Variation in air temperature in a cross-section of an underground airway

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SYNOPSIS

Measurements of air temperatures in underground airways are normally made at only one point in a cross-section, and the air temperatures at other points in the cross-section are assumed not to differ significantly from this. This paper discusses measurements made at a number of points in fifty cross-sections in airways with different air velocities and wetness of floor. These measurements show that significant variations of air temperature can occur in a given cross-section at a given time. The effects of such variations on the accuracy of measurement of rises in air temperature as air passes along an airway are discussed. The importance of considering experimental error in the measured rises in air temperature when attempting to validate theoretical and empirical methods of predicting such rises is also discussed.

SAMEVATTING

Lugtemperatuur word gewoonlik slegs op een punt in 'n dwarsdeursnee in ondergrondse luggange gemeet en daar word dan aangeneem dat die lugtemperatuur by ander punte in die dwarsdeursnee nie baie daarvan verskil nie. Hierdie verhandeling bespreek metings wat by 'n aantal punte in vyftig dwarsdeursneë in luggange met verskillende lugsnelhede en grade van natheid van die vloer gedoen is. Hierdie metings toon dat daar betekenisvolle verskille op 'n bepaalde tyd in 'n gegewe dwarsdeursnee in die lugtemperatuur kan voorkom. Die uitwerking van sulke verskille op die akkuraatheid van die meting van stygings in die lugtemperatuur soos die lug in 'n luggang langs beweeg, word bespreek. Die belangrikheid daarvan om 'n eksperimentele fout in die gemete stygings in die lugtemperatuur in aanmerking te neem wanneer daar gepoog word om teoretiese en empiriese metodes om sulke stygings te voorspel, te bevestig, word ook bespreek.

INTRODUCTION

There is little discussion in the mining literature of the possible differences in air temperatures at different points in the same cross-section of an airway at a given time. The standard procedures for obtaining air temperatures involve measurement at only one point in the cross-section, for example by holding a hygrometer at arm's length upstream from the observer[1]. If the air temperatures vary at different points in the cross-section at a given time, the temperatures obtained at any one point could be significantly different from the average value for the cross-section.

The author previously[2] briefly reported decreases of over 0,5 °C in dry-bulb temperature and increases of up to 1 °C in wet-bulb temperature towards the floor of drives in which the floor was wet and air velocities were between 0,3 and 0,8 m/s. The measurements were made by Assmann psychrometer. Hitchcock and Jones[3] mention that they obtained increases in dry-bulb temperature of approximately 0,6 to 0,8 °C from the floor to the roof of a roadway in a coal mine, and a decrease in wet-bulb temperature of approximately 1,1 °C. They obtained their measurements with thermocouples. The floor was wet; air velocities were not given directly but appeared to be approximately 1 m/s.

The present paper discusses the variation in air temperatures found in a large number of readings made in drives having different air velocities and degrees of wetness.

METHODS OF MEASUREMENT

A Lambrecht Assmann psychrometer in which the thermometers were marked at intervals of 0,2 °C was used, and temperatures were recorded to 0,1 °C. The accuracy of the thermometers was checked against a calibrated thermometer using a temperature bath; no correction was found to be necessary.

After arriving at the drive used for any particular series of readings, at least 5 minutes was allowed for the psychrometer to attain equilibrium with the surroundings before the first measurements were taken. The psychrometer was held in any given position for at least 2 minutes before the temperatures were recorded; a constant reading was usually obtained within the first minute. On several occasions, the psychrometer was kept in position for over 5 minutes and read every minute, but no change in temperature was observed after 2 minutes.

A set of readings was made at several points in each cross-section, and then each set was repeated at least once and often in a different order. The readings were used only if all the readings at a given point agreed to within 0,1 °C, e.g., 29,0 °C or 29,1 °C. Where there was a 0,1 °C difference, the higher reading is the one quoted in this paper. Since the measurements were being made to determine the variation in temperature in the cross-section, i.e., to determine relative values of temperature rather than absolute values, an accuracy of $\pm 0,1$ °C was assumed.

There was rarely a change of more than 0,1 °C in the readings at a given point, even though the initial and final readings at a point were often separated by times of more than 20 minutes. The following are possible reasons for the constancy of the temperatures:

(a) the cross-sections used for measurement were at depths of about 750 m below the surface and at a minimum of 37 m from the intake shafts;

(b) the measurements were made on afternoon shift, when there was less movement of ventilation doors than in day shift, and were made in parts of the mine not currently being used for production.

The psychrometer was held at arm's length and upstream; all measurements were made by the author. Care was taken to avoid errors of parallax.

Air velocities were measured by anemometer on a continuous traverse.

Notes were made on the wetness

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of the drive, using terms including *dry*, *damp*, and *wet*. An area of floor was described as *wet* when there were no pools of water but the floor was saturated with water and soft underfoot. The term *dry* was used when there was no obvious moisture on the floor; *damp* was used to describe the intermediate stage between dry and wet.

CONDITIONS IN THE DRIVE

The drive was of a nominal 2,4 m by 2,4 m square cross-section. There was no splitting of the airflow or sharp bends in the portion used for the experiment. A railway line 0,46 m wide ran down the middle of the drive.

The temperature of the virgin rock was 35 °C. There was no production on the level, and the only ventilation for a number of years, apart from that during the period of the observations, had been leakage through the ventilation doors. An open drain varying in width between 0,3 and 0,5 m ran down one side, but there was very little flow of water. The water temperatures were less than the dry-bulb air temperatures. The surrounding rock was gneiss with no significant mineralization present, and little heat would therefore be produced by oxidation. In the first series of experimental observations, there were no pipes in the drive carrying fluid. In the second series, a compressed-air pipe 5 cm in diameter was used to gradually pump water out of a flooded area, but the pipe was closed off several hours before the measurements were made. The main source of sensible heat for the air-stream was therefore expected to be heat flow from the rock surrounding the drive.

FIRST SERIES OF EXPERIMENTAL OBSERVATIONS

Temperatures were taken on each of the four underground visits in four particular cross-sections. The relative positions of these cross-sections and a description of the degree of wetness of the floor of the drive between them are given in Table I. The drive between cross-sections was sub-divided, for the purposes of description, if the degree of wetness of the floor changed. The walls and roof of the drive were dry.

Air velocities were measured between A and B in a cross-section 60 m from A. The direction of airflow was from A to D.

TABLE I

CROSS-SECTIONS AND DEGREE OF WETNESS DURING FIRST SERIES

Distance from cross-section A m	Cross-section	Wetness of floor between cross-sections
0,0	A	Drain contained a little water, but rest of floor dry.
46,0		Drain filled, but rest of floor slightly damp.
84,4	B	Whole floor covered with water.
114,0	C	Drain filled, but rest of floor dry.
139,6		Floor dry.
196,3	D	

TABLE II

MEASUREMENTS AT C IN THE FIRST SERIES

Date	Temp., °C, and specific humidity (r), g/kg						Change in temp. with height °C		Barometric pressure kPa
	0,15 m above the floor			1,2 m above the floor					
	Wet	Dry	r	Wet	Dry	r	Wet	Dry	
20/11/69	15,0	23,5	6,6	14,2	23,9	5,6	—0,8	0,4	106,7
24/11/69	16,3	25,1	7,4	15,1	25,3	6,0	—1,2	0,2	106,3
1/12/69	18,0	25,1	9,5	17,3	25,3	8,6	—0,7	0,2	105,3
4/12/69	15,5	24,0	7,0	15,0	24,1	6,4	—0,5	0,1	106,1

Temperatures were measured in each cross-section half-way across the floor and with the intake (i.e., the base) of the psychrometer 0,15 m and 1,2 m above the floor.

Cross-section A was 37 m from the intake shaft. No difference was found between the wet-bulb or dry-bulb temperatures at the two heights on any of the four underground visits.

Table I shows that the floor between A and B did not contain much moisture. At point B, the differences between the wet-bulb or dry-bulb temperatures at the two heights was never greater than 0,2 °C. The differences were always increases of dry bulb with height or decreases of wet bulb with height, which suggested that there was a small change of temperature with height but that it was not much greater than experimental error.

The temperatures at C, which was situated immediately after the portion of the floor that was covered with water, are shown in Table II. The differences between some of the temperatures at the two heights was considerable, especially in the wet-bulb temperatures on 24/11/69, which had the maximum difference, namely 1,2 °C.

On the four dates, the air velocities 60 m from A were 0,45 m/s, 0,56 m/s, 0,68 m/s and 0,97 m/s respectively. The average Reynolds number was $1{,}2 \times 10^5$.

Location D, as shown in Table I, had a dry floor and was preceded by 82 m of drive that was either completely dry or had, at most, the drain filled. The difference between the temperatures at the two heights was 0,2 °C or less, with the exception of 24/11/69, on which the wet-bulb decrease with height was 0,5 °C. As shown in Table II, this day had the maximum decrease of wet-bulb temperature with height at C. The changes of temperature with height were always increases of dry-bulb or decreases of wet-bulb temperature.

Thus, in this first series of observations, the air which had no change of temperature with height at A, had only a very small change of temperature with height at B after it had passed over 84 m of relatively dry floor. However, after the air had passed over 30 m of floor covered with water between B and C, large differences of temperature were found between the two heights. After the air had passed over 82 m of almost dry floor between C and D, the differences in temperature between the two heights were considerably less.

SECOND SERIES OF EXPERIMENTAL OBSERVATIONS

The same drive and cross-sections were used in the second series as in the first series. A description of the wetness of the floor is given in Table III. The sides and roof of the drive were dry.

Measurements were made on 13 days in the second series. Air velocities were measured at a cross-section between A and B and 60 m from A. The average velocity was 0,61 m/s, which corresponded to a Reynolds number of $1,2 \times 10^5$. The direction of airflow was from A to D.

The measurements were part of an experiment to determine the gain in enthalpy of the airstream between A and D, and on most days temperatures were measured only at A and D. The temperatures to be discussed first are those measured at each cross-section approximately half-way across the floor and with the intake of the psychrometer both 0,15 m and 1,5 m above the floor.

At A there was no wet-bulb decrease with height greater than 0,2 °C; two of the 14 days showed an increase of 0,1 °C, which was within experimental error. The dry-bulb increase with height averaged 0,14 °C, but there were four days with values greater than 0,2 °C (the maximum was 0,5 °C).

TABLE III

CROSS-SECTIONS AND DEGREE OF WETNESS DURING SECOND SERIES (3/11/70 TO 7/12/70)

Distance from cross-section A m	Cross-section	Wetness of floor between cross-sections
0,0	A	Most of drain either contained water or was damp to wet. Most of rest of floor was dry apart from between the railway lines, where there were some small puddles and associated dampness over a total length of 25 m including the 9 m before B.
84,4	B	Whole floor covered with water.
114,0	C	Drain contained water. Rest of floor dry with damp patches.
157,0		Initially 2/3 of floor including drain covered with water. Water gradually pumped out until, by 30/11/70, water left only in drain but rest of floor damp or wet.
187,1		Initially, drain and rest of floor damp or wet, with small pools of water on rest of floor. By 30/11/70, pools of water had disappeared but floor still damp.
196,3	D	

Tables I and III show that the floor between A and B in the second series contained more moisture than in the first series of observations. The changes in temperature with height on the three days on which temperatures were taken at B are shown in Table IV, along with the differences in temperature at A, C and D. These results show a significant increase in the changes of temperature with height measured at B compared with those measured at A. In the first series, where the floor between A and B was drier, there was only a very small increase in the changes in temperature with height between A and B.

The floor between B and C was covered with water. Measurements were taken at C only on 9/11/70 and 2/12/70. The temperatures obtained on 9/11/70 are given in Table V (no measurements were made at B); the changes in temperature with height on 2/12/70 are shown in Table IV. On both 9/11/70 and 2/12/70, the differences between the temperatures at the two heights at C was an appreciable increase on the differences at the previous cross-sections (A and B respectively). (No measurements were made at B. The air velocity at 60 m from A was 0,51 m/s. The barometric pressure in the drive was 105 kPa.)

Table III shows that the 39 m of floor before D was either covered with water or at least damp for the whole of the second series. At D the average decrease in wet-bulb tem-

TABLE IV

CHANGES IN TEMPERATURE ON DAYS ON WHICH TEMPERATURES WERE MEASURED AT B DURING SECOND SERIES

Date	30/11/70				2/12/70				7/12/70			
Cross-section	A	B	C	D	A	B	C	D	A	B	C	D
Decrease in wet bulb with height	0,0	0,4	*	1,0	–0,1	0,8	1,6	1,0	0,1	0,8	*	0,9
Increase in dry bulb with height	0,5	0,5	*	0,5	0,3	1,0	1,6	1,2	0,0	0,5	*	0,6
Air velocity at 60 m from A, m/s	0,66				0,87				0,83			

* No measurements made at C.

perature with height for the 13 days on which measurements were made was 0,9 °C, with a maximum of 1,3 °C. The average increase in dry-bulb temperature with height was 0,5 °C, with a maximum of 1,2 °C. Table IV shows the changes in temperature with height at D in the last three days of the second series, by which time most of the water had been pumped out from between C and D but much of the floor was still damp. The changes of temperature with height on those three days was average or above average. Tables V and VI show further measurements at D. Thus, the changes in temperature with height at D in the second series were much greater than in the first series. This would have been due mainly to the far greater amount of moisture available for evaporation between C and D in the second series.

In order to provide further information on the changes in temperature with height, measurements were made at D on three days half-way across the floor and with the intake of the psychrometer 0,5 m above the floor, as well as 0,15 m and 1,5 m above the floor. The temperatures and specific humidities are given in Table VI. The specific humidity of the air reduced between 0,15 m and 0,5 m and again between 0,5 m and 1,5 m. Thus, the increase in the specific humidity of the air resulting from evaporation was not limited to a layer near the floor. The temperatures in Table VI also show that, if air temperatures had been measured only at 1,5 m, for example, and the results taken as the average temperatures for the cross-section, then the dry-bulb temperature would probably be an over-estimate and the wet-bulb temperature an under-estimate.

TABLE V

MEASUREMENTS ON 9/11/70 IN THE SECOND SERIES

Cross-section	Temp., °C, and specific humidity (r), g/kg						Change in temp. with height °C	
	0,15 m above the floor			1,5 m above the floor				
	Wet	Dry	r	Wet	Dry	r	Wet	Dry
A	17,8	23,8	9,8	17,8	23,8	9,8	0,0	0,0
C	19,8	24,4	12,0	18,6	24,8	10,4	−1,2	0,4
D	20,2	25,4	12,1	19,6	25,6	11,3	−0,6	0,2

TABLE VI

MEASUREMENTS AT D IN THE SECOND SERIES

Date	Height above floor m	Wet-bulb temp. °C	Dry-bulb temp. °C	Specific humidity g/kg	Barometric pressure kPa	Air velocity at 60 m from A m/s
16/11/70	1,5	17,8	25,0	9,1	106,6	0,51
	0,5	18,1	24,7	9,6		
	0,15	18,5	24,5	10,2		
24/11/70	1,5	17,4	26,1	8,3	105,4	0,54
	0,5	18,0	25,4	9,3		
	0,15	18,6	25,4	10,1		
25/11/70	1,5	17,7	25,6	8,9	105,5	0,64
	0,5	18,4	25,1	9,9		
	0,15	18,9	25,0	10,6		

THIRD SERIES OF EXPERIMENTAL OBSERVATIONS

The measurements in the first and second series were all made in the same drive, and the maximum air velocity was found to be 0,97 m/s. The measurements in the third series were taken to show whether similar differences in air temperature occurred in a different drive with higher air velocities.

Measurements were made in cross-sections A and B in a drive with the same nominal 2,4 m by 2,4 m square cross-section as in the first and second series. For 62 m upstream from A, an open drain varying in width between 0,3 and 0,5 m ran down one side of the drive. The surface of the water in the drain was about 0,1 m below the level of the rest of the floor. There was no obvious dampness on any of the rest of the floor. However, the floor on the opposite side of the drive from the gutter was dusty for a third or more of the way across from the wall, whereas the rest of the floor up to the gutter was compact, suggesting that there might have been a little moisture associated with this central portion. The walls and roof were dry. There was no splitting of the airflow or bends for 62 m upstream of A. The drive was not used for trucking.

Temperatures were measured at A on two days at various heights above three points. One point was half-way across the floor, the second was in the drain 0,3 m from the wall, and the third was on the dusty section of the floor 0,6 m from the wall (the floor was 2,4 m wide). The results are shown in Table VII. Readings were repeated in each position later in the set of measurements as was the usual procedure, but in addition the measurements half-way across the floor and 0,15 m above the floor were repeated approximately every fourth measurement to ensure that there was no general change in the air temperature during the measurements.

The results in Table VII show that, even though the air had passed over 62 m of predominately dry floor, there were differences in air temperature between different points in the cross-section that were greater than could be attributed to experimental error. For example, the rise in dry-bulb temperature with height half-way across the floor on 31/7/75 was 0,4 °C; the dry-bulb temperatures on 7/8/75 covered a range of 0,6 °C. The differences in wet-bulb temperatures were smaller.

Portion B was 14,4 m from A in the direction of airflow. The first 8,1 m from A to B was similar to the drive upstream from A already described. Then the floor began to dip down and become progressively damper, until, by 9,9 m from A, the floor on the side containing the gutter was covered with water for the 0,8 m from the wall to the rail-

TABLE VII

MEASUREMENTS AT A IN THE THIRD SERIES — REYNOLDS NUMBER WAS $2,7 \times 10^5$

Date, barometric pressure, and air velocity	Height* above floor m	Temp., °C, and specific humidity (r), g/kg								
		Above the drain			Half-way across the floor			Above the dusty section		
		Wet	Dry	r	Wet	Dry	r	Wet	Dry	r
31/7/75	1,7	†			17,1	24,1	8,6	17,2	24,1	8,7
107,4 kPa	1,2	17,1	23,9	8,7	17,1	23,9	8,7	17,2	23,9	8,8
1,50 m/s	0,15	17,3	23,7	9,0	17,3	23,7	9,0	17,2	23,8	8,8
7/8/75	1,7	†			16,3	24,1	7,6	16,3	24,3	7,5
108,4 kPa	1,2	16,3	24,0	7,6	16,3	23,9	7,7	16,3	24,1	7,6
1,51 m/s	0,15	16,4	23,7	7,9	16,4	23,8	7,8	16,4	24,0	7,7

* The heights above the floor were measured from the floor adjacent to the gutter.
† Readings could not be obtained owing to the presence of pipes. (The pipes were not currently in use for the transportation of fluids.)

TABLE VIII

MEASUREMENTS AT B IN THE THIRD SERIES

Date, barometric pressure, and air velocity	Height above floor m	Temp., °C, and specific humidity (r), g/kg								
		Above the section covered with water			Half-way across the floor			Above the dry section		
		Wet	Dry	r	Wet	Dry	r	Wet	Dry	r
26/6/75	1,7	*			15,6	23,1	7,3			
107,3 kPa	1,2	15,5	23,0	7,3	15,6	23,0	7,4			
1,51 m/s	0,15	15,8	22,7	7,7	15,7	22,8	7,6			
21/8/75	1,7	*			16,1	24,0	7,5	16,1	24,1	7,5
107,4 kPa	1,2	16,1	23,9	7,5	16,1	23,9	7,5	16,1	23,9	7,5
1,42 m/s	0,5	16,2	23,7	7,7	16,2	23,6	7,8	16,1	23,7	7,6
	0,15	16,4	23,3	8,1	16,4	23,5	8,0	16,2	23,7	7,7

*Readings could not be obtained owing to the presence of pipes. (The pipes were not currently in use for the transportation of fluids.)

way line. The floor between the lines was wet, but the other side of the drive, which was slightly higher, was dry. The floor in the remaining 4,5 m to B was similar.

Temperatures were measured at B on two days at various heights above three points. One point was half-way across the floor, the second was in the section covered with water 0,35 m from the wall, and the third on the dry section 0,5 m from the wall (the floor was 2,4 m wide). The results are shown in Table VIII. As at A, readings were repeated half-way across the floor at 0,15 m above the floor approximately every fourth measurement to ensure that there was no general change in the temperature of the air during the measurements. The temperatures above the dry section on 26/6/75 are not shown, since the opening of ventilation doors upstream towards the end of the survey caused a change in the air temperatures.

The wet-bulb temperatures on 21/8/75 (Table VIII) had a range of 0,3 °C, and the dry-bulb temperatures a range of 0,8 °C. Even if an averaging process were applied, the average temperature would be subject to experimental error greater than the error in the readings at each point. If temperatures were measured only at one point in the cross-section, a systematic error could be introduced in addition to the error in the average temperature.

The measurements on 26/6/75 in Table VIII showed a similar pattern of change in temperature in the cross-section as on 21/8/75.

The measurements at A and B showed that, even when air had passed over a predominantly dry floor with air velocities of approximately 1,5 m/s, the variation in air temperature in the cross-section was sufficient to cause experimental errors in the average air temperatures in the cross-section that were appreciably greater than instrumental errors.

IMPLICATIONS OF THE EXPERIMENTAL RESULTS

If there are differences greater than experimental error in the air temperatures at different points in a cross-section at a given time, then even if temperatures are measured at several points in the cross-section and an averaging process applied, the result will have an experimental error greater than the error in the temperatures at each point. If measurements are made only at one point in the cross-section, these measurements will usually differ from the average temperatures for the cross-section, thereby introducing a systematic error in addition to the error in the average temperatures.

It is essential not to overlook the possibility of such errors when attempting to validate the various theoretical and empirical methods of predicting the rise in temperature of ventilating air as it passes through horizontal airways. The measured rises in temperature that have been compared with predicted values have often been fairly small, which can make the effect of any errors in air temperature large.

Dickson and Starfield[4], for example, compared the increases in wet-bulb temperature predicted by

Starfield's theoretical method[5] with the increases measured in 80 airways. About 90 per cent of the airways had measured wet-bulb increases of less than 1,1 °C (2,0 °F). Even if the error in the temperature at each end of the airway was only ± 0,2 °C, then the error in the increase in temperature would be ± 0,4 °C, which gives an error of 36 per cent in a 1,1 °C rise. If the error in the temperature at each end was ± 0,3 °C, an error of 55 per cent would be produced in a 1,1 °C rise. Larger errors, of course, would be produced in smaller rises. No information was given on the instruments used for the measurements or on the wetness or air velocities in the drives. The temperatures appear to have been measured at only one point in each cross-section.

Wiles and Quilliam[6] gave measurements in 91 airways that were compared by Wiles[7] with increases in wet-bulb temperature predicted according to his theoretical method. Only about 20 per cent of the airways had rises in wet-bulb temperature greater than 1,5 °C. Errors in the temperature at each end of the airway of ± 0,2 °C and ± 0,3 °C respectively would give errors of 27 per cent and 40 per cent in a 1,5 °C rise. No information was given on the instruments used for the measurements, but the wetness of the drives and the air velocities were given. The temperatures appear to have been measured at only one point in each cross-section.

Thus, in the airways discussed in the previous paragraphs, experimental errors of ± 0,2 °C and ± 0,3 °C in air temperatures in the measuring cross-sections could produce errors in the rises in temperature along the airways that would make meaningful comparison with the theoretical values difficult. The temperatures appear to have been measured[4, 6] at only one point in each cross-section and, if differences in temperature at different points in the measuring cross-section actually occurred, then experimental errors of ± 0,2 °C and ± 0,3 °C would be quite feasible. It is not, of course, possible to tell whether such differences in temperature would have occurred in these airways. It is possible only to say that the results obtained by the author suggest that errors of ± 0,2 °C and ± 0,3 °C would occur if wet-bulb temperatures were measured only at one point in the cross-section in airways whose air velocities and wetness of floor are fairly common in mines (and that much larger errors could occur in airways whose wetness of floor would be less common). For example, in B in the second series, which was preceded by 84 m of drive that was mainly dry apart from the gutter and 25 m of the floor between the railway lines, the wet-bulb temperatures at the two heights differed by up to 0,8 °C. Even if measurements had been taken at a number of points in the cross-section and an average temperature found, the error would have been likely to exceed ± 0,3 °C. If the temperatures were measured at one point only, a larger error than this could result.

Thus, it is essential to measure air temperatures at several points in each cross-section and to take the experimental error in the average temperature into account when attempting to validate methods of predicting rises in air temperature along airways.

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AIME Fall meeting

'World Mining and Metals Technology' will be the focus of the 1976 Society of Mining Engineers of AIME Fall meeting and Exhibit, Sept. 1-3, 1976, at Currigan Hall, Denver, Colo. Leading mining and minerals engineers will be discussing the position of the mining industry in the world and relating recent technical advances. Adding further international tones to the meeting will be the Third Mining and Metallurgical Institute of Japan (MMIJ) and American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) Joint Meeting. General chairman of the meeting is P. A. Meyer, manager of mineral commodity evaluation for the Rocky Mountain Energy Co., Denver, Colo.

Nineteen sessions will be presented by SME-AIME, with another 16 scheduled jointly between SME-AIME, TMS-AIME, and the Japanese. SME-AIME sessions include Coal Preparation, Coal Utilization, Underground Mining (M&E), Underground Mining (Coal), Potash, Surface Mining, Ceramics and Refractories, Rock Mechanics/Geological Engineering, Materials Handling, Open Pit Mining, and Compensation in Mineral Industries at Home and Abroad. Joint sessions will be Waste Treatment, Geology, Nickel-Copper-Precious Metallurgy I, Nonferrous Metallurgy, Lead-Zinc Metallurgy, Mineral Economics, Ocean Exploration, Smelter Environmental Controls, Solution Mining, Limestone, Nickel-Copper-Precious Metallurgy II, Computers & Operation Research, Coal Mining, Mineral Processing, and Environmental Control.

For further information and registration forms contact Ruth M. Orologio, SME Meetings Manager, P.O. Box 8800, Salt Lake City, Utah 84108, U.S.A.