# A REPORT ON METEOROLOGICAL CONDITIONS IN WYANBENE CAVE NEW SOUTH WALES

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This paper was first considered when lodging my application to attend this Conference. At that time I felt that I might be in a position to present a short paper should the Conference organisers need papers or require a "fill-in" in their programme. I was somewhat dismayed to find myself allocated a definite time slot in the programme, as I did not find time to fully analyse the material in the intervening period. So rather than present a full scale paper on the Meteorological conditions which prevail in the Wyanbene Cave, I am merely going to report on the work which has been carried out so far, present the results, point out some of the more obvious features and make one or two postulates.

The study of meteorological conditions in Wyanbene Cave is a project of the members of the Metropolitan Speleological Society. I am collating and analysing the results for them. There have been two meteorological studies carried out so far, one in May 1967 and the other in February, 1968. Both were taken over 30 hour periods. The graphical results are depicted at the end of this paper. Information collected regarding moisture content in the cave atmosphere has not been included due to lack of space. Wet bulb temperature readings were taken during both studies however.

The surface stations consisted of automatic recording Thermographs, Hydrographs and Barographs, standardised at the beginning and end of each study with the instruments used in the cave stations.

The cave stations have been manually operated over the full 30 hour period, the reason for selecting such a period being to observe the Diurnal and Semi-diurnal atmospheric cycles, should they reflect their presence in the air movement inside the cave. The equipment used in the cave station has been of necessity more sensitive and accurate than the surface station due to the fact that variations in meteorological conditions are much smaller in magnitude within the cave than their surface counterparts. In these studies, the instruments used were: a 10" dia. Aneroid Barometer reading in inches of mercury to three decimal places; a mercury in glass Fahrenheit thermometer reading to 2/10 of a degree and estimatable to 1/10th;

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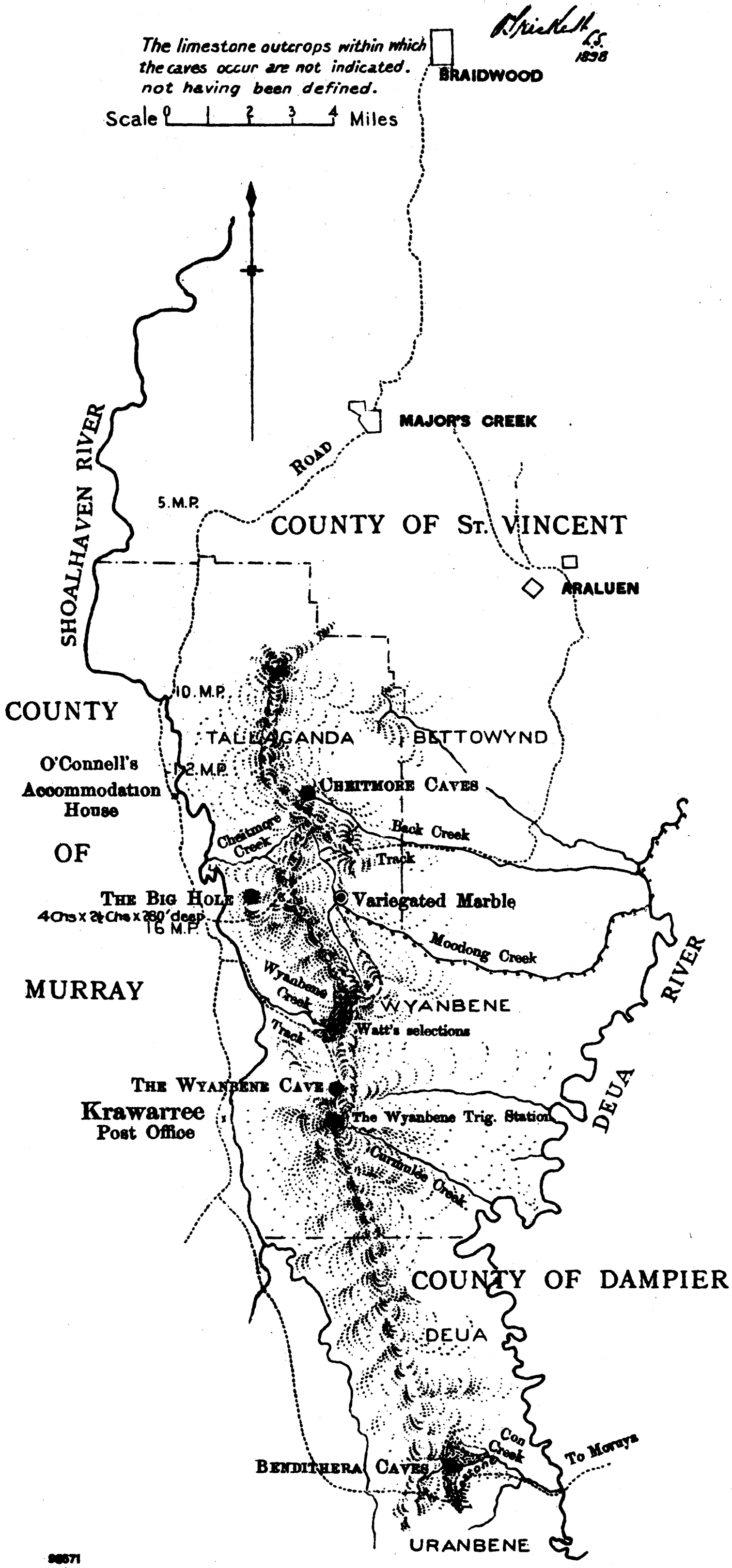
**Sketch shewing the position of the**

# Caves south of Braidwood

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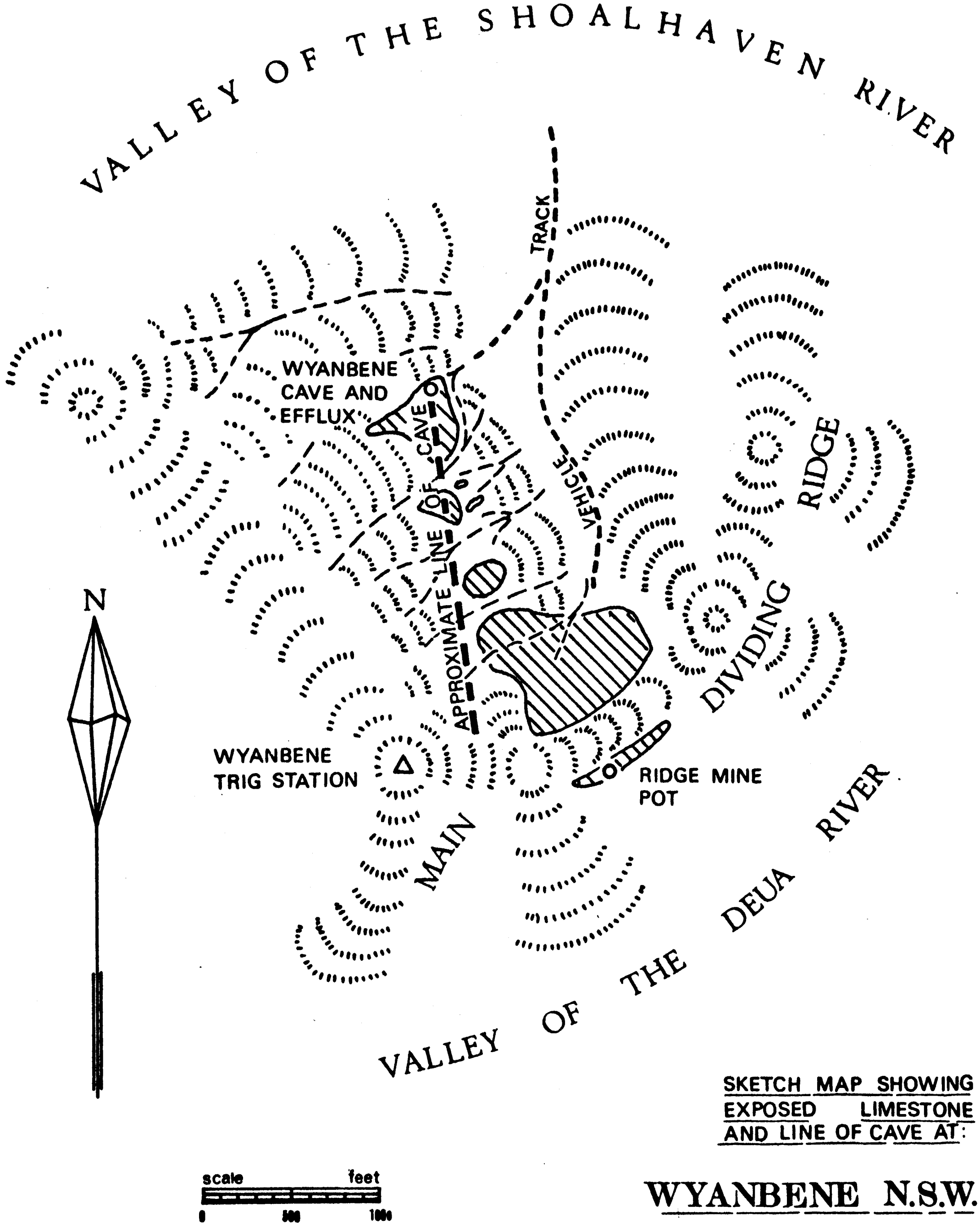


SKETCH MAP SHOWING
EXPOSED LIMESTONE
AND LINE OF CAVE AT:

**WYANBENE N.S.W.**

and a Sling Psychrometer. The 10" Aneroid was standardised against a Fortin Mercury Barometer before and after each study. The mercury in glass had been standardised against an Australian Standards Laboratory thermometer.

There are severe limitations in the instruments used and the methods of recording. The automatic recording instruments are very insensitive and produce results which are often difficult to interpret. They really only indicate trends occurring in surface conditions.

The major limitations underground are derived mainly from the recording and not the instruments. The fact that observers spend some time in close proximity to the instruments brings about undesirable effects. Body heat is transmitted to the instruments via fingers and breath whilst recording and can alter values in excess of the variations occurring naturally. Consequently, whilst care is taken not to handle instruments, to make observations rapidly, and to place observers sufficient distance away from the instruments, the limitations to the results remains a continuing unpredictable hazard. To obtain more consistent results would require equipment far more sophisticated than that being used at present. Apart from the difficulty in obtaining such equipment, the finance required would probably preclude any moves in this direction.

The Wyanbene Cave consists essentially of a single river passage punctuated with a series of chambers along its length. There is only one known entrance, that being situated above the Efflux. The limestone is of Silurian origin overlain with conglomerates and shales and forms part of a series of limestone deposits trending approximately North-South, 25 miles south of Braidwood in the Southern Highlands district of New South Wales.

The ridge containing these limestone deposits forms the divide between the watersheds of the Shoalhaven and Deua Rivers and rises to a height of 3600 feet above sea level. The Shoalhaven Valley to the west falls gradually to 2400 feet and the Deua Valley falls sharply eastward to a height of 800 feet above sea level. The entrance to the cave occurs where the limestone exposes itself in a ridge running north-west into the Shoalhaven Valley. Southward the limestone again is exposed in the main ridge facing the Shoalhaven and contains Bushrangers Cave and other small caves. Evidence of limestone on the Deua side of the divide is indicated by a series of dolines and limestone cliffs high on the ridge. The only other major cave apart from the Wyanbene Cave - the Ridge Mine Pot - occurs at the base of these cliffs, close to the Wyanbene trig station (see map). This is a vertical pothole having a maximum depth of 112 feet. Other dolines and minor depressions occur along the main line of the cave.

Meteorological observations were taken at the "Keyhole", a constricted area of approximately 12 square feet some 200 feet into the cave. Air velocities were taken in the Keyhole using two anemometers, one having a range 10-500 f.p.m. and the other 100-2000 f.p.m. Air flows below 10 f.p.m. were recorded as "low". Dry and wet bulb temperatures and atmospheric pressure were determined some 20 feet away in open cavern space so that air movements would not affect readings.

The maximum velocity of air recorded on both occasions was approximately 1250 f.p.m. although the directions of movement were opposite; in May 1967 the direction being inwards, and in February 1968 being outwards. The two graphs exhibit similar trends of fluctuating velocity in that they have periods of approximately 24 hours.

Cave dry bulb temperatures show a similar periodic trend, although not so apparent due to the smaller variations in readings. The maximum and minimum temperatures recorded in the first study were 56.5°F. and 53.5°F. respectively, a variation of 3°F. The maximum and minimum temperatures recorded in the second study were 61°F. and 57°F. respectively, a variation of 4°F. Ambient maximum and minimum temperatures observed in the first and second studies were 62°F. and 28°F., and 98°F. and 58°F. respectively. The first study was therefore taken under quite cold conditions and the second under hot conditions.

Plots of the variations in cave pressure are shown. In study one, the maximum pressure reached was 30.12"Hg and the minimum 29.96"Hg, with nodes at approximately 6 hour intervals. A general fall in pressure is indicated. In Study 2, similar pressures are observed, the maximum being 30.05"Hg and the minimum 29.90" Hg. Nodes again appear at nominal 6 hour intervals, however they are not so evident. A rapidly falling pressure gradient is quite evident.

Surface pressures in both studies show similar trends and values to those observed in the cave.

Normal diurnal and semi-diurnal cycles are evident in both sets of readings.

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As stated above, both surface and cave pressure recordings exhibit semi-diurnal and diurnal cycles (with periods slightly less than 24 hours). It is evident that the trace of pressure within the cave exhibits a phase shift of some 1½ hours, i.e. the nodes of maximum and minimum pressure occur up to 1½ hours later in the cave than they do on the surface. This phenomenon was observed in the caves of the Nullarbor Plain where a phase shift of $\frac{T}{8}$ or $1\frac{1}{2}$ hours also exists. It is interesting to note that the same phase shift can be observed under widely different cave conditions; the river passage of moderate dimensions at Wyanbene and the enormous caverns of the Nullarbor. Investigations into such parameters as ratio of cross-sectional area at observation point to average cross-section or to distance from entrance to point of measurement could prove interesting.

Dry bulb temperatures on the surface and in the cave show a one to one correspondence in both sets of observations in that variations in surface temperatures are reflected in the recordings of cave temperature. It is of interest to note the 4°F variation and lack of time lag in the second study. Here the direction of air flow was outward. Air moving through the cave has presumably passed along at least 2800 feet of passage sometimes in low, wet crawlways and other times at very low velocities across large chambers. It would be reasonable to expect virtually no variation in cave temperature and considerable time lag if air drawn from the surface enters at the far end of the cave. It is possible, of course, that air bleeds into the cave at several points along its length, probably in the high avens. It should be pointed out though, that the trend in the plot of cave dry bulb during outflow is less obvious than during inflow and is undoubtedly due to the fact that air entering the cave from the efflux entrance has had less time to be affected by frictional contact with walls and water surfaces.

A relationship appears to exist between atmospheric pressure and cave air velocity in the May, 1967 studies, where a coincidence of nodes of minimum pressure is reflected in the velocity graph. The relationship is not apparent in the February study. Further investigations would be required to establish if any relationship exists between these two conditions.

Movements of air into and out of the cave are quite extensive. Calculations based on the velocities recorded and the cross-sectional area of the test point yielded volumes of air passing the test point in any 24 hour period to be 18,000,000 cubic feet and 16,200,000 cubic feet in Studies 1 and 2 respectively.

As this cave resembles in many ways the long, narrow slot model of single entrance similar to the Nullarbor Plains deep caves, application of Wigley's theory to the results, allowing 10% porosity for the Silurian limestone (arbitrary figure) and allowing an average cross-sectional area of 500 square feet, yielded a cave length of approximately 9 miles. As the known length is in the order of 3000 feet with a maximum of possibly 4000 feet, then this result becomes obviously impossible. Alternatively, using the known length of 3000 feet, calculation yields an average cross-section of 6000 sq. ft. It appears then that this theory of cave breathing can be discounted.

Consideration can be given to the relationship between movements of air in the cave and surface temperatures. In the May 1967 study, rises in outside temperature produced a negative inflow of air into the cave until at maximum surface temperature, airflow into the cave had stopped and a slight reversal of direction had occurred. Similarly in the second study, increases in surface air temperature induced increased outflow of air from the cave. Falls in surface temperatures increased inflows and decreased outflows. Further, in considering the relationship between the relative temperature differences between surface and cave conditions, we find that in the second study the surface temperature is always in excess of cave temperature and the flow is outwards, indicating that the cooler, denser cave air is moving towards the lower entrance. In the first study, the situation is more complicated. The surface temperature in this case both rises and falls above and below the cave dry bulb temperature. For most of the study it is in fact equal to or below cave temperature. During this period flow is inwards. For the short period where surface temperature exceeds cave temperature by a few degrees, airflow was weakly outwards. Again this inflow can be attributed to warmer, less dense air rising upwards in the cave, drawing air into the cave.

At this stage it appears that the most obvious relationship explaining the movements of air in Wyanbene Cave is that of convection. However, this presents difficulties in that only two entrances are known, both located at the efflux. Recent discoveries in the cave have located large, high chambers. One in particular, known as the Gun Barrel, is a cylindrical vertical tube of unknown height, the floor of which consists mainly of shales indicating that the overlying shales have been reached by upward mining of the limestone. On the surface, several shallow dolines lie along the direction of the cave, however their exact location with relation to the cave remains to be determined. The Ridge Mine Pot and its associated dolines is also within contactable distance of the furthest points of the cave. This cave, essentially a high aven, has two side passages. One trends north, directly towards the Wyanbene Cave, the other west. Again the exact location of the cave is yet to be determined, however, it would be reasonable to postulate that surface drainage collected in the vicinity of Ridge Mine Pot feeds the Wyanbene System, and that air enters the main Wyanbene Cave through as yet unknown or impenetrable entrances in the Ridge Mine Pot, associated dolines and other dolines along its strike, producing a system of airflow in the Wyanbene Cave based on the convection of air. This may be modified in part by the fact that the cave conforms in some respects to the Long Slit Model giving rise to the significant lags in observed cave pressures.

ACKNOWLEDGEMENTS

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## DISCUSSION

Mike Webb: You mentioned the possibility of further entrances up the hill; this can possibly be substantiated because there's a rockfall chamber which runs back, about 1400 or 1500 feet into the cave, where we found a rather battered collection of bones, probably a fox, and there appears to be no way a fox could have got that far from the known entrance.

John Dunkley, S.U.S.S.: From your map do I take it that Ridge Mine Pot is on a different watershed from Wyanbene?

Ian Wood: Yes, there are a series of pots on the Deua River but the only one which has broken through to the surface is the Pot itself.

Glenn Hunt: That valley which runs north and south, it hasn't got an active stream in it has it?

Ian Wood: No, with the Wyanbene Cave the water runs right out to the entrance then disappears into a rock-pile and doesn't run out the actual efflux itself, except in very wet weather. The area outside is swamp for a few miles and a stream does rise about a mile away, but I don't think it has been proved that this is the rising of the Wyanbene Cave.

Glenn Hunt: In connection with Wigley's paper, he used this time lag between the outside air pressure and the air movement to support his theory that a large volume of the air rushing in and out of the cave is from the bulk of the rock itself, that is from the pore spaces within the rock, and yet here you've got the same, well a similar time lag and yet in very compact limestone. How would you interpret this apparent contradiction?

Ian Wood: I haven't determined exactly what the time lag is and will have to analyse the results more fully. But there must be porosity in the rock, and the walls of the cave must have friction, and the flow in the cave is very turbulent due to the very rough nature of the cave, so I think we could expect a time lag due to many factors. In this case though, the porosity of the rock would probably be fairly neglible.

Ted Anderson: It seems clear that you ought to be able to fit Tom Wigley's theory to this if you recall that he correlates rate of change of external pressure with the velocity of air flow in or out of the cave. Looking at your graphs, I can't see any correlation between the air movement and the rate of change of pressure. As you pointed out there is a much more obvious correlation between air movement and temperature which is quite significant, but I think it's rate of change of temperature which is more important, and I wonder whether you have plotted this out?

Ian Wood: I did do this on the first set of results just after I took them. There is one point I should mention here by the way, and that is that this is a project

Ian Wood cont: which is for the Metropolitan Speleological Society, and most of their club members have done a lot of the observational work, in fact all the first set; I was present during the second set but it is really the members of M.S.S. who are carrying out the project.

Ted Anderson: I could also add perhaps that I know how much effort is involved in getting sufficient data for just that small blackboard. It also seems clear that not too much will come out of this without more data. The present data, is over quite reasonable periods relative to what we have done on the Nullarbor, but the conditions at the time were too stable over that period to give any indication of what the variations over that period might be; the movement is in for the whole of one period and out for the whole of the other.

Ian Wood: No, I don't think so; we're interested in actual variations; the fact that it never goes into the "out" phase doesn't matter. You have the peaks and valleys irrespective of where the base-line is. On several occasions on the Nullarbor we didn't get any change from outwards to inwards flow and this had very little bearing on the calculations. Actually the relationship of these nodes with other factors - nodes in the other observations is what matters. It's purely relative.

Ted Anderson: I think the important thing is that you have complete reversals in the rate of change of pressure and these, if I remember Tom's paper correctly, fit in quite well with the reversals in velocity.

Glenn Hunt: I think another factor which we have got here, is the effect of temperature, which is an overriding effect, and superimposed on this we've got the effect of pressure. Although Tom's model doesn't quite fit this, as temperature is the overriding influence, the graphs show that external air pressure does have some effect on air movement and the fact is that these delays or lags which were registered in Mullamullang are also picked up here. You have got some correspondence between the situation at Mullamullang and the situation at Wyanbene, although the importance of the two factors has been reversed; in Mullamullang external air pressure is the most important, and here, temperature.

Ian Wood: If we go a little bit further and look at the plot of actual air movement, and these are very much stylised as the points are scattered over a wide area, there do appear to be minor peaks which also occurred in the Mullamullang observations. We did think at the time that

Ian Wood cont: some of these minor fluctuations and sudden reversals could be due to the Helmholz pulse influence as well, but there wa n't enough information there to confirm this. The same minor reversals have occurred in this set of readings also.

Glenn Hunt: I presume that no simultaneous observations have been made at the entrance of Wyanbene Cave and at Ridge Mine Pot to see whether you get this flow-in at Ridge Mine Pot and flow-out at Wyanbene Cave?

Ian Wood: We would like to do this but unfortunately we don't have the capacity, we just don't have enough equipment to do it. It would require three complete sets of instruments which are difficult enough to get now, unless somebody is kind enough to donate some.

Yes I think this would be a worthwhile venture to undertake. One of the major problems in doing this sort of work is that you have to take the readings over about a thirty hour cycle to get all the possible variations, and to get people to sit in caves for 3 or 4 hours in a drafty, narrow passage when the temperature is about 55°F. and the velocity 20 miles an hour is getting extremely difficult and the number of starters is getting less and less. I can assure you that you get extremely cold.

Question: Has any work been done at the junction between the two caverns?

Ian Wood: No, I think this is nearly impossible. Although I've not been past the point where we took the observations I know there are large chambers with vast amounts of mud and one section is a water-crawl where you are well and truly in the water and getting the instruments through these places would be just about impossible.

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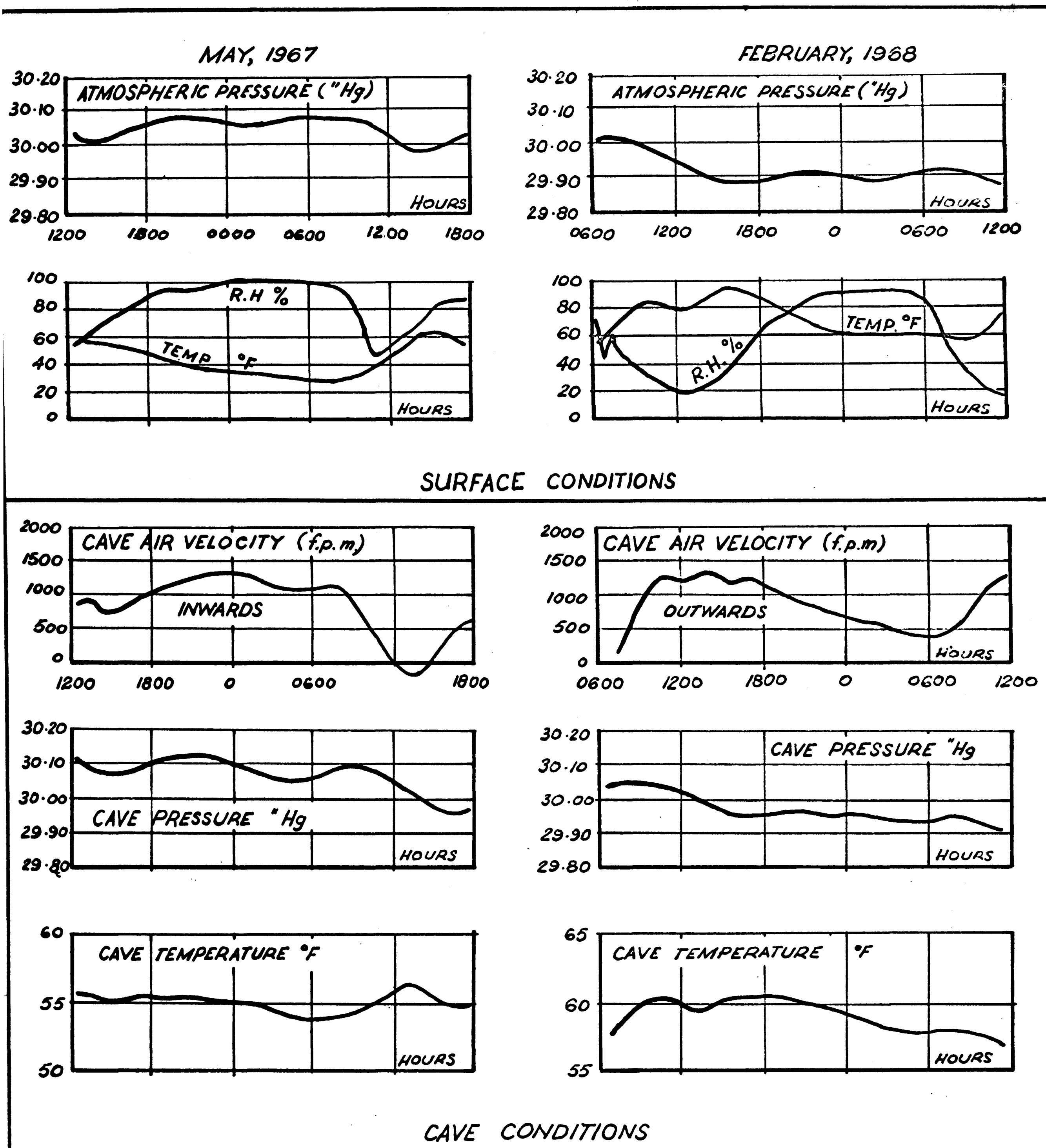


<u>GRAPHS</u>: Showing surface and cave Meteorological Conditions on two occasions in Wyanbene Cave, N.S.W. Viz: 17-19th. May, 1967 (Winter) & 16-17th. February, 1968 (Summer)

<u>OBSERVATIONS</u> recorded by members of the Metropolitan Speleological Society.



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