1.0	0.9
MS-5C	21.6	33.1	37.1	8.2	17.8	18.6	0.5	0.2
MS-5D	10.3	27.8	30.2	31.7	14.6	13.7	0.8	1.1
MS-5E	5.4	15.4	31.1	48.1	16.1	13.1	1.2	0.7
MS-5G	3.8	16.1	22.2	57.9	13.9	7.4	0.6	0.3
MS-5H	9.4	27.3	37.0	26.3	19.2	16.8	1.0	..
MS—5I	11.2	29.4	43.0	16.4	20.3	21.5	0.4	0.8
MS-5I$_1$	2.9	20.1	21.3	55.7	11.4	9.2	0.7	..
MS-5I$_2$	23.1	29.7	40.9	6.3	20.4	18.2	1.4	0.9
MS-23	4.7	21.3	21.3	52.7	12.6	7.6	0.7	0.4
MS-24	11.3	20.2	22.3	46.2	11.9	9.4	0.2	0.8
MS-25	3.6	14.3	15.9	66.2	6.4	9.4	..	0.1
MS-26	2.9	12.7	20.3	64.1	8.1	12.2	..	..
MS-28	2.1	11.5	20.7	65.7	7.8	12.5	0.3	0.1

in two habitats namely with large cells and small cells. Micrinoid is chiefly fine-grained and granular type. Semifusinoid and sclerotinoid are very scarce and hardly exceeds 1%.

The mineral matter chiefly comprising clay minerals, sulphur minerals is very much abundant in the top portion (23, 24, 25, 26 and 28) and exceeds more than 50% thereby relegating the samples to carbargillites and carbonaceous shales. However, the mineral matter is low in samples MS—5, 5a, 5b, 5c and in samples 5i, 5i$_2$.

CHEMISTRY OF COAL

The average analysis of two runs of the fifteen samples of the coal is presented in Table-2.

The means of results of duplicate determinations carried out, on representative samples are found to be acceptable for the determinations. The moisture content due to some technical problems was not determined as sampled out, but determinations are done as received by the analyst. Some corrections due to the test procedures such as blank determinations have not been done.

As may be noted from Table-2, samples (MS—5, 5a, 5b, 5c, 5d and 5i) have a fixed carbon content of 34%, 32%, 58%, 48% and 41% ; Moisture content of 17%, 17%, 10%, 15% and 23% ; Volatile matters of 36%, 43%, 14%, 33% and 34%, respectively. The rank of coal increases with the increase in the amount of fixed carbon content and decrease of moisture and volatile matter. The above listed samples are better than the remaining samples, as volatile matter and fixed carbon are the most important contributors to the energy produced when coal is burnt. This had been verified by the range of appearance of the samples that vary from brown to black. The lower portion coals, which are sub-bituminous are black, while the middle portion coals which are lignites are brown in colour.

Table 2—Chemical composition of coals from Mush Valley Area

Sample	Moisture	Volatile	Ash	Fixed Carbon	Nitrogen	Sulfate Sulpur	Pyritic Sulfur
MS-5	17±1	36±2	14±1	34±1	0.24±0.01	1.8±2	1.2±2
MS-5B	17±1	43±2	8±1	32±1	0.27±0.01	2.1±2	7.2±4
MS-5C	10±1	14±2	19±1	58±1	0.22±0.01	1.3±3	6.0±2
MS-5D	15±1	33±2	4±1	48±1	0.27±0.01	0.74±3	7.6±4
MS-5E	21±1	30±2	30±1	19±1	0.30±0.01	1.5±3	7.2±2
MS-5G	10±1	28±2	54±1	9±1	0.54±0.01	0.3±4	6.4±1
MS-5H	15±1	19±2	62±1	5±1	0.29±0.01	0.1±2	7.0±1
MS-5I	29±1	28±2	28±1	15±1	0.33±0.01	1.1±1	14.6±3
MS-5I_1	14±1	22±2	59±1	6±1	0.24±0.01	0.6±4	5.1±4
MS-5I_2	23±1	34±2	2±1	41±1	0.17±0.01	0.5±1	12.7±3
MS-23	11±1	25±2	56±1	9±1	0.47±0.01	0.3±1	5.6±4
MS-24	10±1	16±2	50±1	24±1	0.59±0.01	0.1±3	2.9±4
MS-25	21±1	17±2	57±1	6±1	0.27±0.01	0.2±4	4.3±2
MS-26	16±1	20±2	56±1	7±1	0.33±0.01	0.4±1	6.4±2
MS-28	15±1	24±2	56±1	5±1	0.39±0.01	0.1±1	14.4±2

Coal contains carbon, hydrogen, nitrogen, sulphur and other elements in small quantities. The proportion in which the major elements are present differs greatly in different kinds of coal, As seen in Table-2, the sulphur content is reasonably high, while the acceptable limit of sulphur in coal should be less than 2%. Samples 5g, 5h, 5i, 23, 24, 25, 26 and 28 have a high content of ash and moisture. The ash (noncombustible residue) of the fifteen samples appear to have different colours. Though spectrographic analysis of the ash has not been carried out, this variation in colour of ash can be explained on the petrography, as due to the presence of titanium, manganese, iron and other inorganic constituents contained in the mineral matter.

Two compositae bulk samples one from the lower horizon (Samples MS—5, 5a, 5b, and 5c) and the other from the middle portion (Samples MS—5i, $5i_1$, $5i_2$) were sent for the calorific values abroad. The first set of samples gave a value of 3600 calories/gm ; while samples from the middle portion gave a value of 2300 calories/gm. The reflectance vitrinoids present in the compositae samples of MS—5, 5a, 5b and 5c conforms to V_3 and V_4 types of Spackman (1958) ; while the vitrinoids of the compositae samples (MS—5i, $5i_1$, $5i_2$) can be hardly called vitrinoids as its reflectance is less than 0.30% and hence falls under the category of xylinoids, characteristic of lignites.

ORIGIN OF THE DEPOSIT

From the nature and mode of occurrence, the coal bearing strata seems to be of fluviatile origin deposited on the basalt substratum. This is inferred from the fine-grained size, the presence of woody lignite beds that contain petrified stumps in growth position, the predominant dark colour, and the predominance of sedimentary structures such as laminations and horizontal beddings. As these coal bearing sediments rests on the porphyritic basalts, it indicates that the coal bearing sediments are much younger than the basalts. This fact also explains the lower degree of carbonization of the coals of the Mush Valley, high moisture and ash content and low calorific value. Subsequently, the coal beds must have been partly eroded by the Mush river.

CONCLUSION

The bulk of the coals, based on the petrography fall under carbargillite and carbonaceous shales. Only the lower portion comprising the samples (MS—5, 5a, 5b, 5c) fall under the category of sub-bituminous coals and the samples (5i, $5i_2$) under lignite with a shale parting (5i). The calorific value is also low, but the samples of lower part (MS—5, 5a, 5b, 5c) possess relatively a better value as compared to (MS—5i, $5i_1$). The coals of the lower portion possess vitrinoids of the type V_3 and V_4, once again pointing to sub-bituminous high volatile coals while the middle portion comprising (MS—5i, $5i_1$) are characterized by xylinoids (less than 0.3% reflectance) characteristic of lignites.

On the basis of petrography the fifteen samples can be grouped into four units namely : Unit-1 comprising samples (MS-5, 5a, 5b and 5c) ; Unit-2 comprising the samples (MS---5d, 5e, 5g and 5h) ; Unit-3 comprising the samples (MS—5i, $5i_1$, $5i_2$) and, Unit-4 comprising the samples (MS—23, 24, 25, 26 and 28). Among these four units Unit-2 and Unit-4 are practically useless being essentially carbargillite and carbonaceous shales. But Unit-1 and Unit-3 falls under coal proper in which Unit-1 being sub-bituminous with a relatively better calorific value ; Unit-3 being lignite with a shale parting in between ($5i_1$) with a lower calorific value. Unit-1 is not occurring as a stratified deposit, but occurs as pockets in silty sandstones and hence is not economical from the point of commercial exploitation. But the Unit-3 with the shale parting measures a thickness of about 4 meters and contains 40 to 50% carbonaceous matter. It also extends considerably along the depositional strike. This unit can be exploited by small scale open cast mining and can be used after beneficiation (washing or heavy media separation), so that considerable shaly matter is removed and quality of the coal is increased. The alternative is to gasify the low content coal at the spot for commercial exploitation after assessing the amount of available reserves.

Owing to the high ash content, low carbon content, low calorific value and the inaccessibility of the area and difficult transport facilities, the coal deposit is not economical for large scale commercial exploitation. However, small scale mining can be undertaken for limited use, after beneficiation. Because of the low content of carbon, it is suggested that these coals may be gasified at the spot and used.

ACKNOWLEDGEMENTS

The authors place on record their sincere thanks to Ato Haile Sellassie Gebre Egziabher for affording facilities to prepare the pellets of coal at the Mines and Survey. The authors are also indebted to the Department of Chemistry and the Ethiopian Nutrition Institute of Addis Ababa for affording facilities to carry out the proximate analysis and determination of nitrogen and to Ato Aberra Mogessie and Ato Araya Redda for their help during field work.

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