

EFFECT OF EXTERNAL MAGNETIC FIELD ON THE
VOLATILIZATION OF ELEMENTS IN THE D.C. ARC

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Abstract

In the present investigation opposite magnetic fields are applied to the free burning carbon arc, with a silicate sample (granodiorite) in its anode crater. The magnetic field promoted the selective volatilization of the elements present in the sample. As a result a depression in the spectral line intensities of Mn, Ti, Th and Fe as well as the background was observed. At the same time the intensity of the spectral lines of Ag, Ge, Pb, In and Cu is enhanced. The latter elements are of great significance since they are used as pathfinders for gold.

INTRODUCTION

Selective volatilization is a phenomenon observed in many light sources used in spectrochemical excitation specially in the d.c. arc. When a sample containing several elements is arced, it may happen that one or more elements distill almost completely before other elements begin to volatilize. It is generally attempted to eliminate or reduce the selective volatilization. On the other hand, there are cases in which it is desirable to improve it. In these cases it may be useful to suppress the emission of an element, which emits a complex spectrum, an intense background or both. This background as well as very complex spectra lower the sensitivity of detection and cause line interference.

Scribner and Mullin⁽¹⁾ described a method for the analysis of impurity elements in uranium oxide in which they added 2% Ga₂O₃ to suppress the volatilization of uranium, but not that of the more volatile elements. If the exposure is terminated before the main volatilization of uranium

starts, the spectra of the impurity elements can be examined in a relatively clean spectrum, resulting in a marked improvement of detection limits for a number of elements.

The application of stationary external magnetic fields to the d.c. arc in order to increase the spectral line intensity has been investigated by many researchers during the past decade. Vukanovic et al.^(2,3,4,5), Todrovic⁽⁶⁾, Lummerzheim and Nickel⁽⁷⁾, Leushacke and Nickel^(8,9) and others applied the external magnetic field to the d.c. arc to improve the sensitivity of detection of the elements under consideration.

Vukanovic⁽⁴⁾ compared the effect of the external magnetic field with that of the addition of Ga_2O_3 , in the analysis of ZrO_2 and found that both have the same tendency of lowering the detection limit of some impurity elements.

The aim of the present investigation is to explore the possible application of external opposite magnetic fields to the d.c. arc for improving selective volatilization, thus minimizing line interference of some major elements in the spectrum of a natural silicate sample. The sample under investigation is a granodiorite rock collected from the Fawakhir gold mine in Eastern Desert near red sea, Egypt. The elements Ag, Ge, Pb, In, and Cu are present in the sample in trace amounts. These elements are of great significance, since they are used as pathfinders for gold. On the other hand, the elements Mn, Ti, Th and Fe are present with concentrations higher than 1%.

EXPERIMENTAL AND RESULTS

The arc is placed between the two coils of an electromagnet, connected together to produce opposite magnetic fields with the neutral point at the center of the arc gap. The magnetic induction measured at the end of each coil could be varied between 0 and 200 gauss. Anode excitation technique has been used. In order to avoid globule formation, graphite powder was

maximum increase in spectral line intensities, for these elements, is achieved with magnetic induction values between 50 and 100 gauss. Copper is the only element whose magnetic response curve shows two maxima, the first one at 50 gauss and a second weaker one at 150 gauss.

For the elements Mn, Al, Th, and Fe, the magnetic field effect is to decrease the intensity of their spectral lines. Figure (2) shows the magnetic response curves for this group of elements.

Volatilization behaviour in the magnetic field:

The effect of the magnetic field on the volatilization behaviour of the different elements in the sample was investigated. The anode craters were packed with samples and arced till completion with zero gauss and 75 gauss respectively, under the optimal conditions achieved. During the burning, the plate holder was racked every 10 seconds. From the obtained spectra, the time-intensity curves were plotted for the different elements under consideration. The results obtained are shown in figures 3 - 11.

From these figures it is obvious that the elements Ag, Ge, Pb and In show a similar behaviour. One can also see again that applying the magnetic field increases the spectral line intensity for these elements. In both cases, with and without magnetic field, the maximum of the time-intensity curve is reached almost after the same time. All curves show a tendency for complete evaporation in a slight shorter time by the application of the magnetic field. Without the magnetic field, the time-intensity curve for copper has two maxima; the first maximum after 10 seconds and another weaker one after 40 seconds. With the magnetic field applied, the intensity of the copper line reaches a maximum after 60 seconds then another maximum after 90 seconds. Copper is among those elements which show an increase in spectral line intensity in presence of the magnetic field.

For the elements Mn, Ti, Th, and Fe the magnetic field affects in delaying

added to the sample in ratio 1:5 . A medium quartz spectrograph Q 24 (Carl Zeiss Jena) was used with a slit width of 10 microns. The spectra were recorded on kodak spectral analysis plates No. 3 . The plate emulsion was calibrated using a platinum-on-quartz six step filter attached to the spectrograph slit.

The elements considered in this study are Ag, Ge, Pb, In, Cu, Mn, Ni, Zn and Fe. Preliminary experiments showed that the opposite magnetic fields applied to the arc caused a remarkable depression in the background of the whole spectrum and an increase in the line intensity of Ag, Ge, Pb, In and Cu. On the other hand the spectral lines of Mn, Ni, Zn and Fe showed decrease in intensity in the presence of the magnetic field.

The excitation conditions were chosen, which give the maximum increase in the intensity for the Pb line at 2833.07 \AA , taken as a test line. The change in spectral line intensity due to the magnetic field was measured in the intensity ratio (with background correction) I/I_0 with and without magnetic field. These conditions are as follows :

- a) Arc gap : 4 mm.
- b) Arc current : 4 amperes.
- c) Exposure time : 60 seconds.
- d) Anode : graphite rod 6.2 mm in diameter, with a cavity of 4.6 mm in diameter, wall thickness 0.8 mm and a central depth of 4.0 mm .
- e) Counter electrode : graphite rod of 4.5 mm in diameter pointed at its end to form a cone of solid angle of 28° .

Effect of the magnetic ^{field} on the intensity of the spectral lines :

Figure (1) shows the enhancement of the spectral line intensity I/I_0 as a function of the magnetic induction B, (as measured at the end of the coil) for those elements which show an increase in line intensity, in the presence of the magnetic field. From the figure one can see that the

their evaporation curves remarkably. Considering Mn, as an example, the maximum of the time-intensity curve is reached after 60 minutes without the magnetic field. Applying the magnetic field shifts the maximum about 220 seconds. Accordingly if the exposure is terminated after 60 seconds, the Mn spectral lines will hardly appear in the spectrum. This may give an explanation for the observed decrease in intensity of the spectral lines of these elements with the application of the magnetic field.

DISCUSSION

From the present study it is obvious that the external opposite magnetic fields applied to the d.c. arc have a remarkable effect on the volatilization behaviour of the elements present in the silicate sample under consideration. The elements investigated can be classified into two groups : The first group consists of those elements whose spectral line intensities increase with the application of the magnetic field. For these elements the magnetic field enhances the rate of volatilization and the evaporation is completed in slight shorter time. Fortunately these elements are mainly those used as pathfinders for gold.

For the second group of elements, which are mainly those constituting the major elements in the sample, applying the magnetic field results in delaying their evaporation with appreciable time intervals. Thus it can be concluded that the opposite magnetic fields, enhanced the selective volatilization of the elements present in the silicate sample. This observation can be useful, in the spectrochemical analysis of the natural silicates, in minimizing line interference.

REFERENCES

- 1) B.F. Scribner and H.K. Mullin, J. Res. Natl. Bur. Std., 37, 397, 1946
- 2) V. Vukanovic, V. Georgijevic, N. Konjovic and D. Vukanovic, Proc. XII Coll. Spectrum Int. Exeter, P. 193, 1965
- 3) V. Vukanovic and V. Georgijevic, Z. Anal. Chem., 225, 137, 1967
- 4) V. Vukanovic, V. Georgijevic, D. Vukanovic and H. Rodorovic, Spectrochim. Acta, 24B, 555, 1969
- 5) V. Vukanovic, M. Simic and D. Vukanovic, Spectrochim. Acta, 29 B, 33, 1974
- 6) M. Rodorovic, V. Vukanovic and V. Georgijevic, Spectrochim. Acta, 24 B, 571, 1969
- 7) D. Lummerzheim and H. Nickel, Z. Anal. Chem., 245, 267, 1969
- 8) D.F. Leushacke and H. Nickel, Spectrochim. Acta, 26 B, 391, 1971
- 9) D.F. Leushacke and H. Nickel, Spectrochim. Acta, 27 B, 273, 1972

Figure Captions

- Fig. (1) Intensity ratio I/I_0 with and without magnetic field as a function of the magnetic induction B
- Fig (2) Intensity ratio I/I_0 with and without magnetic field as a function of the magnetic induction B
- Fig (3) Time-intensity curves for Ag.
- Fig.(4) Time-intensity curves for Pb.
- Fig. (5) Time-intensity curves for Ge.
- Fig. (6) Time-intensity curves for In
- Fig. (7) Time-intensity curves for Cu.
- Fig. (8) Time-intensity curves for Mn.
- Fig. (9) Time-intensity curves for Ni
- Fig. (10) Time-intensity curves for Ni.
- Fig. (11) Time-intensity curves for Fe.

تأثير المجال المغناطيسى العكسى على تيخر العناصر فى القوس الكهربي المستمر

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يتناول هذا البحث دراسة تأثير المجال المغناطيسى العكسى على تبيخر العناصر الموجودة فى الخامات الطبيعية مثل خام الجرافايد يوريت ، عند تحليلها طيفيا باستخدام القوس الكهربي المستمر .

وقد وجد من الدراسة ان بعض هذه العناصر مثل المنجنيز والتيتانيوم والثاليم والحديد يتأخر تبيخرها فى وجود المجال المغناطيسى . اما البعض الاخر مثل الفضة والجرمانيم والرصاص والاندسيوم والنحاس فانه يسهل تبيخرها فى مدة زمنية اقل . والعناصر الاخيرة لها اهمية كبيرة فى الكشف عن الذهب . ولذلك فانه يمكن الاستفادة من هذه الدراسة فى التحليل الطيفى لعنث هذه الخامات .