COMMONWEALTH OF KENTUCKY

State Department of Mines and Minerals

GEOLOGICAL DIVISION

SERIES VIII, BULLETIN 1

MOUNTAIN BUMPS IN THE COAL FIELDS OF HARLAN COUNTY, KENTUCKY

BY

D. J. JONES, GEOLOGIST
N. M. WILDER, ASSISTANT GEOLOGIST
JOHN F. MAURICE, MINING ENGINEER

MINING ENGINEERING BUILDING
UNIVERSITY OF KENTUCKY
LEXINGTON

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JOHN F. DANIEL, CHIEF

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DECEMBER 1, 1934

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FOREWORD

FOR THE PAST SEVERAL YEARS COAL OUTBURSTS, COMMONLY KNOWN AS "MOUNTAIN BUMPS", HAVE OCCURRED IN SOME OF THE MINES LOCATED IN HARLAN COUNTY, AND AS PRACTICALLY ALL OF THESE OUTBURSTS HAVE CAUSED THE DEATH OF ONE OR MORE WORKMEN, THE REASON FOR THESE BUMPS AND THEIR PREVENTION HAS BEEN WIDELY DISCUSSED.

THIS DISCUSSION HAS BEEN ENTERED INTO NOT ONLY BY LOCAL MINE OFFICIALS AND WORKMEN, BUT ALSO, BY MINING ENGINEERS AND MINE OFFICIALS OF CONSIDERABLE REPUTE FROM WITHOUT THE STATE, AS WELL AS IN FOREIGN COUNTRIES. THE VARIOUS OPINIONS DISAGREED TO SUCH AN EXTENT, THAT IT WAS DEEMED ADVISABLE BY THE DEPARTMENT OF MINES AND MINERALS TO MAKE A THOROUGH STUDY OF THE SITUATION, SO AS TO FULLY ESTABLISH THE CAUSE OF BUMPS AND WHAT COULD BE DONE TO PREVENT THEM FROM OCCURRING AND ELIMINATE THE LOSS OF LIFE CAUSED THEREBY.

DUE TO THE ABOVE, PERSONS FULLY COMPETENT WERE SELECTED TO CONDUCT THIS INVESTIGATION, AND THEIR FINDINGS WHICH HAVE BEEN ARRIVED AT AFTER CONSIDERABLE STUDY AND COST ARE, WE FEEL, VERY LOGICAL AND CONCLUSIVE.

John F. Daniel

JOHN F. DANIEL, CHIEF
DEPARTMENT OF MINES AND MINERALS

INTRODUCTION

An investigation of the causes and suggestions for the prevention of "Bumps" in the coal fields of Harlan County, Kentucky has been made at the request of Mr. John F. Daniel, Chief of the Department of Mines and Minerals.

The field party was composed of Daniel J. Jones, Geologist, Newell M. Wilder, Assistant Geologist and John F. Maurice, Mining Engineer.

The problem has been discussed from the point of view of the local and regional geological aspects as fundamental contributing factors. Mining methods are discussed in relation to both geologic conditions and what we regard as sound mining principles for operating in the Cumberland Overthrust Block. This restricted area, due to horizontal crustal movement and intense compressional forces exerted on the coals, sandstones and shales demands not only the adoption of certain recommended mining methods, but a careful supervision of the minute details of the removal of pillars. The writers fully realize there are many contributing factors to bumps and they are interwoven in such a way as to demand far more attention to the details of mining than is necessary in any of the adjacent areas. Also it is evident that methods of mining that have proven satisfactory in other areas will not apply here for reasons set forth in this report.

The writers wish to acknowledge the enthusiastic support of the various operators and individuals of Harlan County. The following mines were visited and we were either conducted through the mines, provided with maps or given ample time for discussion, whichever was requested: Black Mountain Corporation, Clover Splint Coal Company, Clover Fork Coal Company, Cornett-Lewis Coal Company, Darby Coal Company, King Harlan Coal Company, Mary Helen Coal Corporation, Melcroft Coal Company, Perkins Harlan Coal Company, United States Coal and Coke Company and the Wisconsin Steel Company. Especially, we wish to express appreciation to the United States Coal and Coke Company and the Wisconsin Steel Company. These companies assembled data, placed men at our disposal for several days and enabled us to make a detail study over a large area because of the magnitude of their operations. We also wish to thank the Stonega Coal and Coke Company at Big Stone Gap, Virginia, for courteous reception given us at their mines and offices.

We are also indebted to Mr. Joseph F. Davies, District Engineer of the United States Bureau of Mines at Norton, Virginia, Mr. James F. Bryson, Safety Director of the Harlan County Coal Operators Association and Mr. Roy H. Gonia, Mine Inspector of the Harlan District, and Mr. T. W. English of the Consolidation Coal Company at Jenkins, Kentucky.

IN SECURING DATA FOR THIS REPORT, WE MADE A SPECIAL EFFORT TO GET THE VIEWPOINTS OF EVERYONE CONCERNED. WE DISCUSSED THE PROBLEM WITH VARIOUS OFFICIALS, OPERATORS, ENGINEERS, SUPERINTENDENTS, MINE FOREMEN, ASSISTANT FOREMEN AND ESPECIALLY WITH MINERS WHO HAVE ACTUALLY EXPERIENCED BUMPS. WE HAVE ENDEAVORED IN THIS MANNER TO AVOID BIASED OPINIONS AND THUS ARRIVE AT WHAT WE BELIEVE TO BE SOUND CONCLUSIONS.

WE HAVE TRIED TO BE PRACTICAL IN THE MATTER OF RECOMMENDATIONS FOR CHANGES IN MINING. WHEREVER POSSIBLE, ONLY SLIGHT MODIFICATIONS IN MINING METHODS HAVE BEEN SUGGESTED, ALWAYS KEEPING IN MIND THE ADDED COST RESULTING FROM ANY SUCH SHIFTS. THE RESULTS OF OUR INVESTIGATIONS LEAD US TO BELIEVE THERE IS NOTHING MYSTERIOUS IN THE OCCURRENCE OF BUMPS IN THIS FIELD AND OUR REMEDIES ARE CONFINED TO THE ADVOCATION OF SOUND MINING PRINCIPLES, WHICH IF FOLLOWED, WE BELIEVE WILL LESSEN THE HAZARD OF BUMPS IN THIS PARTICULAR AREA, AND THEREBY ELIMINATE LOSS OF LIVES FROM THAT CAUSE.

HISTORY

PRODUCTION

Coal was first shipped from this field in 1911, when 25,814 tons were produced from three mines. These figures evidently do not include coal from local wagon mines. Production increased steadily until 1929 when 15,050,367 tons of coal were mined in this county. The production graph for the coal mined east of a North and South line through Harlan or in other words coal mined from the "Bump Area" shows the rate of extraction from 1910 to 1933 inclusive. See Plate I. These figures show that approximately 75 percent of the coal mined in Harlan County has been from this area.

Reports of the Department of Mines reveal that preparations were being made for large scale operations in 1910. Three mines started operations and others were ready in 1911. The number of operators increased year by year and production figures showed a steady increase through the year of 1924 when the total production for that year in Harlan County was 9,076,269 tons. It is noticeable that in the year of 1925 there was an increase to 11,766,359 tons, which is an increase of 2,690,090 tons over 1924. Production figures mounted each year until a total of 15,050,367 tons were mined in 1929.

During these five years of feverish industrial activity in the United States, steadily increasing demands were made on the operators to produce more and more coal. These demands naturally put an added burden on the Engineering Department of the various companies. It became impossible to keep up with all the details of mining, especially in the process of pulling pillars. As demands increased stumps and pillars that could not be extracted at a profit were left behind in many instances. Production costs were watched carefully at the main offices of the various companies, and consequently coal was mined wherever extraction could be carried on with the lowest cost and highest tonnage. Thus we see that economic conditions may have played an important role in setting up possible conditions for future bumps. The effects of the above mentioned conditions, which were set up in the early stages of mining are discussed on page 20 , "CAUSES OF BUMPS".

Through the fault of no one from the miner to the company official, apparent at the time, the stage was set for the occurrence of bumps. Economic conditions and no thought on the part of anyone that bumps might appear in this area resulted in no precautionary measures being taken until the damage was done.

BUMPS

The first bump, causing a fatality, of which we have a record occurred in 1923. As pillar work increased in the various mines,

BUMPS HAVE INCREASED IN FREQUENCY AND INTENSITY. DURING THE FIRST TEN MONTHS OF 1934 THERE WERE EIGHT FATALITIES, RESULTING FROM THIS CAUSE, REPORTED FROM FOUR MINES.

REFERENCE TO THE PRODUCTION GRAPH, PLATE I, INDICATES THAT THE RATE OF EXTRACTION HAS A DEFINITE BEARING ON THE FREQUENCY OF BUMP FATALITIES. IT DOES NOT FOLLOW, HOWEVER, THAT THE YEAR OF THE HIGHEST TONNAGE SHOULD NECESSARILY BE THE YEAR OF THE GREATEST NUMBER OF BUMP FATALITIES. CONDITIONS THAT RESULT IN BUMPS MAY BE SET UP IN ONE YEAR AND THE CRITICAL SECTION IN WHICH THE BUMP FINALLY OCCURS MIGHT NOT BE MINED UNTIL A LATER DATE.

BUMPS OF VARYING INTENSITY, SHOOTING FROM A FEW POUNDS TO SEVERAL TONS OF COAL FROM THE RIBS ARE OF FREQUENT OCCURRENCE. THESE OUTBURSTS MAY OR MAY NOT RESULT IN INJURIES OR LOSS OF TIME AND ARE NOT REPORTED.

LOCATION OF THE BUMP AREA

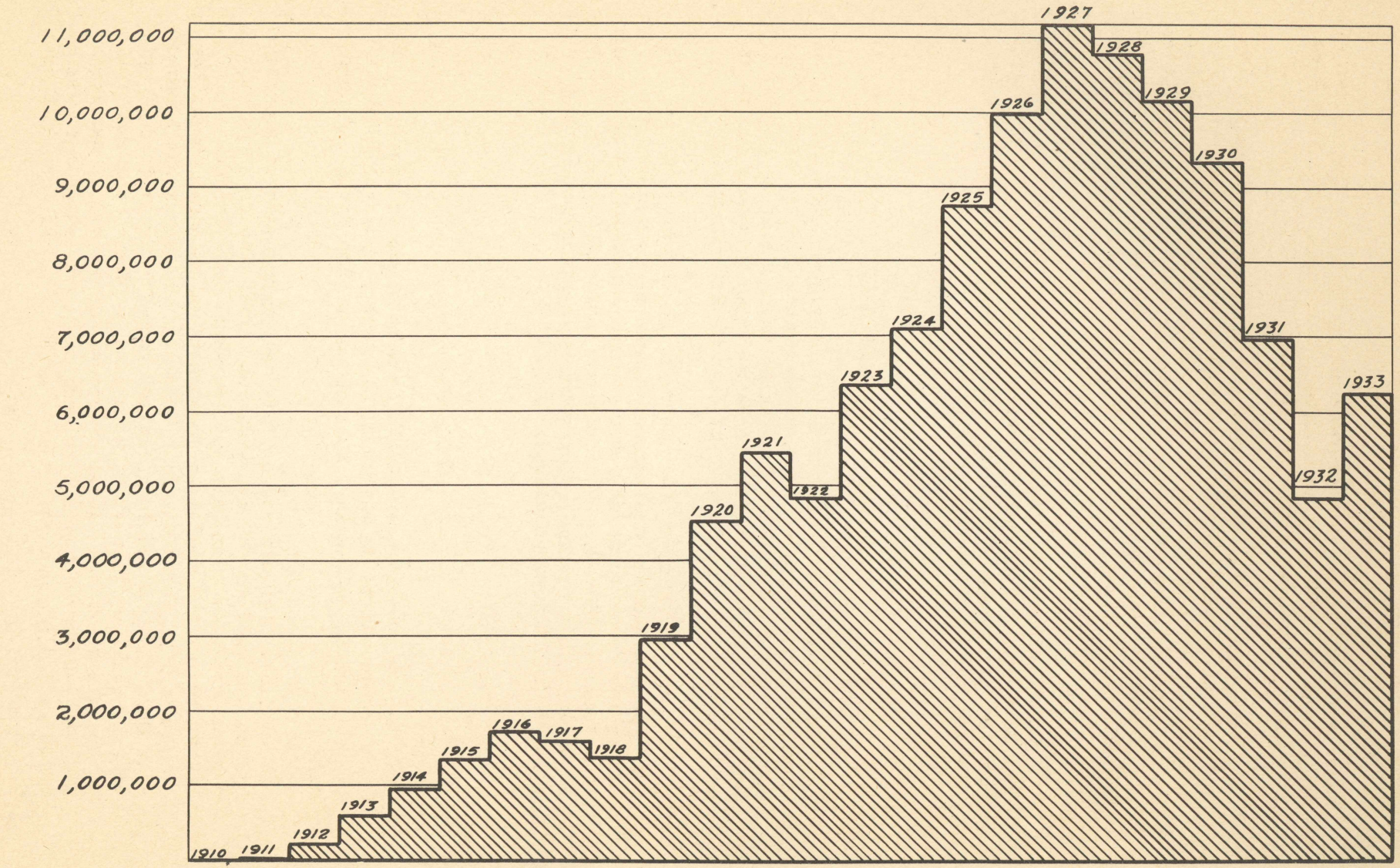
COAL BUMPS HAVE OCCURRED WITH INCREASING FREQUENCY IN THAT PART OF THE MIDDLESBORO SYNCLINE IN HARLAN COUNTY, KENTUCKY, SOUTH OF THE POOR FORK OF CUMBERLAND RIVER, EAST OF A NORTH AND SOUTH LINE THRU HARLAN, NORTH OF STONE MOUNTAIN AND IN THE WESTERN PART OF WISE COUNTY, VIRGINIA. SEE PLATE II.

MINOR INSTANCES OF THE SHOOTING AND CLEAVING OF COAL FROM THE RIBS HAVE OCCURRED OUTSIDE THE AREA DESCRIBED BUT NOT OF SUFFICIENT FORCE TO BE OF DANGER TO THE MINERS OR TO BE CLASSED AS A "MOUNTAIN BUMP". THESE VIOLENT OUTBURSTS THEN, MAY BE SAID TO OCCUR ALMOST WHOLLY IN THE PRONOUNCED STRUCTURAL TROUGH KNOWN AS THE MIDDLESBORO SYNCLINE.

TOPOGRAPHY

THE PHYSIOGRAPHY OF THIS REGION IS SHOWN IN DETAIL BY THE TOPOGRAPHIC SHEETS OF THE U. S. GEOLOGICAL SURVEY. THIS AREA IS INCLUDED IN THE HARLAN, NOLANSBURG AND BIG STONE GAP QUADRANGLES.

RELIEF: THE SURFACE OF THIS REGION CONSISTS OF MOUNTAINS, RIDGES AND VERY NARROW AND STEEP VALLEYS. TWO OF THE MOUNTAIN SYSTEMS STRIKING NORTHEAST AND SOUTHWEST ARE PARALLEL AND FORM THE NORTHWEST AND SOUTHEAST BOUNDARIES OF THE MIDDLESBORO BASIN, SEE PLATE III. THESE ARE PINE MOUNTAIN AND CUMBERLAND MOUNTAIN. PINE MOUNTAIN RANGING IN ELEVATION FROM 2700 FEET TO 3000 FEET IS VERY STRIKING IN THAT IT MAINTAINS A FAIRLY STRAIGHT COURSE AS CONTRASTED TO THE RADIAL STRUCTURE OF THE RIDGES AND MOUNTAINS TO THE SOUTH OF IT. ITS WESTERN SLOPE, WHERE THE PINE MOUNTAIN FAULT COMES UP, IS VERY STEEP, FALLING OVER 2000 FEET



COAL EXTRACTION

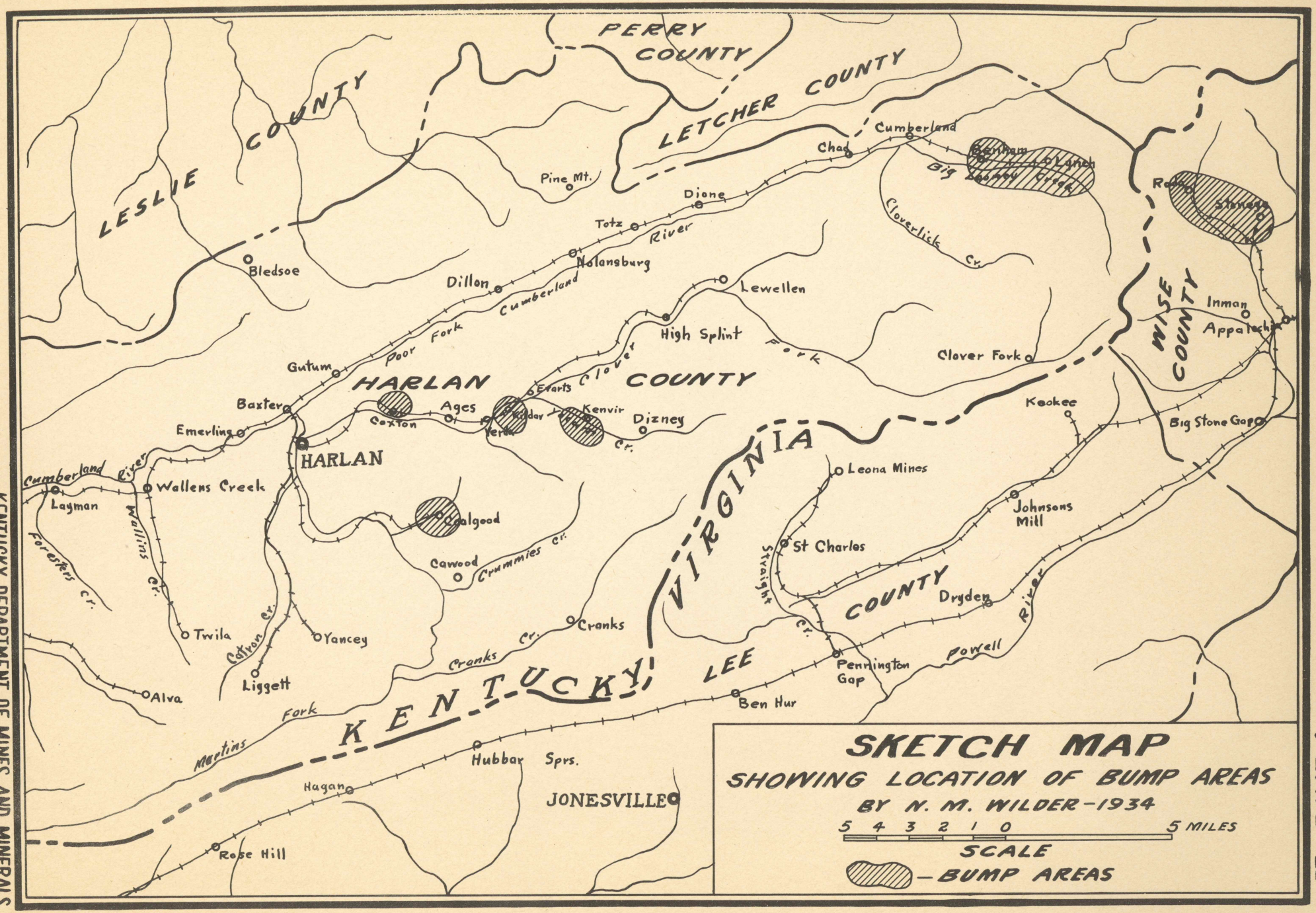
FROM THE BUMP AREA OF HARLAN COUNTY, KENTUCKY

BY D. J. JONES AND N. M. WILDER

1934

KENTUCKY DEPARTMENT OF MINES AND MINERALS
GEOLOGICAL Lexington, Kentucky DIVISION

PLATE I



KENTUCKY DEPARTMENT OF MINES AND MINERALS
GEOLOGICAL Lexington, Kentucky DIVISION

PLATE II

IN LESS THAN A MILE. THE EASTERN FLANK, SLOPING ON THE LEE FORMATION IS MORE GENTLE. SEE PLATE III.

CUMBERLAND MOUNTAIN IS SOMEWHAT SIMILAR TO PINE MOUNTAIN IN THAT ITS COURSE IS MAINTAINED IN A GENERALLY STRAIGHT DIRECTION AND THAT IT ATTAINS ELEVATIONS SIMILAR TO THOSE OF PINE MOUNTAIN. ALTHO ITS FLANKS ARE STEEP, THEY DO NOT DROP SHARPLY AS DO THOSE ON PINE MOUNTAIN.

BLACK MOUNTAIN ENTERING FROM THE NORTHEAST FOLLOWS A RATHER TWISTING COURSE ON THE EAST AND SOUTH OF LYNCH AND BENHAM. SOUTHWEST OF BENHAM IT CUTS BACK NORTH UNTIL IT REACHES POOR FORK OF CUMBERLAND RIVER WHERE IT LEVELS OFF PARALLEL TO PINE MOUNTAIN AND TERMINATES IN THE VICINITY OF HARLAN.

BLACK MOUNTAIN, WITH AN ELEVATION OF 3800 FEET ABOVE SEA LEVEL RISES AT THE DOUBLE TO 4150 FEET, WHICH IS SOME 1300 FEET ABOVE THE HEAD OF LOONEY CREEK. TO THE SOUTHEAST WHERE IT PARALLELS PINE MOUNTAIN IT REACHES NEAR 2000 FEET ABOVE POOR FORK OF CUMBERLAND RIVER. SOUTH OF BENHAM IT HOLDS AN ALTITUDE OF 3900 FEET WHICH IS SOME 1900 FEET ABOVE CLOVER FORK OF CUMBERLAND RIVER TO THE SOUTH. BENHAM SPUR OF BLACK MOUNTAIN WITH A SUMMIT ELEVATION OF 3800 FEET LIES JUST SOUTH OF BENHAM AND TAPERS OFF TO THE JUNCTION OF LOONEY CREEK AND CLOVERLICK CREEK AT CUMBERLAND, KENTUCKY. LOONEY RIDGE WHICH RISES TO THE NORTH OF LYNCH RUNS WEST OFF OF BLACK MOUNTAIN WITH A SUMMIT ELEVATION OF 3500 FEET AND STANDS ABOUT 1800 FEET ABOVE THE LEVEL OF LOONEY CREEK AT LYNCH, KENTUCKY.

LITTLE BLACK MOUNTAIN STARTING ON THE VIRGINIA-KENTUCKY LINE JUST SOUTH OF THE DOUBLE RUNS SOUTHEAST AND FORMS THE STATE BOUNDARY LINE FOR ABOUT 13 MILES. IT RUNS OUT AT THE JUNCTION OF CLOVER FORK AND MARTINS FORK AT HARLAN, KENTUCKY. THE ELEVATION OF LITTLE BLACK MOUNTAIN IS FROM 3300 TO 3750 FEET ABOVE SEA LEVEL AND IS APPROXIMATELY 2000 FEET ABOVE CLOVER FORK AT KILDAV ON THE NORTH AND ABOUT 1750 FEET ABOVE CRUMMIES CREEK TO THE SOUTH.

THE REGION IS DISSECTED BY MANY STREAMS WHICH HAVE FORMED DEEP V-SHAPED VALLEYS WITH VERY LITTLE FLAT LAND. THIS DISSECTION HAS LEFT THE RIDGES WITH VERY NARROW CRESTS AND WITH SLOPES THAT RISE FROM 800 FEET TO OVER 1500 FEET.

DRAINAGE: THE MAIN DRAINAGE SYSTEM FOR ALL THE WATERS OF THIS FIELD IS THE CUMBERLAND RIVER WHICH HEADS WITH POOR FORK NORTHEAST OF CUMBERLAND, KENTUCKY, AND WITH CLOVER FORK WHICH LIES TO THE SOUTH OF BENHAM AND LYNCH, KENTUCKY, AND PARALLELS LITTLE BLACK MOUNTAIN, ON THE KENTUCKY-VIRGINIA STATE LINE. IN THIS FIELD, THE CUMBERLAND RIVER IS RUNNING SOUTHWEST AND PARALLELS PINE MOUNTAIN ON THE SOUTHEAST SIDE. ABOUT 5 MILES SOUTHEAST OF PINEVILLE THE RIVER TURNS SHARPLY TO THE NORTHWEST AND CUTS STRAIGHT ACROSS PINE MOUNTAIN THRU THE PINEVILLE GAP. THIS IS THE ONLY STREAM IN THIS REGION THAT HAS BEEN ABLE TO DIRECT ITS COURSE ACROSS THE PINE MOUNTAIN BARRIER. THE SOUTHEAST FLANK OF PINE MOUNTAIN IS CUT AT INTERVALS OF ABOUT EVERY $\frac{1}{2}$-MILE BY SMALL

STREAMS WHICH DRAIN INTO CUMBERLAND RIVER PROPER AND POOR FORK OF CUMBERLAND RIVER. IN CONTRAST, THE STEEP SLOPE OF THE OPPOSITE SIDE OF THE MOUNTAIN IS UNALTERED BY STREAM DISSECTION FOR A DISTANCE OF OVER 30 MILES.

THE STREAMS DRAINING THE CENTRAL PART OF THE BASIN ARE LOONEY CREEK, WHICH HEADS ON THE WEST FLANK OF BLACK MOUNTAIN AND FLOWS WESTWARD THROUGH A DISTANCE OF SOME 9 MILES TO CUMBERLAND, KENTUCKY WHERE IT ENTERS POOR FORK OF CUMBERLAND RIVER; CLOVERLICK CREEK, ABOUT 3 MILES SOUTH OF LOONEY CREEK, WHICH FLOWS NORTHWEST AND ALSO ENTERS POOR FORK AT CUMBERLAND; AND STILL FARTHER SOUTH THE HEAD WATERS OF CLOVER FORK DRAIN THE AREA AT THE NORTH, OR RATHER THEY DRAIN THE SLOPES ON THE SOUTH OF BLACK MOUNTAIN, WHICH AT THIS LOCALITY HAS TURNED WESTWARD. CLOVER FORK PARALLELS LITTLE BLACK MOUNTAIN AND THE STATE LINE FOR ABOUT 5 MILES AND THEN TURNS NORTHWEST UNTIL IT APPROACHES WITHIN $2\frac{1}{2}$ MILES OF POOR FORK WHERE IT LEVELS OFF AGAIN AND PARALLELS PINE MOUNTAIN TO HARLAN, KENTUCKY WHERE IT TURNS NORTH AND JOINS CUMBERLAND RIVER AT THE POOR FORK JUNCTION.

THE AREA SOUTH OF POOR FORK AND SOUTHEAST OF HARLAN, KENTUCKY IS TAKEN CARE OF BY STREAMS RUNNING SOUTHEAST, NAMELY, CRUMMIES CREEK AND CRANKS CREEK WHICH ARE TRIBUTARIES OF MARTINS FORK. MARTINS FORK DRAINS NORTH AND NORTHWEST AND ENTERS CLOVER FORK AT HARLAN, KENTUCKY. CATRON CREEK, SOUTH OF HARLAN, FLOWS NORTHWARD AND ENTERS MARTINS FORK JUST BELOW HARLAN, KENTUCKY.

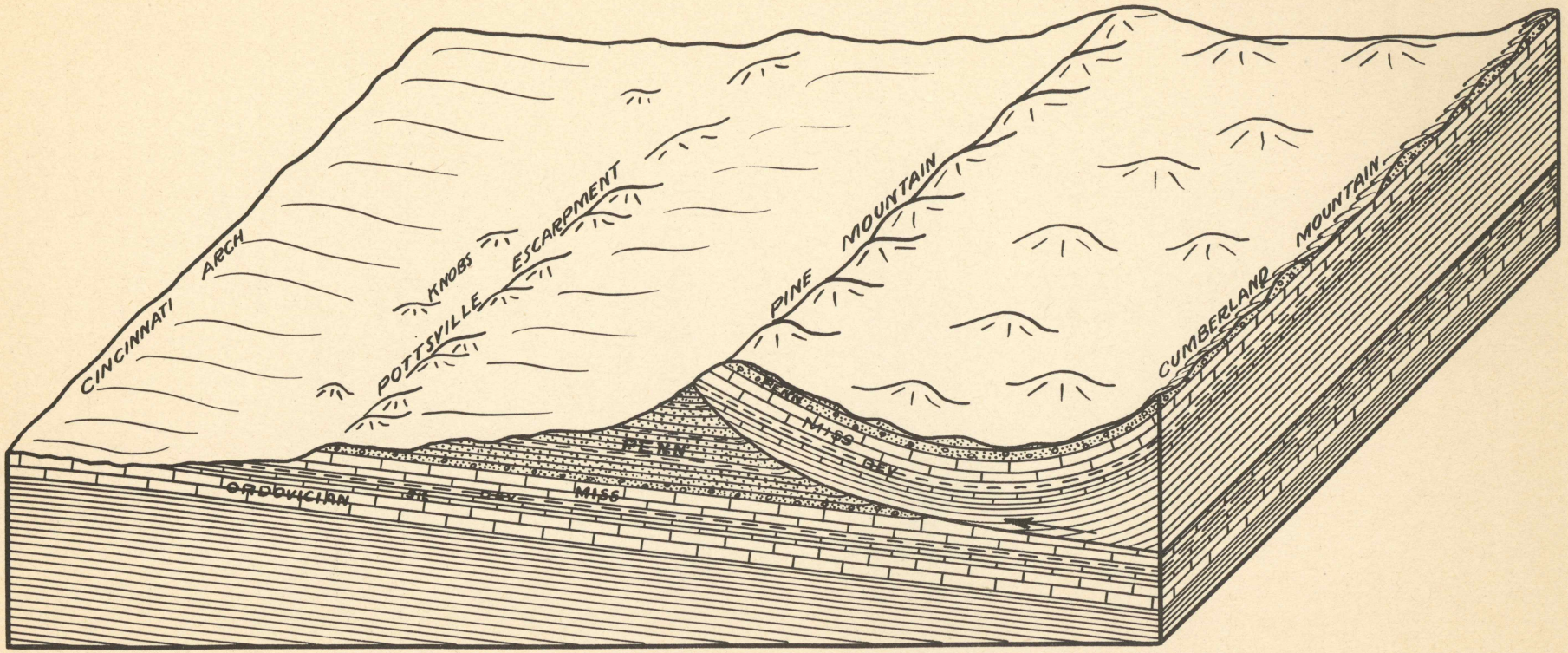
ALL THE ABOVE NAMED STREAMS LIE WITHIN THE "BUMP" AREAS, AND THEIR WATERS FLOW INTO CUMBERLAND RIVER, PROPER, AT A POINT ABOUT $\frac{3}{4}$ OF A MILE NORTH OF HARLAN, KENTUCKY.

GEOLOGIC STRUCTURE

THE TERM "GEOLOGIC STRUCTURE" MEANS THE LAY OF THE ROCKS OR THE MANNER IN WHICH THE STRATA ARE ARRANGED WITH REGARD TO FLATNESS, DIP, FOLDING, BREAKING OR FAULTING, ETC.

FAULTING HERE SHOULD NOT BE CONFUSED WITH THE COAL MINERS DEFINITION OF A FAULT, WHICH USUALLY APPLIES TO A "ROLL" IN THE ROOF OR FLOOR OF A MINE, A SPLIT IN THE COAL SEAM, OR A PARTING OF SHALE OR "RASH" IN THE SEAM. THE TERM "FAULTS" AS USED IN THIS PART OF THE PAPER ARE GEOLOGIC FAULTS. THEY ARE BREAKS IN THE EARTH'S SURFACE, WHICH EXTEND TO GREAT DEPTHS AND ALONG WHICH THE ROCK STRATA ON ONE SIDE OF THE BREAK HAS BEEN PUSHED UP, DOWN OR OVER, SO THAT IT IS NO LONGER CONTINUOUS WITH THE CORRESPONDING STRATA ON THE OTHER SIDE OF THE BREAK.

STRATIFIED ROCK SUCH AS THOSE OF THIS REGION WERE DEPOSITED IN A HORIZONTAL PLANE, OR IN A POSITION APPROACHING A HORIZONTAL PLANE. SINCE THE TIME OF DEPOSITION THE CONTINUITY OF FLATNESS HERE HAS BEEN DISRUPTED DUE TO GREAT DISTURBANCES CAUSED BY COOLING AND CONTRACTION OF THE EARTH. IN THE SHRINKING OR COOL-



BLOCK DIAGRAM

SHOWING THE POSITION OF THE CUMBERLAND OVERTHRUST BLOCK WITH RELATION TO THE UNDERLYING STRATA AND CINCINNATI ARCH

BY N. M. WILDER
1934

KENTUCKY DEPARTMENT OF MINES AND MINERALS
GEOLOGICAL DIVISION
Lexington, Kentucky

PLATE III

ING OF THE EARTH, THE CRUSTAL SURFACE MUST UNDERGO ADJUSTMENTS SO AS TO OCCUPY LESS SPACE, AND SO IT HAS HAPPENED HERE.

TO THE EAST OF THIS REGION, THE DIFFERENT STRATA OF ROCKS WERE WARPED, WRINKLED, FOLDED OVER, AND BROKEN, THUS STACKING UP ON TOP OF EACH OTHER. THESE EXCESSIVE OVERLOADS PILING UP WERE IN TURN A SOURCE OF PRESSURE AND SET UP COMPRESSIONAL STRESSES WHICH WERE TRANSMITTED TO OTHER ROCKS CAUSING FURTHER DEFORMATION, TO ROCKS THAT WERE ONCE IN A FLAT-LYING POSITION OR IN A NEARLY HORIZONTAL PLANE.

THESE HORIZONTAL FORCES COMING FROM A SOUTHEASTERLY DIRECTION CONTINUED TO THE VICINITY OF THE HARLAN COAL FIELD WHERE THE RESULTS OF DEFORMATION CAN BE SEEN IN A GENERAL NORTHEAST-SOUTHWEST DIRECTION FOR A DISTANCE OF 125 MILES. THIS PARTICULAR STRUCTURE IS KNOWN AS THE CUMBERLAND OVERTHRUST BLOCK, SEE PLATE III. THE NAME CUMBERLAND BLOCK WAS FIRST APPLIED BY C. K. WENTWORTH. THE FORCES ACTING IN THIS DIRECTION FOLDED THE ROCKS UNTIL THEY WERE BROKEN AND THEN THE WHOLE MASS WAS PUSHED, INTACT, NORTHWESTWARDLY FOR A DISTANCE OF A FEW MILES. ACCORDING TO BUTTS THE BLOCK SEEMS TO HAVE BEEN PIVOTED OR RETARDED SOMEWHAT ON THE NORTHEAST END, WHICH IS BOUNDED BY THE RUSSELL FORK FAULT. WENTWORTH ESTIMATES THIS END TO HAVE MOVED OVER A HORIZONTAL DISTANCE OF ABOUT 2 MILES. THE SOUTHWEST END WHICH IS BOUNDED BY THE JACKSBORO FAULT IS CALCULATED BY WENTWORTH AS HAVING MOVED OVER A HORIZONTAL DISTANCE OF 10 MILES. THE PRESENT WIDTH OF THE BLOCK IS ABOUT 25 MILES AND IS BOUNDED ON THE NORTHWEST BY THE PINE MOUNTAIN FAULT AND ON THE SOUTHEAST BY THE HUNTER VALLEY FAULT. BUTTS ESTIMATES THAT ORIGINALLY, BEFORE EROSION, THE WIDTH OF THE BLOCK MUST HAVE BEEN 30 MILES, OR 5 MILES WEST OF ITS PRESENT LIMIT.

THE GEOLOGIC STRUCTURE OF THIS AREA IS THAT OF A BROAD FLAT-BOTTOMED TROUGH OR SYNCLINE WITH THE AXIS RUNNING NORTHEAST-SOUTHWEST, AND PARALLEL TO PINE AND CUMBERLAND MOUNTAINS. IT IS ALSO NEARLY PARALLEL TO AND A LITTLE SOUTH OF CUMBERLAND RIVER. IN THE AXIAL CENTER OF THE BASIN THE ROCKS ARE COMPARATIVELY FLAT WITH THE EXCEPTION OF A FEW DIPS OF LOW ANGLE AND LOCAL DISTURBANCES. IN GENERAL THE DIPS THRU HERE DO NOT AVERAGE MORE THAN 100 FEET TO THE MILE. THE BASIN IS DOTTED WITH LOW HILLS AND MOUNTAINS, SOME OF WHICH ATTAIN ELEVATIONS HIGHER THAN THE BRIM OF THE SYNCLINE.

GOING AWAY FROM THE AXIS ON EITHER SIDE, THE ROCKS RISE WITH A GENTLE DIP UNTIL THEY APPROACH THE EDGE OF THE SYNCLINE, WHERE THEY ARE ABRUPTLY TURNED UP INTO THE TWO MOUNTAINS THAT BOUND THE BASIN ON THE NORTHWEST AND THE SOUTHEAST, NAMELY, PINE MOUNTAIN AND CUMBERLAND MOUNTAIN. THE TOPS OF THESE TWO MOUNTAINS WHICH PROBABLY REPRESENT THE OLD SCHOOLEY PENEPLANE LEVEL, HAVE LONG WITHSTOOD EROSION AND ARE HELD UP DUE TO THE FACT THAT HERE THE VERY RESISTANT LEE CONGLOMERATE SANDSTONE OF THE POTTSVILLE FORMATION IS BROUGHT UP TO THE SURFACE. ON STONE AND LITTLE STONE MOUNTAINS THIS CONGLOMERATE DIPS AS MUCH AS 60 TO 90 DEGREES. AN IDEA OF THE ENORMOUS AMOUNT OF BURDEN WHICH HAS BEEN THRUST

OVER AN AVERAGE HORIZONTAL DISTANCE OF 6 MILES CAN BE REALIZED WHEN ONE LOOKS AT THE SECTION OF POTTSVILLE, MISSISSIPPIAN LIMES, AND DEVONIAN SHALES THAT ARE BROUGHT TO THE SURFACE AT THE PINE MOUNTAIN FAULT.

THIS MAJOR OVERTHRUST FAULT ACCOUNTS FOR THE UP-TURNING OF THE STRATA ALONG PINE MOUNTAIN WHILE ON THE SOUTHEAST THE FORMATION OF THE POWELL VALLEY ANTICLINE, WHICH WAS WARPED UP AT THE SAME TIME THAT THE MIDDLESBORO BASIN WAS FORMED, HAS CAUSED THE UP-TURNING OF THE ROCK STRATA IN CUMBERLAND MOUNTAIN. TRAVERSE FOLDING IS NOT NOTICEABLE EXCEPT IN THE VICINITY OF MIDDLESBORO AND PINEVILLE, WHERE A BELT OF FAULTING AND CRUSHING CROSSES THE BASIN.

THE COALS OF THE HARLAN DISTRICT WHERE MOUNTAIN BUMPS HAVE OCCURRED MORE FREQUENTLY IN THE LAST FIVE YEARS, LIE WITHIN THIS SYNCLINE OR BASIN AND WHETHER OR NOT THEY ARE AFFECTED BY STRESSES THAT MAY STILL BE TIED UP IN THIS STRUCTURE IS NOT DEFINITELY KNOWN. THIS IS DISCUSSED FURTHER IN ANOTHER PART OF THIS PAPER.

STRUCTURE AND TEXTURE OF COAL

THE COALS OF THE HARLAN COUNTY COAL FIELD LIE WITHIN THE TROUGH-SHAPED BASIN KNOWN AS THE MIDDLESBORO SYNCLINE OR BASIN, WITH THE AXIS RUNNING NORTHEAST-SOUTHWEST. THIS SYNCLINE OR BASIN IS SITUATED IN THE CUMBERLAND OVERTHRUST BLOCK. SEE PLATE III.

ON APPROACHING THE BRIM OR THE UPTURNED EDGES OF THE BASIN WHERE THE STRATA IS STEEPLY INCLINED, THERE SEEMS TO BE A GENERAL ABSENCE OF COAL BEDS. AN OCCASIONAL BED IS NOTICEABLE ALONG CERTAIN ROAD SECTIONS WHERE THE INCLINED STRATA SHOW EXPOSURES OF GREAT THICKNESS. THE ABSENCE OF THE COAL BEDS HERE IS ACCOUNTED FOR IN THAT THE THRUSTING AND THE FORMATION OF THE POWELL VALLEY ANTICLINE ELEVATED THESE SEAMS AND SUBJECTED THEM TO A MORE RAPID PROCESS OF EROSION SO THAT THEY ARE NOW STRIPPED OFF.

THE STRUCTURE OF THE COAL BEDS FOLLOWS THE GENERAL STRUCTURE OF THE REGION, WHICH HAS BEEN DESCRIBED IN ANOTHER PART OF THIS PAPER UNDER THE HEADING "GEOLOGIC STRUCTURE". GENERALLY SPEAKING THE COAL BEDS ARE FLAT BUT DIP GENTLY FROM THE FOOT OF THE UPTURNED STRATA ON EITHER SIDE OF THE SYNCLINE TOWARD ITS AXIS WHICH IS A LITTLE NORTHWEST OF THE CENTER OF THE BASIN.

LOCAL DIPS AND SAGS ARE PRESENT IN NEARLY ALL OF THE MINES AND SOMETIMES THE SAG OR DEPRESSION IS ACCOMPANIED BY A ROLL IN THE ROOF. LIKEWISE ROOF ROLLS MAY OCCUR WHERE THERE IS NO DEPRESSION IN THE BASE OF THE COAL SEAM. SOME OF THESE ROLLS ARE KNOWN TO EXTEND DOWN INTO THE COAL BED AS MUCH AS THREE FEET. WHEN THIS

IS TRUE THE THICKNESS OF THE COAL IS NATURALLY DIMINISHED, AND IS DUE TO EROSION ON THE SURFACE OF THE COAL BED PRIOR TO DEPOSITION OF THE ROOF MATERIAL, WHICH IN THESE CASES IS USUALLY SANDSTONE. THE IDEA THAT THESE CONDITIONS ARE DUE TO THE EFFECTS OF EROSION MAY BE FURTHER SUBSTANTIATED BY THE FACT THAT ERODED PEBBLES OF COAL ARE FOUND SOMETIMES QUITE FREQUENTLY IN THE OVERLYING SANDSTONE ROOF. ONE OF THESE PEBBLE SPECIMENS, WHICH IS NOW IN POSSESSION OF ONE OF THE COAL COMPANIES, IS ROUNDED VERY NICELY, SHOWING THE EFFECTS OF STREAM OR WATER EROSION PRIOR TO ITS DEPOSITION. IT IS FROM $2\frac{1}{2}$ TO 3 INCHES IN DIAMETER AND THE SURFACE IS PITTED WITH SMALL HOLES AND NICKS THAT ARE PARTIALLY FILLED WITH SAND GRAINS. THIS PARTICULAR SPECIMEN WAS FOUND IMBEDDED IN THE SOLID SANDSTONE ROOF IMMEDIATELY OVERLYING THE COAL SEAM. IN THESE INSTANCES, THE SANDSTONE ROOF WAS IN DIRECT CONTACT WITH THE PURE COAL, THERE BEING NO PARTING OF SHALE OR RASH IN BETWEEN. WHEN CONDITIONS LIKE THE ABOVE MENTIONED ARE PRESENT IT MAY RIGHTLY BE ASSUMED THAT THE COAL SEAMS WERE ONCE THICKER THAN THEIR PRESENT MEASUREMENTS INDICATE.

IN SOME INSTANCES THE COAL BEDS ARE ROLLING WITH SUCH FREQUENCY THAT IN EFFECT THEY REPRESENT WAVES, WHILE IN OTHERS LONG HILLS ARE ENCOUNTERED, DUE TO SUDDEN CHANGES IN THE DIRECTION AND AMOUNT OF DIP.

ON THE WESTERN FLANK OF BLACK MOUNTAIN NEAR BENHAM AND LYNCH A RATHER SHARP DIP IS SHOWN IN THE HARLAN COUNTY STRUCTURAL MAP WHICH IS BASED ON THE KELLIOKA (FIRE CLAY) COAL. IN OUR VISITS THRU THE MINES OF THIS LOCALITY IS WAS FOUND THAT ONLY A VERY GENTLE DIP WAS PRESENT IN MOST PLACES AND A FAIRLY GENERAL LEVEL SEEMED TO PREVAIL THRU-OUT. THE COALS IN THIS PARTICULAR LOCALITY LIE VERY NEAR THE AXIAL CENTER OF THE SYNCLINE AND IT WOULD BE EXPECTED THAT THEY POSSESS A MORE OR LESS UNIFORM LEVEL.

IN THE PREPARATION OF THIS REPORT, STRUCTURAL CONTOURS HAVE BEEN DRAWN ON THE "C" COAL OF THIS AREA SHOWING THAT THE DIPS ARE RATHER GENTLE. SEE PLATE IV.

IT IS OF NOTE TO MENTION THAT THE HARLAN COUNTY STRUCTURAL MAP SHOWS SEVERAL LARGE BASINS, AND ONE IN PARTICULAR JUST SOUTH OF CHAD, WHICH SHOWS A DEPRESSION OF ABOUT 150 FEET MORE OR LESS. FROM THE STRUCTURAL MAP REFERRED TO IN PLATE IV OF THIS REPORT, IT IS INDICATED THAT DEPRESSIONS ARE NOT SO PRONOUNCED IN THIS AREA. PROSPECT LEVELS ON THE COAL JUST SOUTH OF CHAD, SHOW ELEVATIONS DIFFERING FROM THOSE ON THE COUNTY MAP OF AS MUCH AS 150 FEET OR MORE.

SOMETIMES A COAL SEAM SPLITS OR DIVIDES INTO TWO SEAMS AND IS THEN KNOWN AS THE UPPER AND LOWER BENCH OF THE ORIGINAL SEAM NAME. MINING USUALLY FOLLOWS THE THICKER BENCH, DEPENDING, OF COURSE, UPON THE THICKNESS OF BOTH BENCHES, PURITY OF COAL AND THE ABSENCE OF PARTINGS. IN SOME INSTANCES BOTH BENCHES ARE MINED WHERE THE INTERVENING DISTANCE BETWEEN DOES NOT PROHIBIT THE PROFITABLE EXTRACTION OF THE COAL. IT IS NOT UNCOMMON TO ENCOUNTER A SECOND SPLIT IN EITHER THE LOWER OR UPPER BENCH OF THE ORIGINAL.

SOMETIMES THESE SPLIT SEAMS THIN OUT TO SUCH AN EXTENT THAT IT IS IMPRACTICAL TO MINE THEM.

SPLITS ARE PROBABLY DUE TO A LOCAL OR GENERAL SUBSIDENCE OF A PART OF THE COAL FORMING SWAMP DURING THE PERIOD OF DEPOSITION, THE INTERMEDIATE DEPTH BEING GRADUALLY BUILT BACK UP TO THE GENERAL SWAMP LEVEL BY THE DEPOSITION OF DRAINAGE MATERIAL AND IMPURE CARBONACEOUS MATTER SUCH AS SHALES, ETC.

AS TO THE TEXTURE OF THE COAL IT IS EXTREMELY BRITTLE AND POSSESSES A GOOD HARDNESS FOR BITUMINOUS COAL. IT BREAKS AND SHATTERS READILY UNDER A BLOW OR STRAIN. THIS UNUSUAL BRITTLENESS MAY BE A DETERMINING FACTOR IN THE CAUSES OF "BUMPS".

IN APPEARANCE, THE COAL HAS A DARK, GLOSSY, BLACK COLOR, BUT UPON PULVERIZATION A DUST IS PRODUCED THAT SHOWS THE TRUE DARK BROWN COLOR OF BITUMINOUS COAL.

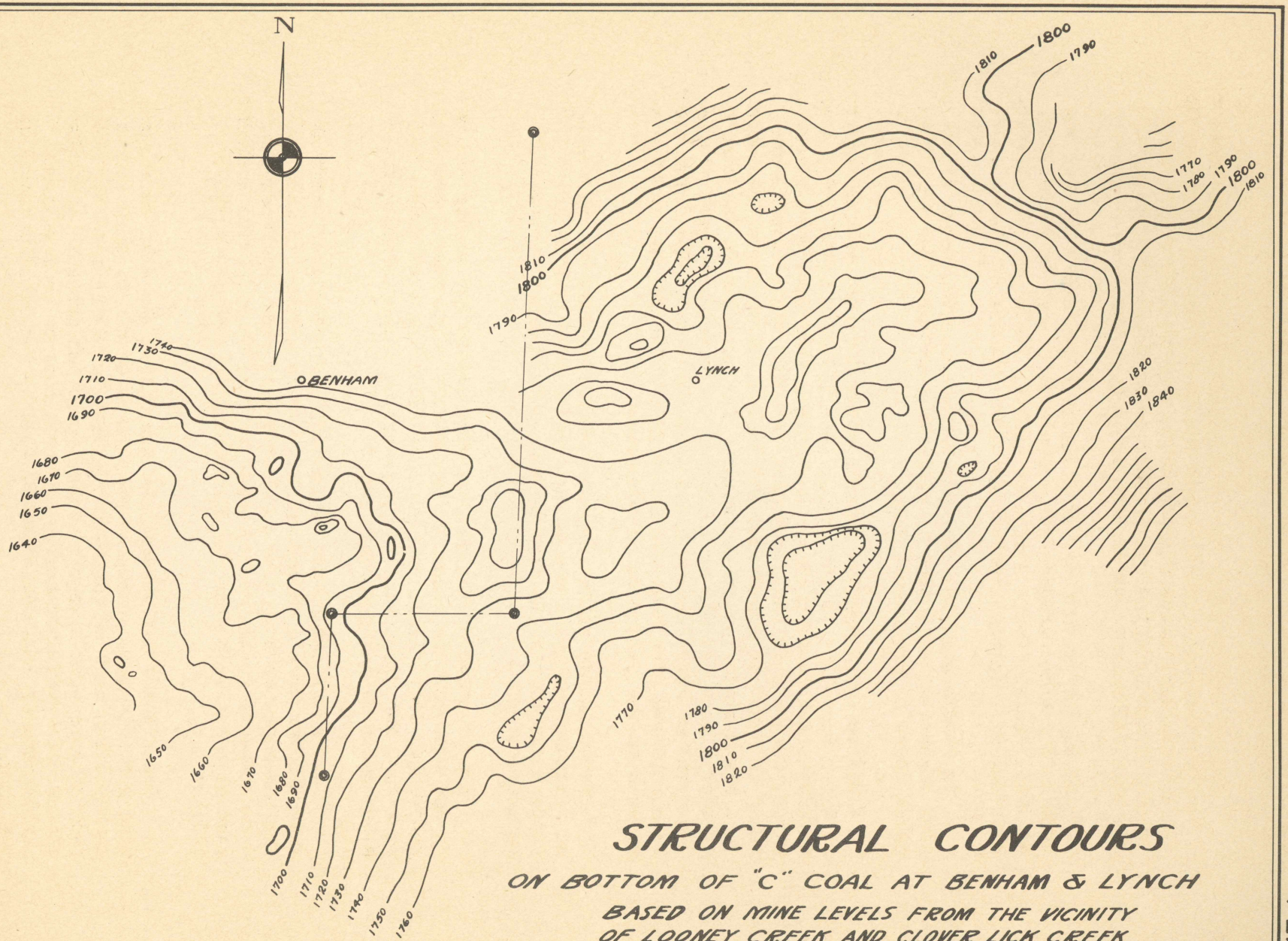
DUE TO THE INTENSIVE LATERAL PRESSURES THAT WERE TRANSMITTED FROM THE SOUTHEAST TO THE COALS, (SEE GEOLOGIC STRUCTURE), A WELL DEVELOPED SYSTEM OF CLEAVAGE HAS BEEN ESTABLISHED THROUGH-OUT THE FIELD. CLEAVAGE IS THE CAPABILITY OF BEING SPLIT INTO SMOOTH FACES IN DEFINITE DIRECTIONS AND TRUE CLEAVAGE CAN BE PRODUCED IN A GIVEN DIRECTION AT ANY POINT. THE CLEAVAGE IN THE COAL IS PRETTY WELL DEFINED TO A GENERAL NORTHEAST-SOUTHWEST DIRECTION, THE AVERAGE READING BEING NORTH 59° EAST. THIS DIRECTION PARALLELS THE PINE MOUNTAIN FAULT (SEE JOINTING) AND IS PERPENDICULAR TO THE DIRECTION OF THRUSTING.

THE CLEAVAGE FACES IN THE NORTHEASTERN PART OF THE FIELD NEAR BENHAM AND LYNCH RUN IN AN AVERAGE DIRECTION OF NORTH 65° EAST, WHILE IN THE VICINITY OF HARLAN THIS ANGLE IS SOMEWHAT SMALLER.

THE FRACTURE OF THE COAL IS VERY UNEVEN AND RAGGED AND NOT AT ALL LIKE THAT OF CANNEL OR ANTHRACITE WHICH HAVE A CONCHOIDAL FRACTURE. BUTT FACES, HOWEVER, ARE SOMETIMES VERY SMOOTH AND NUMEROUS, AND USUALLY LIE IN A DIRECTION WHICH APPROXIMATES A RIGHT ANGLE TO THE CLEAVAGE FACES.

BUTT FACES SHOULD NOT BE CONFUSED WITH CLEAVAGE FACES AS THEY ARE NOT TRUE CLEAVAGE PLANES. IF AN ATTEMPT IS MADE TO SPLIT A BLOCK OF COAL JUST BACK OF A BUTT FACE, AN IRREGULAR, HACKLY FRACTURE WILL OCCUR, WHILE IF THIS IS ATTEMPTED ANYWHERE BACK OF A CLEAVAGE FACE THE RECURRENCE OF A SMOOTH PLANE IS BROUGHT OUT.

THESE COALS ARE VERY BRIGHT AND GLOSSY AND HAVE AN ADAMANTINE LUSTER, WHICH IS THE APPEARANCE OF BROKEN GLASS. IN THE NORTHEASTERN PART OF THE FIELD, CLOSER TO THE EDGE OF THE BLOCK, THEY SEEM TO HAVE A MORE FINISHED GLOSS AND REFLECT LIGHT MORE EASILY. FARTHER SOUTHEAST, THE OCCURRENCE OF DULL OR SILKY LAYERS BECOMES MORE NUMEROUS, SHOWING UP THE BEDDING PLANES IN THE COAL.



STRUCTURAL CONTOURS

ON BOTTOM OF "C" COAL AT BENHAM & LYNCH

BASED ON MINE LEVELS FROM THE VICINITY
OF LOONEY CREEK AND CLOVER LICK CREEK

CONTOUR INTERVAL 10'

0 ——— 1 MILE

SCALE

BY D.J. JONES & N.M. WILDER

KENTUCKY DEPARTMENT OF MINES AND MINERALS
GEOLOGICAL Lexington, Kentucky DIVISION

PLATE IV

Bedding planes are usually well pronounced in all of the coals and especially in the center of the seam where thin beddings or layers of the so-called "Mother Coal" are quite frequently present. "Mother Coal" is a more or less pure carbon and still shows the cell structure of the original plant when studied under the microscope. It is very soft and has a satin luster.

All of the coals that are being mined at the present time are quite pure. They are relatively free from sulphur and contain only small percentages of ash and moisture. (See Analyses below) Most of the mines are very dry, but in cases where water does accumulate it is taken care of by drainage ditches and electric pumps. Partings of shale, bone and rash sometimes occur and this is very undesirable as they must be separated and thrown out. "Bone" is a layer of hard, impure coal which sometimes grades uniformly into the adjacent softer coal and sometimes it is sharply separated from it. "Bone" is usually a mixture of clay particles with the coad, the clay particles being well distributed. "Rash" is a substance grading about halfway between a coal and a shale and looks somewhat like an oil shale except that it is more flexible. It usually occurs in very thin flakes or sheets at the bottom, the top, or within the coal seam. The color is usually dark but frequently grades to a lighter shade. "Draw Slate" is a layer of hard shale between the top of the coal bed and the solid roof. The thickness of draw slate is usually from 8" to 30".

The following analyses are representative of Harlan, "C" or "Kellioka" and Darby coals.

Seam	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulphur	B. T. U.
Harlan	3.0	36.6	56.1	3.5	0.8	14,011
"C"	2.6	36.8	58.5	2.1	0.5	14,580
Darby	3.9	37.8	54.1	4.2	0.8	13,720

STRATIGRAPHY

The rocks exposed in the Harlan County coal field all belong to the Pottsville series of the Pennsylvanian system with the possible exception of a few outliers of Allegheny, also Pennsylvanian, which are shown on the Geologic map of Kentucky. Rocks of the Mississippian and the Devonian systems are exposed just outside the field on the west of Pine Mountain as represented in Plate III. The Pottsville is the lower member of the Pennsylvanian system of rocks and includes the coal bearing formations of the Middlesboro Basin, the region under discussion.

The Pottsville series here is the same as that of the adjoining areas in that it is made up principally of sandstones,

SHALES AND COALS. SANDSTONES, SHALES AND THEIR INTERMEDIATE GRADATIONS OCCUPY NEARLY THE WHOLE OF THE SECTIONS WITH SANDSTONES PREDOMINATING.

A SUBDIVISION OF THE PENNSYLVANIAN ROCKS OF THE ADJACENT COAL FIELD OF SOUTHWEST VIRGINIA AS MADE BY THE VIRGINIA GEOLOGICAL SURVEY IS SHOWN BELOW AT THE LEFT. AT THE RIGHT IS A SIMILAR CLASSIFICATION MADE BY ASHLEY AND GLENN FOR THE CUMBERLAND GAP COAL FIELD, WHICH INCLUDES THE SOUTHWESTERN PART OF THE REGION DEALT WITH IN THIS PAPER.

HARLAN FORMATION	BRYSON FORMATION
WISE FORMATION	HIGNITE FORMATION
GLADEVILLE SANDSTONE	CATRON FORMATION
NORTON FORMATION	MINGO FORMATION
LEE FORMATION	LEE FORMATION

IN THE GEOLOGY OF THE MIDDLESBORO BASIN, WENTWORTH THINKS THAT THE HARLAN FORMATION OF THE VIRGINIA SUBDIVISION IS REPRESENTED IN THE CUMBERLAND GAP FIELD BY THE COAL MEASURES INCLUDED IN THE HIGNITE AND BRYSON FORMATIONS. HOWEVER, NO ATTEMPT WILL BE MADE HERE TO APPLY FORMATION NAMES EXCEPT WHERE POSITIVELY IDENTIFIED, TO THE ACCOMPANYING SECTIONS OR TO CORRELATE BETWEEN THESE TWO AREAS, DUE TO THE UNCERTAINTY OF CORRELATIONS BETWEEN THE COALS OF THE HARLAN FIELD, AND TO INSUFFICIENT TIME FOR FIELD WORK. ONLY A GENERAL DESCRIPTION OF THE ROCKS EXPOSED AND THOSE SHOWN IN THE SECTIONS WILL BE DISCUSSED.

THE LEE FORMATION WHICH IS BASAL POTTSVILLE DOES NOT OUTCROP WITHIN THE BASIN BUT IS EXPOSED AT THE RIM WHERE ITS CONGLOMERATIC PHASE CAPS THE CREST OF PINE AND CUMBERLAND MOUNTAINS, SEE PLATE III. IT IS A VERY RESISTANT AND MASSIVE SANDSTONE CONTAINING ROUNDED QUARTZ PEBBLES FROM ONE-EIGHTH TO ONE INCH IN DIAMETER, AND IS COMMONLY KNOWN AS THE LEE CONGLOMERATE. BELOW THE LEE FORMATION ROCKS OF MISSISSIPPIAN AND DEVONIAN AGE ARE EXPOSED ON THE WEST FLANK OF PINE MOUNTAIN DUE TO THEIR BEING BROUGHT TO THE SURFACE BY THE PINE MOUNTAIN FAULT, SEE PLATE III

SANDSTONES OF THAT PART OF THE POTTSVILLE EXPOSED AT THE SURFACE ARE OF VARYING THICKNESSES RANGING FROM A FEW FEET TO OVER 100 FEET. THICKNESSES OF SANDSTONES IMMEDIATELY OVERLYING THE WORKABLE COALS RUN ALL THE WAY FROM A FEW FEET TO OVER 60 FEET AND IN SOME LOCALITIES AS MUCH AS 90 FEET OF SAND ROCK IS REPORTED AS IMMEDIATELY OVERLYING THE COAL. IN THE LOWER POTTSVILLE, SANDSTONE MEMBERS OF THE LEE FORMATION ARE AS MUCH AS 200 FEET THICK AND SOME ARE IN EXCESS OF THIS.

THE SHALES ALSO RUN TO GREAT THICKNESSES AND OCCUR ALMOST AS FREQUENTLY AS THE SANDSTONES. THE THICKER SANDSTONES ARE MORE COMMON AT THE TOP AND BOTTOM OF THE SECTIONS AS SHOWN ON PLATES V AND VI.

MISSISSIPPIAN LIMESTONES ARE EXPOSED ON THE WEST FLANK OF PINE MOUNTAIN AND THE ONLY OTHER LIME PRESENT IN THIS FIELD IS OF PENNSYLVANIAN AGE AND LIES ABOUT 870 FEET BELOW THE DOUBLE

ELEVATION

THE DOUBLE — TOP OF BLACK MT.

4150 4100 4050 4000 3950 3900 3850 3800 3750 3700 3650 3600 3550 3500 3450 3400 3350 3300 3250 3200 3150 3100

2" COAL
6" COAL
4' COAL
6" COAL
COVERED
COAL & SHALE
6'-7" COAL
6" COAL
1'-9" COAL
8" LIMESTONE
8" COAL
4" ASH
1'-4" COAL
4½" COAL
4'-8" COAL

3050 3000 2950 2900 2850 2800 2750 2700 2650 2600 2550 2500 2450 2400 2350 2300 2250 2200 2150 2100 2050

2'-1" COAL
7" COAL & SHALE
COVERED
4" COAL
1'-1" COAL
2' COAL
1'-6" COAL & SHALE
1'-1" COAL
7" COAL
1'-8" COAL
2' COAL
1' COAL
5'-4½" COAL & SHALE
11" COAL
6" COAL
6" COAL
2'-6" COAL
2'-2" COAL
10" COAL
1' COAL
E" SEAM
3" COAL

2000 1950 1900 1850 1800 1750 1700 1650 1600 1550 1500 1450 1400 1350 1300 1250 1200 1150 1100 1050 1000

3" COAL
1'-2" COAL
2'-8" COAL
2'-7" COAL TOP "C"
3'-4" BOTTOM "C"
1'-11" COAL "B" SEAM
2'-6" COAL
1'-5" COAL
2'-3" COAL
2'-6" COAL
7" COAL
3' COAL "A" OR IMBODEN
7" COAL
6" SS.
1' SANDY SH.
2" SHALE
3" COAL
3" SHALE
2' COAL
1' FIRE CLAY
3' FIRE CLAY
1' FIRE CLAY
1' COAL
2' COAL
4' COAL
3' FIRE CLAY

950 900 850 800 750 700 650 600 550 500 450 400 350 300 250 200 150 100 50 0 -50

1' FIRE CLAY
5' FIRE CLAY
9' CONGLOMERATE

PENNSYLVANIAN

MISSISSIPPIAN

-100 -150 -200 -250 -300 -350 -400 -450 -500 -550 -600 -650 -700 -750 -800 -850 -900 -950 -1000 -1050 -1100

71.5' SS. CONG.
4' COAL
1' COAL U. FREEPORT
2' COAL L. FREEPORT
SHALE & SHELLS
SHALE & SHELLS
MAXON SAND
SANDSTONE & SHELL
4' RED BX.

STRATIGRAPHIC SECTION

HEAD OF LOONEY CREEK — HARLAN COUNTY, KENTUCKY

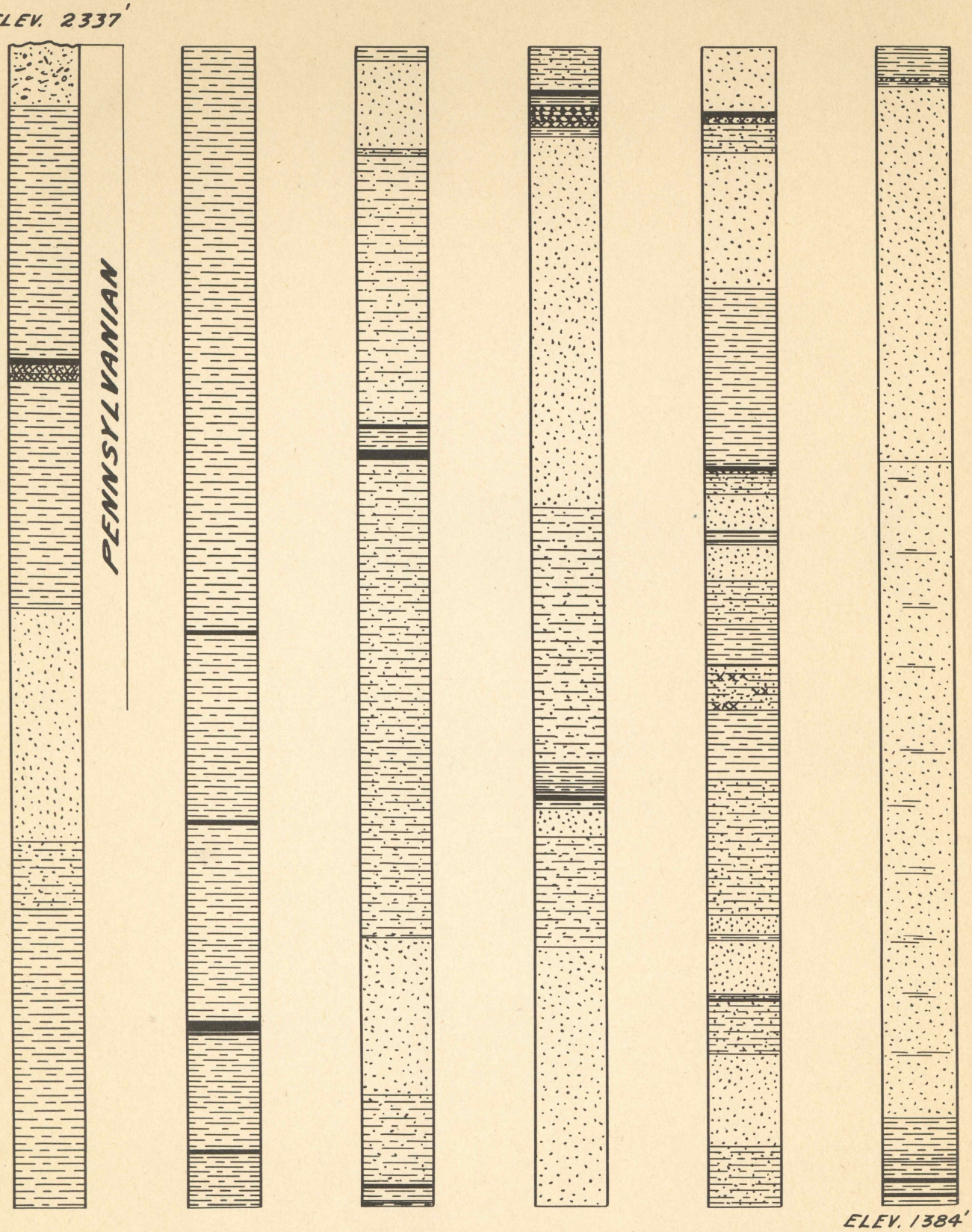
COMPILED BY D. J. JONES AND N. M. WILDER

0 50 100 Feet
SCALE

1934

KENTUCKY DEPARTMENT OF MINES AND MINERALS
GEOLOGICAL DIVISION
Lexington, Kentucky

PLATE V



STRATIGRAPHIC SECTION

COMPILED FROM DIAMOND DRILL RECORD ON MILL CREEK, HARLAN COUNTY, KY.

BY D. J. JONES & N. M. WILDER
1934
SCALE 1" = 20'

KENTUCKY DEPARTMENT OF MINES AND MINERALS
GEOLOGICAL Lexington, Kentucky DIVISION

ON BLACK MOUNTAIN. SEE PLATE V. THIS IS A FINE GRAINED FOSSILIFEROUS LIMESTONE, DARK IN COLOR AND IS ABOUT 8 INCHES IN THICKNESS. AMONG THE FOSSILS RECOGNIZED ARE LOPHOPHYLLUM, PRODUCTUS, ORTHOCERAS, ASTARTELLA, CHONETES, AND OTHERS. THE MORE COMMON PLANT FOSSILS OF THE PENNSYLVANIAN SANDS, SUCH AS LEPIDODENDRON, SIGILLARIA, CYCADS, CALAMITES, ETC. WERE FOUND QUITE FREQUENTLY BOTH ON THE SURFACE AND INSIDE THE MINES.

THE COALS IN THESE SECTIONS VARY FROM A FEW INCHES TO OVER 6 FEET IN THICKNESS. IN OTHER PARTS OF THE FIELD SOME OF THE COALS ARE KNOWN TO BE AS MUCH AS 80 INCHES THICK. THE NAMES OF THE COALS AS APPLIED IN THESE SECTIONS ARE THOSE USED BY THE OPERATING COMPANIES.

PLATE V OF THIS REPORT SHOWS A SECTION OF PENNSYLVANIAN STRATA PROBABLY THE THICKEST EVER COMPILED IN KENTUCKY. THIS IS THE BLACK MOUNTAIN SECTION AND IS COMPILED FROM DIAMOND DRILL AND BORE HOLE RECORDS AND FROM SECTIONS MADE BY THE AUTHORS OF THIS REPORT. THIS SECTION EXTENDS FROM THE DOUBLE ON BLACK MOUNTAIN THRU THE PENNSYLVANIAN SEDIMENTS AND INTO THE TOP PART OF THE MISSISSIPPIAN, A TOTAL THICKNESS OF OVER 5000 FEET.

JOINTING

PRONOUNCED JOINTS IN THE SANDSTONES, SHALES, AND COALS OCCUR IN THIS AREA. THE STRIKE OF JOINTS AND CRACKS WERE MEASURED ON THE SURFACE AS WELL AS INSIDE THE VARIOUS MINES. THE CLASSIFICATION OF TWO HUNDRED JOINTS SHOWS THE FOLLOWING RESULTS: 47 AVERAGE N 64° E; 46 AVERAGE N 24° W; 37 AVERAGE N - S; 22 AVERAGE N 22° E; 35 AVERAGE N 65° W AND 14 AVERAGE E - W.

THE SETS OF JOINTS N - S; N 24° W; AND N 22° E MIGHT BE COMBINED AS ONE GROUP. THOSE EXTENDING EAST AND WEST ARE OBSERVED INFREQUENTLY. THIS GROUPING WOULD RESULT IN THREE MAIN SETS OF JOINTS AND CRACKS; NAMELY, N - S; N 64° E AND N 65° W.

CLEAVAGE FACES OF COAL RANGE IN VARIOUS PARTS OF THE AREA FROM N 45° E TO N 72° E, THE AVERAGE BEING N 59° E. THE FACES IN THE MINES RELATIVELY CLOSE TO THE STEEP DIPS FLANKING THE PINE MOUNTAIN FAULT AVERAGE N 65° E OR APPROXIMATELY PARALLEL TO THE STRIKE OF THE FAULT.

BUTT FACES ARE NOT AS WELL DEFINED. THEY FREQUENTLY APPROXIMATE RIGHT ANGLES TO THE FACES. IN SOME OF THE MINES THE BUTTS ARE VERY IRREGULAR. AS A WHOLE THE CLEAVAGE FACES PARALLEL THE PINE MOUNTAIN FAULT AND ALSO THE INTENSE FOLDING ALONG CUMBERLAND MOUNTAIN TO THE SOUTH.

CRACKS AND JOINTS OBSERVED INSIDE THE MINES WERE AS FOLLOWS: N 47° E; N 50° E, N 55° E, N 65° E ---- N 65° W, N 85° W ---- N - S, N 12° W, N 25° E. THESE CRACKS FALL IN THE GENERAL CLASSIFICATION OF THOSE OBSERVED ON THE SURFACE. JOINTING IN THE

MINES UNDER COVER SUFFICIENT TO NOT BE EFFECTED BY SLUMPING IS MANIFESTED USUALLY BY VERY FINE LINES OR CRACKS NOT EASILY VISIBLE AND SELDOM ARE MINERALIZED BEYOND THE WALLS OF THE CRACK. ON THE OTHER HAND, CRACKS IN THE ZONE OF SLUMPS OR SLIPS AND ON THE SURFACE ARE USUALLY MINERALIZED AND FREQUENTLY CLAY-FILLED.

NEAR THE ENTRIES WHERE THE OVERBURDEN DOES NOT EXCEED 500 FEET THE CRACKS AND JOINTS ARE MORE PRONOUNCED. JOINTS IN THIS ZONE (0 - 500 FEET) ALSO CORRESPOND IN DIRECTION TO THOSE FARTHER INSIDE THE MINES WHERE THE COVER IS GREATLY IN EXCESS OF 500 FEET. THEY ALSO CORRESPOND IN DIRECTION TO THE SETS OF JOINTS OBSERVED ON THE SURFACE IN THIS AREA. THIS CONDITION CAN BE PARTICULARLY NOTED IN ONE OF THE MINES AT COXTON.

JOINTING IN AREAS NORTH OF THE OVERTHRUST BLOCK

IMMEDIATELY NORTH OF PINE MOUNTAIN THE COAL MEASURES ARE JOINTED AND FISSURED TO ABOUT THE SAME EXTENT AS THOSE IN THE MIDDLESBORO BASIN. IN A ZONE BEGINNING 5 TO 7 MILES NORTH AND PARALLEL TO PINE MOUNTAIN AND NORTH OF THE NORTH FORK OF THE KENTUCKY RIVER, JOINTS OCCUR THAT FALL IN THE SAME GENERAL CLASSIFICATION AS THOSE IN THE MIDDLESBORO BASIN. IT IS NOTICEABLE THAT JOINTING IS NOT AS INTENSE IN THIS AREA IN THE SANDSTONES AND SHALES. THE FACE CLEATS IN THE COAL ARE NOT AS WELL DEVELOPED AND THE BUTT CLEATS ARE IRREGULAR.

SURFACE CRACKS

AS A RESULT OF THE REMOVAL OF THE UNDERLYING COAL, THE ROOF BREAKS TO THE SURFACE IN LONG CRACKS. SEE PLATE VII, FIGS. 1 AND 2. THIS COMMONLY OCCURS WHERE THE OVERBURDEN DOES NOT EXCEED 300 FEET. SURFACE CRACKS WHERE THE OVERBURDEN IS MORE THAN 500 FEET ARE NOT COMMON. IT IS LIKELY THAT MANY SUCH CRACKS OCCUR THAT ARE NOT OBSERVED. ALSO THEY MAY NOT OPEN WIDE ENOUGH TO BE VISIBLE THROUGH THE TOP SOIL.

IT IS REPORTED THAT IN THE VICINITY OF LEWELLEN ON CLOVER FORK OF CUMBERLAND RIVER, A CRACK HAS COME THRU TO THE SURFACE WHERE THE OVERBURDEN IS ABOUT 800 FEET. THE APPROXIMATE COURSE OF THIS CRACK IS N 20° E.

CRACKS OF THIS NATURE WERE OBSERVED ON A SPUR OF LOONEY RIDGE ABOUT ONE-HALF MILE NORTHEAST OF LYNCH, KENTUCKY. THIS OPENING IS APPROXIMATELY SIX FEET IN WIDTH AND EXTENDS IN A COURSE N 70° W FOR A DISTANCE OF, AT LEAST, A QUARTER OF A MILE. IT IS SAID THAT WHEN FIRST DISCOVERED, THE DEPTH WAS SO GREAT THAT A PEBBLE DROPPED IN AT THE SURFACE COULD NOT BE HEARD AS IT HIT THE BOTTOM. THE VERTICAL DISTANCE FROM THE C SEAM TO THE CREST OF THE RIDGE WHERE THE CRACK OCCURS IS APPROXIMATELY

1000 FEET. AT THE PRESENT TIME, THE SPACE BETWEEN THE ROCK WALLS IS NEARLY FILLED WITH DEBRIS. THIS CRACK PROJECTED TO THE MINED AREA IS PARALLEL TO THE GOB LINE BUT IN SOLID COAL, 150 FEET BACK INTO THE PILLAR. A SURFACE CRACK LOCATED ON RAGGED SPUR OF BENHAM SPUR BETWEEN MAGGARD AND GAP BRANCHES STRIKES NORTH AND SOUTH. THIS CRACK PROJECTED TO THE C. SEAM TAKES A POSITION PARALLEL TO THE GOB LINE, VERY CLOSE TO THE PILLAR LINE. IN A CONVERSATION WITH THE MAN WHO FIRST DISCOVERED THIS CRACK, WE LEARNED THAT HE WAS SUPERVISING TWO TIMBER OPERATIONS IN 1930 AND IN WALKING FROM ONE OF THESE TO THE OTHER, HIS PATH LEAD ACROSS THIS CRACK. THE DISCOVERY WAS NOT MORE THAN 90 DAYS AND POSSIBLY WITHIN 30 DAYS AFTER THIS OPENING APPEARED ACROSS THE SPUR. HE FURTHER STATED THAT HE WAS IMPRESSED BY THE FACT THAT THE SURFACE WALLS WERE NOT FRESH FRACTURES, BUT DECIDEDLY WEATHERED, WHICH WOULD INDICATE PLANES OF WEAKNESS PRIOR TO THE EXISTENCE OF THE OPENING. THE CRACK IS SLIGHTLY MORE THAN TWO FEET IN WIDTH AND THE VERTICAL DISTANCE FROM No. C COAL IS APPROXIMATELY 2,000 FEET.

WE UNDERSTAND, FROM THE STONEGA COKE AND COAL COMPANY AT BIG STONE GAP, VIRGINIA THAT SURFACE CRACKS OCCUR ABOVE THEIR MINING OPERATIONS IN WISE COUNTY, VIRGINIA, WHERE THE OVERBURDEN EXCEEDS 1000 FEET. THESE CRACKS CONFORM TO THE DIRECTION OF REGIONAL JOINTING. TWO OF THEM STRIKE AS FOLLOWS, ONE N 40° E AND THE OTHER N 18° W.

SIGNIFICANCE OF SURFACE CRACKS

SURFACE CRACKS WHERE THE OVERBURDEN IS LESS THAN 800 FEET HAVE NOT BEEN DISCUSSED. CRACKS FREQUENTLY OCCUR WHERE THERE IS LITTLE OVERBURDEN IN THE COURSE OF ORDINARY PILLAR WORK. IT IS TO BE NOTED THE CRACKS THAT APPEAR AT THE SURFACE IN THE AREAS MENTIONED ABOVE LINE UP VERY WELL WITH THE MAIN SYSTEMS OF JOINTING FOUND IN THIS AREA. THESE CRACKS EMERGING AT THE SURFACE THRU FROM 800 TO 2000 FEET OF OVERBURDEN HAVE NO DOUBT COME UPWARD ALONG JOINT PLANES AND PLANES OF WEAKNESS. IT IS EVIDENT THAT BETTER MOUNTAIN CAVINGS ARE ATTAINED WHERE PILLAR LINES PARALLEL ONE OF THESE MAIN SYSTEMS OF JOINTING.

THE TWO CRACKS DESCRIBED ON A SPUR OF LOONEY RIDGE AND ON RAGGED SPUR OF BENHAM SPUR, ARE OVER PILLAR LINES IN EXCESS OF 4000 FEET IN LENGTH. ALSO, IN VIEW OF THE FACT THAT THESE CRACKS, ONE NORTH AND SOUTH AND THE OTHER N 70° W ARE IDENTICAL WITH TWO OF THE MAIN SYSTEMS OF JOINTING IN THIS REGION, IT IS ADVISABLE TO PULL PILLARS ON LONG LINES PARALLEL TO ONE OF THESE MAIN SETS OF JOINTS. IF THIS PLAN IS FOLLOWED IT IS LIKELY THAT THE ROOF CAN BE MORE FREQUENTLY BROKEN TO THE SURFACE THRU COVER OF 2000 FEET. PORTIONS OF OVERBURDEN IN WHICH TENSION HAS BEEN RELIEVED IN THIS MANNER SHOULD GIVE NO FURTHER TROUBLE AND A CONTINUATION OF PILLAR WORK PARALLELING JOINT SYSTEMS SHOULD RESULT IN THE PROGRESSIVE BREAKING OF ANY OVERBURDEN ENCOUNTERED IN THE HARLAN FIELD. HOWEVER, WHERE LONG LINES ARE NOT POSSIBLE, A SYSTEM OF DRIVING ENTRIES AND ROOMS AND DRAWING NO PILLARS SEEMS ADVISABLE. (SEE RECOMMENDATIONS FOR THE PREVENTION OF BUMPS)

EXPLANATION TO PLATE VII

FIGURE 1 IS A VIEW OF A SURFACE CRACK WHICH OCCURRED OVER A WORKABLE COAL. CRACKS OF THIS NATURE HAVE OCCURRED IN COVER OF OVER 2000 FEET.

FIGURE 2 IS AN INTERIOR VIEW OF ANOTHER SURFACE CRACK WHICH OCCURRED OVER COAL BEING WORKED BELOW. NOTE THE SMOOTH FACE OF THE WALL WHICH IS INDICATIVE OF JOINTING.

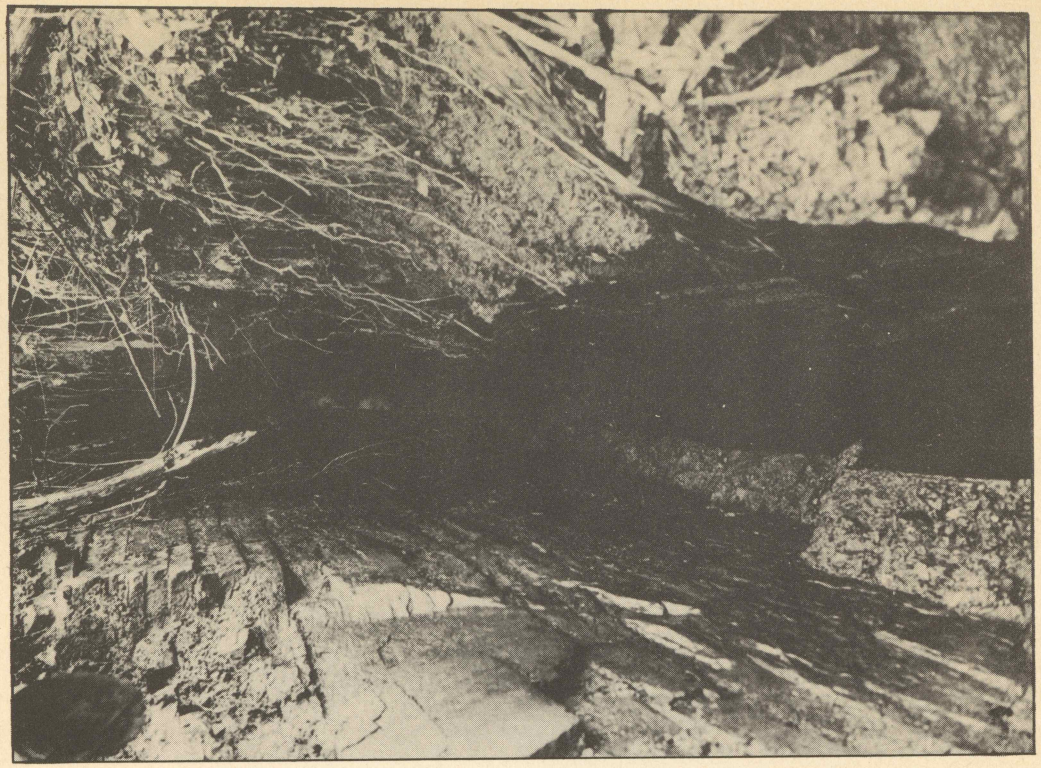


FIG. 2

FIG. 1

SHORT PILLAR LINES NOT CONFORMING TO JOINT SYSTEMS ARE APT TO RESULT ONLY IN SMALL FALLS AND VERY LITTLE TENSION IS RELEASED FROM THE PILLARS. UNDER THIS PROCEDURE ANY MINOR IRREGULARITY IN THE PILLAR LINE MIGHT EASILY RESULT IN A BUMP.

CHARACTERISTICS OF BUMPS

THE TERM "BUMP" IS ENGLISH IN ORIGIN, ACCORDING TO GEORGE S. RICE, CHIEF MINING ENGINEER OF THE U. S. BUREAU OF MINES. A BUMP IN THE COAL FIELDS OF HARLAN COUNTY, KENTUCKY MAY BE DEFINED AS A SUDDEN VIOLENT EXPULSION OF COAL FROM ONE OR MORE PILLARS, ACCOMPANIED BY A LOUD REPORT AND EARTH TREMORS. SHATTERING AND PULVERIZATION ARE ALWAYS CHARACTERISTIC OF A BUMPED PILLAR. SEE PLATE VIII, FIGURES 1 AND 2. A FINE BROWN DUST, THE RESULT OF EXTREME PULVERIZATION, IS ALWAYS RRESENT. ROOF OR FLOOR MOVEMENTS MAY OR MAY NOT BE PERCEPTIBLE.

OF ALL THE PROBLEMS TO BE SOLVED IN A COAL MINE BY THE SAFETY ENGINEER, BUMPS ARE THE MOST DIFFICULT OF SOLUTION, BECAUSE THEY OCCUR SUDDENLY AND WITHOUT WARNING. THEY OCCUR, IN ALL CASES INVESTIGATED, IN PILLAR WORK, PANELS OF ABOUT 20 ROOMS ARE USUALLY PILLARED OUT, THE BREAK LINE FREQUENTLY BEING AT A 45° ANGLE WITH THE ENTRY, BUT, AT LEAST, ONE COMPANY MAINTAINS A BREAK LINE PARALLEL TO THE ENTRY. PILLARS ARE USUALLY WORKED ON THE BACK END WITH ONE SIDE OF THE WORKING PLACE OPEN TO THE PILLARED AREA. EXCEPT WHEN A PILLAR SECTION IS STARTING THE PILLARS ARE MINED BY PICK WORK, WITH FROM TWO TO FOUR MEN ON EACH PILLAR.

SOME OF THE OFFICIALS AND WORKMEN QUESTIONED, HAVE STATED THAT THERE IS AN UNUSUAL "QUIETING" OF THE PILLAR AND THAT THE COAL TIGHTENS OR BECOMES WOODY, JUST BEFORE A BUMP OCCURS. IN OTHER CASES INVESTIGATED THIS WAS NOT TRUE, THE BUMP OCCURRING WHEN NO CHANGE TOOK PLACE IN THE USUAL WORKING OF THE PILLAR.

THE VIOLENCE OF A BUMP IS USUALLY MEASURED BY THE AMOUNT OF COAL SHATTERED, THIS VARYING IN CASES INVESTIGATED FROM A FEW TONS TO 3,000 TONS. THE COAL IS THROWN OFF IN GREAT VIOLENCE, TAKING TIMBERS, TRACK, MINE CARS AND EVERYTHING IN ITS PATH ALONG WITH IT. SEE PLATE VIII, FIGURE 2. MINE CARS, IF OF WOOD, ARE BROKEN TO PIECES AND IF OF STEEL CONSTRUCTION, THEY ARE BENT AND TWISTED OUT OF SHAPE. TWENTY AND THIRTY POUND STEEL RAILS ARE BENT. SOMETIMES THE FLOOR HEAVES WHILE IN OTHER CASES THE ROOF BREAKS. SOMETIMES BOTH OCCUR, WHILE AGAIN, NEITHER OCCURS.

THE FORCE OF THE BUMP SEEMS TO COME FROM WITHIN THE PILLAR AND NOT FROM THE GENERAL VICINITY OF THE PILLAR. EVEN THOUGH THE WHOLE PILLAR, OR ONLY A PART OF A PILLAR IS SHATTERED AND COAL THROWN OFF ALL AROUND THE PILLAR, THERE SEEMS TO BE A WELL DEFINED LINE OF GREATEST FORCE, LEAVING IN THE PILLAR A FUNNEL-SHAPED EXCAVATION SEVERAL FEET IN DIAMETER. SEE PLATE VIII, FIGURE 1.

EXPLANATION TO PLATE VIII

FIGURES 1 AND 2 SHOW THE RESULT OF A MAJOR BUMP WHERE HUNDREDS OF TONS OF COAL WERE EXPELLED FROM THE PILLARS. IN FIGURE 1 THE FUNNEL-SHAPED OPENING AT THE TOP OF THE SEAM IS VERY CHARACTERISTIC, IN THAT IT IS NEARLY ALWAYS PRESENT IN A BUMPED PILLAR AND SHOWS THE DIRECTION FROM WHICH THE GREATEST LINE OF FORCE CAME.

FIGURE 2 IS CHARACTERISTIC OF THE DAMAGING RESULTS OF A BUMP. THE COAL, ALONG WITH TRACK AND TIMBERS, WERE BLOWN ACROSS THE HAULWAY AND COMPLETELY FILLED THE ROOM. A STEEL RAIL MAY BE SEEN PROJECTING FROM THE COAL AT THE EXTREME RIGHT OF THE FIGURE.

FIG. 1

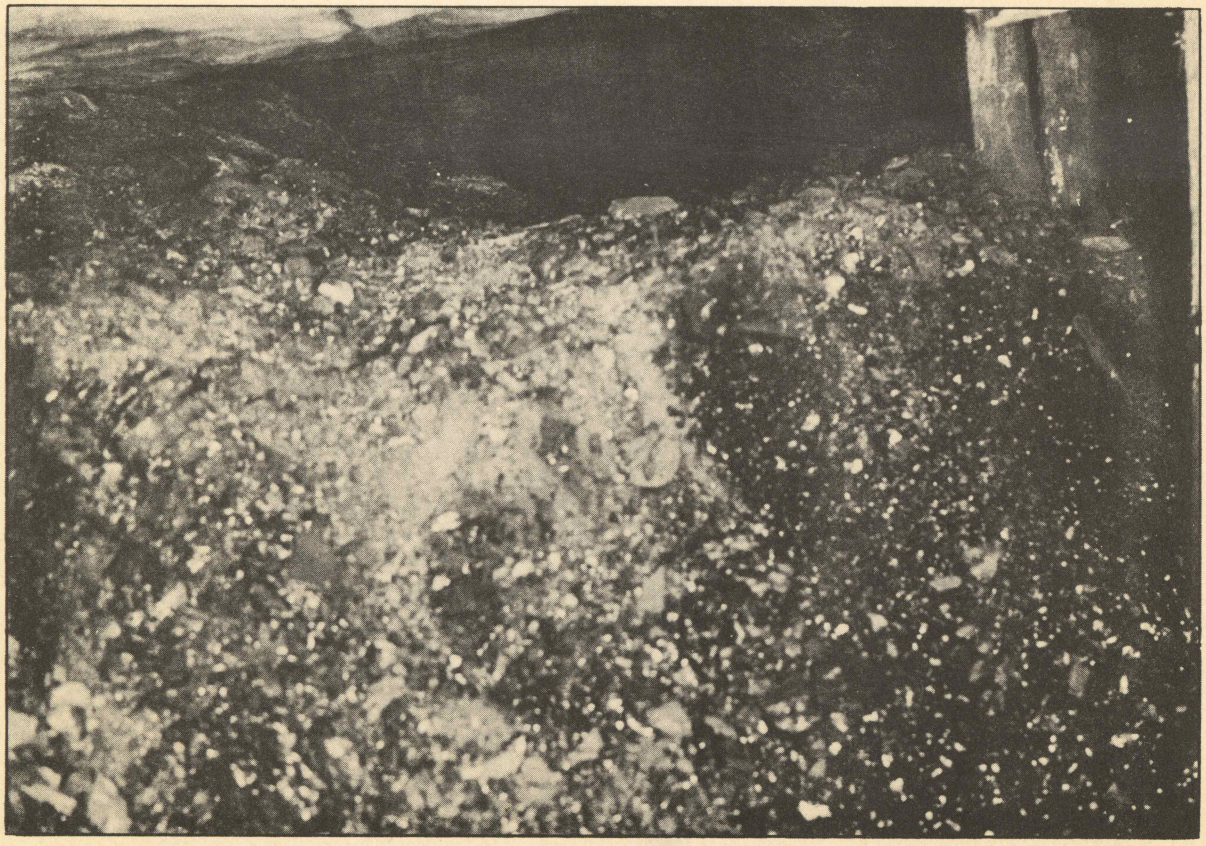


FIG. 2

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ONE BUMP IN WHICH ABOUT 100 TONS OF COAL WERE VIOLENTLY THROWN OFF, LEFT A COMPLETELY EXCAVATED HAULWAY IN THE PILLAR, THROUGH WHICH A 48" GAUGE TRACK WAS LAID WITHOUT ANY CLEANING UP BEING NECESSARY.

IN ANOTHER CASE, EIGHT PILLARS ABOUT 60 FEET BY 40 FEET BY 5 FEET, WERE COMPLETELY SHATTERED, FILLING ALL OF THE EXCAVATIONS AROUND EACH PILLAR WITH COAL. IN NEARLY ALL CASES, THE COAL THROWN OFF IS BROKEN DOWN SMALL ENOUGH TO LOAD INTO MINE CARS BY SHOVEL. A GREAT DEAL OF PULVERIZATION TAKES PLACE AS IS EVIDENCED BY BROWN COAL MARKINGS ON ROOF AND WALLS. IN MOST CASES, AFTER A BUMP OCCURS, THERE IS A GAP OF FROM ONE TO SEVERAL INCHES BETWEEN THE TOP OF THE PILLAR AND THE ROOF.

THE MOST VIOLENT BUMPS ARE NOT ALWAYS THE MOST DANGEROUS. SOMETIMES A BUMP OF LITTLE VIOLENCE HAS CAUSED INJURY OR DEATH, WHILE A BUMP OF GREAT VIOLENCE HAS CAUSED NO INJURY. THIS IS SOMETIMES ACCOUNTED FOR BY THE LOCATION OF THE MEN IN THE WORKING PLACE AND SOMETIMES BY THE FACT THAT A BUMP MAY OCCUR IN AN IDLE SECTION OR IT MIGHT OCCUR ON AN IDLE DAY. IN SOME INSTANCES, WHERE THERE ARE TWO MEN WORKING IN THE SAME PLACE, ONE MAY BE KILLED, WHILE THE OTHER, ONLY FIVE FEET AWAY, ESCAPES INJURY. THE MOST VIOLENT BUMP, WHERE AT LEAST THREE THOUSAND TONS OF COAL WERE THROWN OFF OF SEVERAL PILLARS, CAUSED DEATH TO BUT ONE MAN, ALTHOUGH FOURTEEN MEN WERE INVOLVED. ANOTHER BUMP, WHERE ONLY ABOUT 15 TONS OF COAL WERE THROWN OFF, KILLED TWO MEN.

EVIDENCE SHOWS THAT, GENERALLY, BUMPS DO NOT OCCUR WHERE THE OVERBURDEN IS LESS THAN 800 FEET, BUT THERE HAS BEEN AT LEAST ONE BUMP UNDER 500 FEET OF COVER. IN THE LATTER CASE THERE WAS VERY LIKELY A TRANSFERENCE OF WEIGHT FROM AN ADJACENT SECTION OF THE MINE HAVING AT LEAST 800 FEET OF COVER.

PLATE IX SHOWS IN DETAIL THE ACTUAL CONDITIONS OF A BUMP IN WHICH TWO MEN WERE KILLED IN THE HARLAN COUNTY FIELDS.

IN THIS CASE, A SLAB WAS BEING DRIVEN IN THE ENTRY PILLAR BETWEEN NO. 4 AND NO. 5 ROOMS. THE SLAB HAD BEEN DRIVEN ABOUT 12 FEET WHEN THE BUMP OCCURRED. AS SHOWN BY THE SKETCH, THE SLAB WAS ABOUT 25 FEET WIDE AT THE FACE. THE COAL WAS 55" IN THICKNESS. TWO MEN WERE WORKING IN THIS PLACE. AT THE TIME OF THE BUMP NO. 1 MAN WAS WORKING IN THE LEFT HAND CORNER AT THE FACE. NO. 2 MAN WAS WORKING AT THE LEFT HAND RIB ABOUT 12 FEET BACK FROM THE FACE. A WITNESS WAS STANDING IN THE ENTRY ABOUT 40 FEET FROM WHERE THE NO. 1 MAN WAS WORKING. AN EMPTY MINE CAR AND A GATHERING LOCOMOTIVE WERE IN THE PLACE, THE MOTOR BEING OUTBY THE CAR.

FROM THE SKETCH IT WILL BE SEEN THAT ABOUT 45 TONS OF COAL WERE SUDDENLY BLOWN OUT, ADVANCING THE WORKING FACE ABOUT 16 FEET. ABOUT HALF OF THE BLOWN OUT COAL WAS IN ONE LUMP.

THE MAN WORKING AT THE FACE WAS THROWN, ALONG WITH THE COAL, AGAINST THE END OF THE MINE CAR WITH A FORCE SUFFICIENT

TO CRUSH THE END OF THE CAR. THIS MAN WAS FOUND INSIDE THE CAR, WHICH WAS FORCED DOWN THE TRACK A DISTANCE OF 25 FEET. THE MOTOR WAS FORCED DOWN THE TRACK A DISTANCE OF ABOUT 35 FEET AND THEN DERAILED. THE MAN WORKING 16 FEET FROM THE FACE WAS FOUND ON THE ENTRY. HE HAD BEEN KNOCKED A DISTANCE OF 16 FEET. STANDING TIMBERS THROUGHOUT THIS AREA AND 60 FEET FROM THE FACE WERE KNOCKED OUT.

THE SKETCH IN THE UPPER RIGHT HAND CORNER SHOWS THAT THE FORCE OF THIS BUMP WAS COMING FROM THE ROBBED AREA. ITS DIRECTION WAS EXACTLY ALONG THE FACE CLEATS OF THE COAL.

THIS PARTICULAR ACCIDENT IS TYPICAL AND GIVES AN IDEA OF THE INTENSITY OF A MINOR BUMP AFFECTING ONLY A SMALL PORTION OF A PILLAR. IT IS EASILY SEEN THAT THE LOSS OF LIFE MIGHT BE GREATER, IN THE EVENT THAT MORE THAN ONE PILLAR IS SIMULTANEOUSLY AFFECTED.

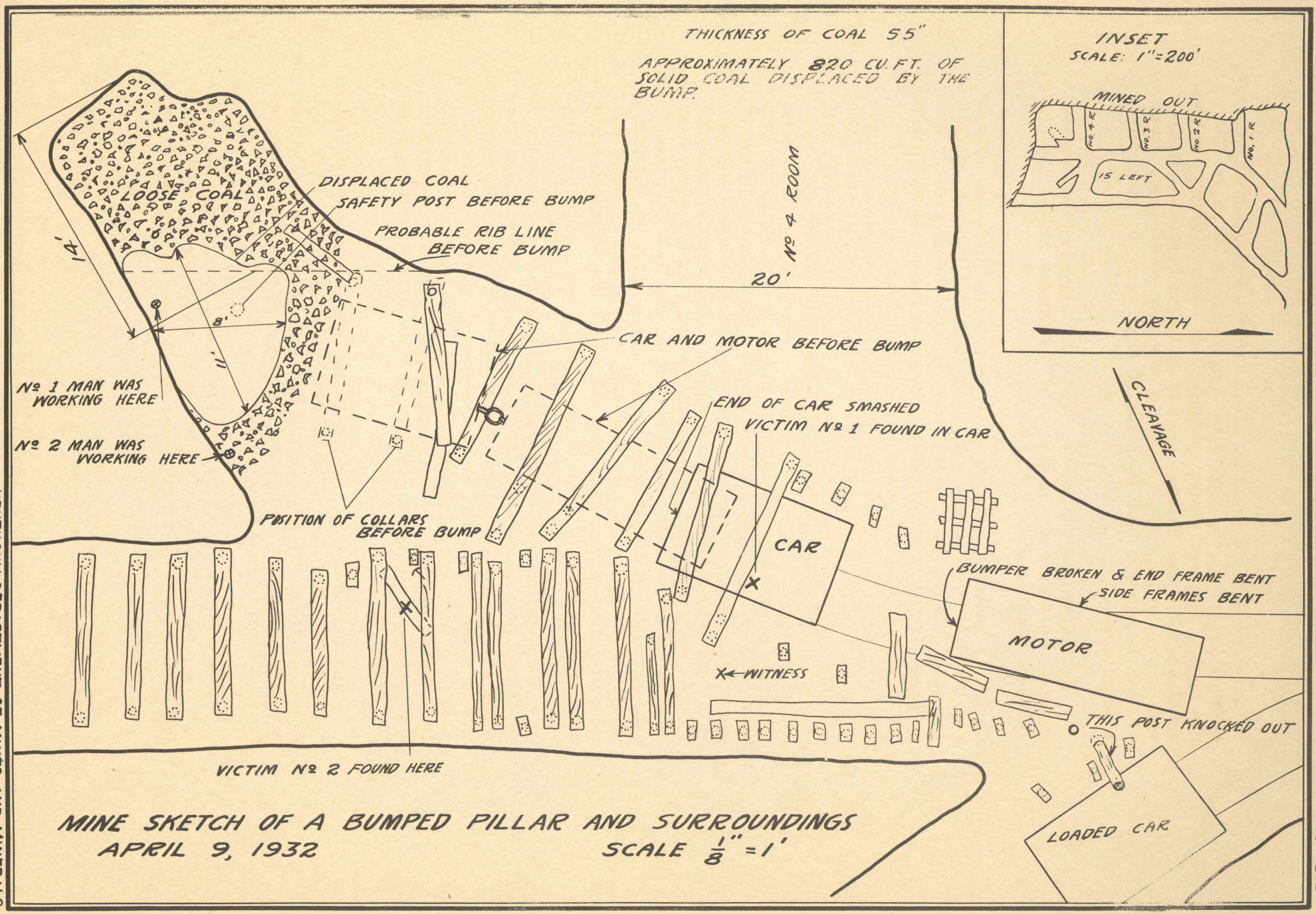
RELATION OF BUMPS TO GEOLOGIC STRUCTURE

THE COMPRESSIONAL FORCES RESULTING IN THE NORTHWESTWARD THRUSTING OF THE CUMBERLAND BLOCK HAVE DEVELOPED A SYSTEM OF JOINTS AND FISSURES IN THE SANDSTONES, SHALES AND COALS IN THIS PART OF THE MIDDLESBORO SYNCLINE. THE FORCES NECESSARY TO PUSH THIS HUGE MASS OF SEDIMENTARY ROCK AN ESTIMATED DISTANCE OF 7 MILES ACROSS THE INCLINED PLANE OF THE PINE MOUNTAIN FAULT HAVE RESULTED IN STRESSES WHICH MAY STILL EXIST IN THE COAL MEASURES OF THIS AREA. AT ANY RATE, THE FORCES OF OVERTHRUSTING HAVE DEVELOPED PRONOUNCED CLEAVAGE PLANES AND A MARKED BRITTLENESS OF THE COAL.

THESE CONDITIONS WORK HAND IN HAND WITH THE EXCESSIVE OVERBURDEN SO THAT IN THE PROCESS OF THE REMOVAL OF PILLARS CERTAIN AREAS ARE THROWN OUT OF ADJUSTMENT. THIS SHIFTING OF PRESSURE CAUSES SUDDEN OUTBURSTS OF COAL WHICH ARE COMMONLY CALLED "BUMPS". THEY ARE OF VARYING VIOLENCE, FREQUENTLY RESULTING IN THE LOSS OF LIFE AND PROPERTY DAMAGE. IT IS, THEREFORE, THE REGIONAL STRUCTURAL ASPECTS THAT ARE A CONTRIBUTORY FACTOR TO BUMPS.

PLATE IV SHOWS THAT THE DIPS IN THIS PARTICULAR PORTION OF THE BUMP AREA ARE SELDOM IN EXCESS OF 100 FEET PER MILE. THE NORMAL REGIONAL DIP FOR EASTERN KENTUCKY RANGES FROM 30 TO 40 FEET PER MILE. THE RATE OF DIP IN THIS AREA IS SO SLIGHT THAT THE SEAMS ARE CLASSED AS "FLAT-LYING".

THE DIPS AND TYPES OF FOLDING REMAIN FAIRLY CONSTANT THRUOUT THE BUMP AREA AND WE ARE NOT ABLE IN ANY CASE TO ATTRIBUTE THE CAUSE OF A BUMP TO ANY LOCAL STRUCTURAL FEATURES.



MINE SKETCH OF A BUMPED PILLAR AND SURROUNDINGS

APRIL 9, 1932 SCALE $\frac{1}{8}$" = 1'

KENTUCKY DEPARTMENT OF MINES AND MINERALS
GEOLOGICAL Lexington. Kentucky DIVISION

PLATE IX

RELATION OF BUMPS TO OVERBURDEN

THERE IS A DIRECT RELATION OF BUMPS TO OVERBURDEN. ALL OF THE SEVERE BUMPS HAVE OCCURRED IN AREAS WHERE THE OVERBURDEN RANGES FROM 500 TO 2000 FEET.

BUMPS ORDINARILY DO NOT OCCUR IN AREAS WHERE THERE IS A COVER LESS THAN 500 FEET. ALSO, FALLS EXTENDING TO THE SURFACE COMMONLY OCCUR IN THIS ZONE (0 - 500 FEET) AS THE JOINT PLANES ARE WEATHERED TO SOME EXTENT AND ARE FREQUENTLY CLAY-FILLED. THE ROOF IS EASILY BROKEN UNDER THESE CONDITIONS THUS RELIEVING ANY EXCESSIVE STRESS ON THE PILLAR.

BUMPS OCCUR WHERE THE OVERBURDEN IS IN EXCESS OF 500 FEET AS A RESULT OF ADDED PRESSURE ON THE PILLARS AND THE INFREQUENCY OF ROOF FALLS EXTENDING TO THE SURFACE.

REFERENCE TO THE STRATIGRAPHIC SECTION, PLATE V, SHOWS THAT APPROXIMATELY TWO-THIRDS OF THE STRATA ABOVE THE "C" AND HARLAN SEAMS OF COAL CONSISTS OF SANDSTONE, AND ONE-THIRD IS SHALE. THE AVERAGE WEIGHT PER CUBIC FOOT OF SANDSTONE IN THIS AREA IS ABOUT 147 POUNDS AND THAT OF SHALE IS 162 POUNDS PER CUBIC FOOT. THE WEIGHT IN POUNDS PER SQUARE FOOT WITH AN OVERBURDEN OF 2000 FEET IS APPROXIMATELY 304,000 POUNDS AND THE WEIGHT WITH 500 FEET OF OVERBURDEN IS APPROXIMATELY 75,000 POUNDS PER SQUARE FOOT. THE WEIGHTS PER SQUARE INCH BEING 2,111 AND 521 POUNDS RESPECTIVELY.

TO THE CASUAL OBSERVER, THESE OVERBURDEN WEIGHTS MAY SEEM TO BE IN EXCESS OF THE CRUSHING STRENGTH OF THE COAL. ORDINARILY THEY ARE NOT, BUT WHERE THE OVERBURDEN IS NOT PROPERLY HANDLED ADDITIONAL WEIGHT IS SHIFTED TOWARD THE COAL, WHICH FREQUENTLY IS IN EXCESS OF ITS CRUSHING STRENGTH. FOR A FURTHER DISCUSSION OF THIS, SEE CAUSES OF BUMPS.

CAUSES OF BUMPS

BUMPS ARE NOT LIMITED TO ANY ONE CAUSE. HOWEVER, AS A RESULT OF A STUDY OF THIS PROBLEM, IT IS EVIDENT THAT CERTAIN CONTRIBUTING FACTORS ARE OUTSTANDING.

THE FORCE REQUIRED FOR THE MOVEMENT AND CRUSTAL DEFORMATION OF THE CUMBERLAND OVERTHRUST BLOCK SET UP COMPRESSIONAL STRESSES WITHIN THE SANDSTONES, SHALES AND COALS. UNDER CERTAIN MINING METHODS, NOT DESIGNED TO CONTROL OR RENDER THEM HARMLESS, THESE POTENTIAL FORCES ARE SUDDENLY RELEASED RESULTING IN THE SHATTERING OF A PART OR, IN SOME CASES, A WHOLE PILLAR.

BUMPS OF GREAT INTENSITY HAVE NOT OCCURRED IN ANY OF THE MINES IN HARLAN COUNTY WHERE THE OVERBURDEN IS LESS THAN 500 FEET. EXCESSIVE OVERBURDEN, NOT PROPERLY HANDLED, THEN SEEMS ONE OF THE REQUIRED FACTORS. THERE ARE AREAS IN THE ADJACENT

EXPLANATION TO PLATE X

FIGURE 1 SHOWS THE GRADUAL SETTLING OF THE ROOF BEHIND THE LINE OF EXTRACTION. EVIDENTLY, SINCE SUPPORTING TIMBERS NEAR THE COAL SHOW NO SIGNS OF BENDING, THIS CONDITION WOULD HAVE NO EFFECT IN CAUSING A BUMP AS LONG AS COAL EXTRACTION IS KEPT AHEAD OF THE RATE OF BENDING IN THE ROOF.

FIGURE 2 SHOWS THE METHOD OF REMOVAL OF COAL IN A SINGLE PILLAR. THE CORNER "A" IS USUALLY KEPT AHEAD OF THE OUTSIDE CORNER BUT WHEN IT IS TOO FAR IN ADVANCE, IT IS LIKELY TO TIGHTEN AND A BUMP MAY RESULT. A PART OF THIS PILLAR IS LEFT PROJECTING IN THE GOB WHILE THE ADJACENT PILLARS HAVE BEEN SLABBED ALL THE WAY ACROSS.

FIGURE 3 SHOWS AN INCORRECT WAY TO WORK A PILLAR AND IS LIKELY TO RESULT IN A BUMP AT "A".

FIGURE 4 SHOWS THE RESULT OF HOGGING THE LOOSE COAL AT "A". TIGHT CORNERS ARE LEFT PROJECTING BACK OF THE EXTRACTION LINE THUS CREATING A BUMP CONDITION.

FIGURE 5 SHOWS A CONDITION BROUGHT ABOUT BY GOUGING A PILLAR. A SET UP LIKE THIS HAS CAUSED A WHOLE PILLAR TO BUMP AND KILL TWO MEN.

FIGURE 6 SHOWS WORKING ROOMS OF ORIGINAL BARRIER PILLAR WHICH HAS BEEN SUBJECTED TO ADDITIONAL WEIGHT DUE TO POOR ROBBING. CONDITIONS LIKE THIS HAVE RESULTED IN BUMPS AND THE DEATH OF MEN.

FIGURE 7 SHOWS TWO 45° PILLAR LINES (45° ANGLE TO ENTRIES) IN A PANEL CONVERGING AT "A". THIS CONDITION IS VERY LIKELY TO RESULT IN A BUMP IN THE VICINITY OF "A".

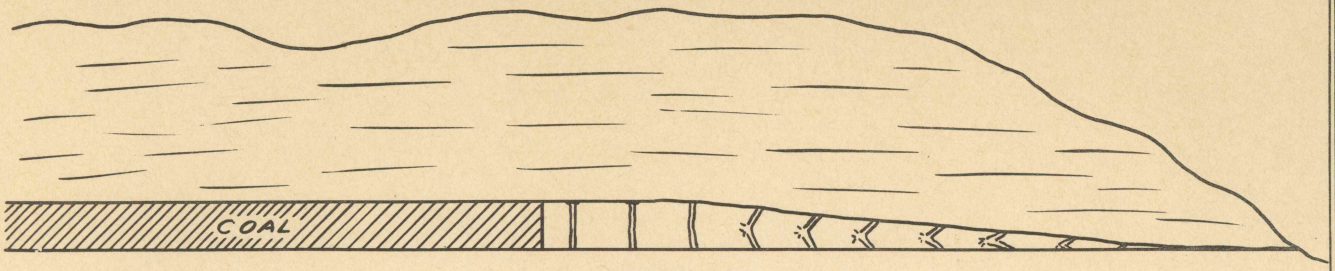


FIG. 1

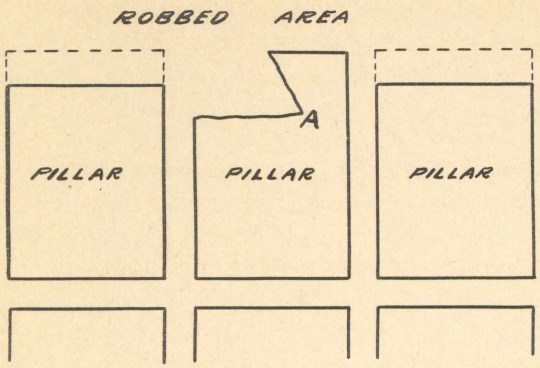


FIG. 2

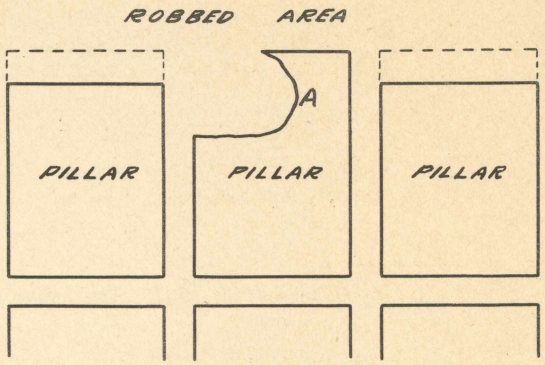


FIG. 3

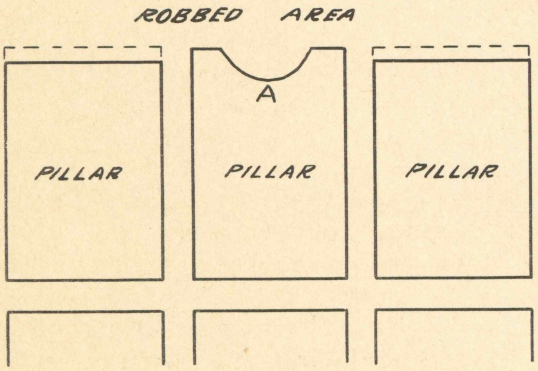


FIG. 4

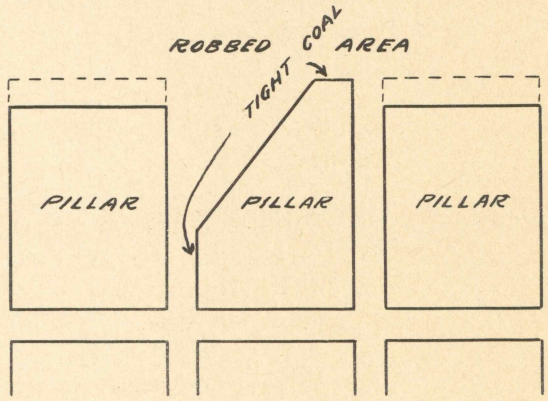


FIG. 5

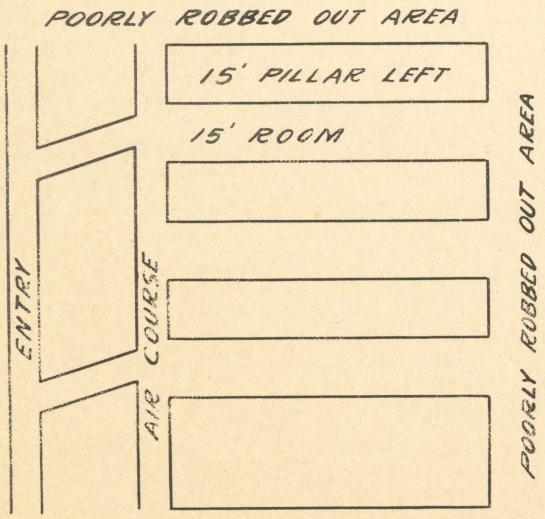


FIG. 6

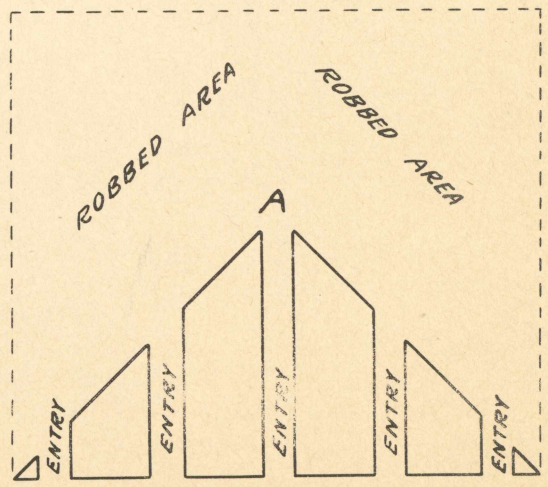


FIG. 7

PILLAR SKETCHES BY JOHN MAURICE

KENTUCKY DEPARTMENT OF MINES AND MINERALS
GEOLOGICAL Lexington, Kentucky DIVISION

COAL FIELDS OF KENTUCKY, WEST VIRGINIA AND VIRGINIA WHERE COVER IS SUFFICIENT TO PRODUCE BUMPS, IF THAT WERE THE SOLE CAUSE. THE FACT THAT BUMPS IN THIS REGION ARE CONFINED TO THE CUMBERLAND OVERTHRUST BLOCK INDICATES THAT THEY OCCUR AT LEAST PARTIALLY AS A RESULT OF THE COMPRESSIONAL FORCES CAUSED BY THIS CRUSTAL MOVEMENT.

THE SUDDEN SHIFTING IN THE OVERBURDEN OF CERTAIN AREAS AS THE RESULT OF THE RELEASE OF PRESSURE AT ONE POINT AND ITS CONSEQUENT INCREASE AT ANOTHER, CAUSES VIBRATIONS OF THE ROOF, FLOOR AND COAL PILLARS SUFFICIENT IN INTENSITY TO CAUSE THE PILLARS TO BUMP. THESE LOCAL EARTH TREMORS NEED NOT BE ACCOMPANIED BY APPRECIABLE VERTICAL OR LATERAL MOVEMENTS.

AT THE TIME THE MINES IN THIS PORTION OF THE CUMBERLAND OVERTHRUST BLOCK WERE OPENED THERE WAS NO THOUGHT GIVEN TO THE POSSIBILITY THAT THE STRUCTURAL CONDITIONS AND EXCESSIVE OVERBURDEN MIGHT RESULT IN BUMPS. MINES WERE, THEREFORE, NOT DESIGNED TO COPE WITH THESE CONDITIONS. IN THE EARLY STAGES OF PILLAR WORK AREAS WERE ROBBED, NATURALLY, WHERE THE COAL COULD BE MINED AT THE LOWEST POSSIBLE COST. AS A RESULT SOME MINES HAVE ROBBED AREAS SCATTERED PROMISCUOUSLY THRUOUT THEIR PROPERTIES. THIS HAS BROUGHT ABOUT, AT PRESENT, CONDITIONS WHICH INDUCE BUMPS AND WILL CONTINUE TO DO SO IN A GREATER DEGREE UNLESS THESE SMALL SCATTERED ROBBED AREAS ARE BROUGHT TOGETHER BY NEW ROBBING SO AS TO GIVE A FEW LARGE ROBBED AREAS WHERE THE MOUNTAIN WILL BE CAVED TO THE SURFACE AND BROUGHT TO REST ON THE FLOOR OF THE SEAM.

GENERALLY SPEAKING, AN EFFORT IS MADE IN PILLAR WORK TO REMOVE ALL THE PILLARS. HOWEVER, WHERE COAL IS THIN, DUE TO THE PRESENCE OF A "FAULT" OR THE COAL BECOMES BADLY LAMINATED THERE IS A TENDENCY TO LEAVE THESE PILLARS BEHIND. BAD SLATE FALLS AND THE HIGH COST OF ITS REMOVAL MAKE IT SEEM ADVISABLE TO LEAVE CERTAIN PILLARS AND STUMPS UNMINED. THESE CONDITIONS RESULT IN THE WEIGHT OF THE OVERLYING STRATA BEING SHIFTED. THIS ARTIFICIAL ADJUSTMENT, FREQUENTLY IS IN A DIRECTION TOWARD THE WORKING FACE, AND IN SOME CASES, RESULTS IN BUMPS. PRESSURE THUS EXERTED MAY BUMP EITHER PILLARS ON THE PILLAR LINE OR THOSE BACK OF IT.

THE COAL HAS A CRUSHING STRENGTH WHICH IS SUFFICIENT TO WITHSTAND THE PRESSURE OF 2000 FEET OR MORE OF OVERBURDEN IF MINING IS CARRIED ON PROPERLY. HOWEVER, IN ALL CASES INVESTIGATED WHERE BUMPS HAVE OCCURRED, THERE WAS EVIDENCE IN THE COAL AND ADJACENT STRATA, AND TESTIMONY OF WORKMEN AND OFFICIALS, SUFFICIENT TO FORCE US TO THE CONCLUSION THAT COAL WAS LEFT IN ROBBED SECTIONS IN SUCH QUANTITIES AND IN SUCH LOCATIONS THAT IT WOULD BRING UPON THE BUMPED PILLAR, A PRESSURE BEYOND IT STRENGTH TO BEAR.

IN FACT, IT WAS FOUND THAT IN SOME CASES PILLARS WERE ROBBED WITHOUT ANY REGARD, WHATSOEVER, TO THE SIGNIFICANCE AND AMOUNT OF THE OVERBURDEN. IT WAS FOUND, ALSO, THAT SOME COMPANIES DOING EXCELLENT MINING IN REGARD TO THESE CONDITIONS,

WERE HAVING BUMPS BECAUSE THEIR NEIGHBOR OPERATOR HAD NOT DONE SO.

A COMPETENT BED OF SANDSTONE DIRECTLY ABOVE THE COAL SEAM IS AN IMPORTANT CONTRIBUTING FACTOR TO BUMPS. A GREATER PART OF THE BUMPS OF THE HARLAN FIELD HAVE OCCURRED WHERE THERE WAS A SANDSTONE OR PERHAPS A VERY SANDY SHALE (SLATE) ROOF.

THE PRESENCE OF A TOUGH, DENSE, RESISTANT SANDSTONE ABOVE THE COAL PREVENTS GOOD FALLS ESPECIALLY ON SHORT PILLAR LINES. IN THE PROCESS OF ROBBING, LARGE MASSES OF UNBROKEN SANDSTONE PROJECT BEYOND THE PILLAR LINES. IN ONE CASE IT WAS OBSERVED THAT THE SANDSTONE ROOF BENT TO THE FLOOR WITHOUT BREAKING AND PROJECTED OVER A HORIZONTAL DISTANCE OF AT LEAST ONE HUNDRED YARDS. SEE PLATE X, FIGURE 1.. THE VERTICAL DISTANCE IN THIS PARTICULAR CASE WAS ABOUT FOUR FEET. AS THE ROOF GRADUALLY BENDS TOWARD THE FLOOR SHEARING STRESSES ARE LIKELY TO ORIGINATE NEAR THE WORKING FACE OF THE COAL AND ORDINARILY THIS IS NOT ENOUGH TO BUMP A PILLAR UNLESS CONDITIONS ARE PRESENT LIKE THOSE SHOWN IN PLATE X, FIGURES 2 - 7.

IT HAS BEEN NOTED THAT WHEREVER A SANDSTONE OR SANDY SHALE EXISTS ABOVE THE COAL THERE IS A SLIGHTLY UNDULATING SURFACE OR, IN CASE OF A ROLL, A DECIDED CHANNELING IN THE COAL. IN AREAS WHERE A FINE GRAINED CLAY SHALE EXISTS AS A ROOF, THE CONTACT BETWEEN THE COAL AND SHALE IS A MORE EVEN SURFACE. THE INFERENCE TO BE DRAWN IS THAT THE UNDULATING SANDSTONE ROOF RESISTS BY FRICTION ANY LATERAL MOVEMENT OF THE COAL AND PLACES THE COAL UNDER ADDITIONAL STRAIN. THE EVEN SURFACE OF CLAY SHALE SERVES AS A ZONE OF FLOWAGE AND YIELDS TO LATERAL MOVEMENT, THUS AVOIDING BUMPS IN CASES WHERE LATERAL PRESSURES MIGHT OTHERWISE CAUSE THE PILLARS TO BUMP. THIS PHENOMENON HAS BEEN OBSERVED WHERE THE SHALE SHOWED EVIDENCE OF SLICKENSIDING (POLISHED, SCRATCHED OR STRIATED ROCK SURFACES PRODUCED ALONG THE PLANE OF MOVEMENT) AND WAS CRUSHED AND SQUEEZED OUT OF ITS POSITION WHICH WAS ORIGINALLY JUST OVER THE COAL. IT WAS NOTICEABLE AT THIS PARTICULAR LOCALITY THAT THE SLATE WAS PROJECTING AS MUCH AS THREE INCHES BEYOND THE FACE OF THE COAL. THE SLICKENSIDING AND CRUSHED SLATE PROVING THAT THE SLATE IS CAPABLE OF GIVING WAY TO FORCES RATHER THAN TRANSMITTING THESE FORCES ON TO THE COAL.

RECOMMENDATIONS FOR THE PREVENTION OF BUMPS

IN THE OPINION OF THE WRITERS, BUMPS CAN BE ELIMINATED OR AT LEAST, MINIMIZED TO THE POINT OF RARE OCCURRENCES IN THE MINES OF HARLAN COUNTY IF MINING IS DONE WITH DUE REGARD TO THE UNUSUAL AMOUNT AND CONDITION OF THE OVERLYING STRATA.

IN MINES WHERE BUMPS HAVE BEEN MORE FREQUENT, WHERE PRESENT CONDITIONS ARE SUCH THAT THEY WILL LIKELY CONTINUE, AND WHERE MINING METHODS HAVE BEEN PURSUED TO THE EXTENT THAT A CHANGE IS IMPRACTICAL OR IMPOSSIBLE, THERE IS NO REMEDY EXCEPT THE ABANDON-

MENT OF THAT PARTICULAR SECTION OF THE MINE.

MINES IN WHICH BUMPS HAVE NOT OCCURRED SHOULD GIVE SPECIAL ATTENTION TO SOUND MINING METHODS, AS THEIR HAZARDS ARE INCREASED WITH THE CONSTANT EXTRACTION OF COAL.

THERE SHOULD BE A COOPERATIVE UNDERSTANDING BETWEEN OPERATORS IN THE REMOVAL OF COAL ALONG, OR NEAR, COMMON PROPERTY LINES, TO THE EXTENT THAT THEIR RESPECTIVE WORKINGS WILL OPERATE FOR THEIR MUTUAL BENEFIT AND NOT BE DETRIMENTAL TO EITHER OR BOTH.

IN MAKING SUGGESTIONS FOR THE PREVENTION OF BUMPS, IT IS DIFFICULT TO DISSOCIATE ANY ONE RECOMMENDATION FROM THE OTHERS. IN OTHER WORDS, ALL THE SUGGESTIONS HEREIN MENTIONED SHOULD BE CARRIED OUT IN UNISON TO OBTAIN THE BEST RESULTS IN GETTING ROOF FALLS AND GUARDING AGAINST BRINGING ON UNDUE STRESSES AND PRESSURES.

ONE OF THE MOST IMPORTANT FACTORS IN THE PREVENTION OF BUMPS IS KEEPING A STRAIGHT PILLAR LINE, AND A RESULTING STRAIGHT BREAK LINE. THIS LINE SHOULD BE AS LONG AS POSSIBLE, SO THAT A BREAKING LEVERAGE CAN BE PRODUCED IN THE OVERLYING STRATA. A PILLAR SECTION SHOULD NOT BE STARTED UNTIL IT HAS BEEN DETERMINED THAT EXTRACTION CAN CONTINUE OVER AN AREA OF NOT LESS THAN 100 ACRES. ORDINARILY THIS WOULD REQUIRE THE EXTRACTION OF A THREE ENTRY PANEL ABOUT 1000 FEET WIDE, AND 4500 FEET LONG. THE PANEL SHOULD BE ISOLATED FROM THE ADJACENT WORKINGS BY STRONG BARRIER PILLARS SUFFICIENT TO BREAK THE OVERBURDEN. WHERE THIS METHOD HAS BEEN PRACTICED AND EXTRACTION HAS BEEN COMPLETE, THE OVERBURDEN HAS BEEN BROKEN TO THE SURFACE ALMOST VERTICALLY ALONG THE BARRIER PILLARS. THE WHOLE AREA HAS BEEN SET DOWN ON THE FLOOR OF THE SEAM AND DISCONNECTED FROM THE REST OF THE MINE, ELIMINATING ITS INFLUENCE ON BUMPS. THIS HAS OCCURRED WHERE THE OVERBURDEN WAS MORE THAN 2000 FEET THICK.

IN CONNECTION WITH THE IDEA MENTIONED ABOVE, IT IS WELL TO KEEP IN MIND THE GEOLOGIC STRUCTURE OF THE OVERLYING ROCKS. IT SEEMS THAT BEFORE THIS TIME, THERE HAS BEEN NO OCCASION, IN THIS FIELD, TO ASSOCIATE MINING METHODS WITH GEOLOGY, AND HERE LIES ONE OF THE MOST IMPORTANT FACTORS IN THE PREVENTION OF BUMPS. BY THIS IT IS MEANT, THAT MINING METHODS SHOULD BE BASED ON A PREVIOUS STUDY OF THE REGIONAL GEOLOGY.

IN ANOTHER SECTION OF THIS PAPER, ENTITLED JOINTING IS A FULL DISCUSSION ON JOINT PLANES (PLANES OF WEAKNESS OR CRACKS). FROM FIELD OBSERVATIONS AND RESULTANT STUDIES IT IS FOUND THAT THESE CRACKS HAVE WELL DEFINED DIRECTIONS IN ALL PARTS OF THE BUMP AREA. IT IS NOTICEABLE ALSO THAT SURFACE CRACKS, HAVING OCCURRED OVER MINES WITH HEAVY COVER, WERE ALONG THESE JOINTS OR PLANES OF WEAKNESS. SOME MINES HAVE EXPERIENCED DIFFICULTY IN BREAKING THE OVERLYING STRATA, AND IT IS TRUE, THAT IT IS NOT AN EASY TASK WITHOUT FIRST MAKING A STUDY OF EXISTING CONDITIONS. WITH A KNOWLEDGE OF THE EXISTENCE, AND DIRECTION, OF THESE CRACKS MINING CAN, AND WE RECOMMEND THAT IT BE, CARRIED ON WITH PILLAR

LINE EXTRACTION PARALLEL TO ONE OF THESE SYSTEMS OF JOINTS. THIS OF COURSE, PERTAINS TO SYSTEMS THAT INVOLVE PILLARING.

SOME OF THE OPERATORS HAVE STATED THAT THIS GREAT AMOUNT OF STRONG OVERBURDEN, CANNOT BE BROKEN TO THE SURFACE, BUT IT IS OF NOTE TO MENTION HERE THAT, THE COMPRESSIONAL FORCES IN THE CUMBERLAND OVERTHRUST BLOCK HAVE ALREADY ACCOMPLISHED THIS IN THE FORM OF JOINTS AND CRACKS AND IT SEEMS THAT WITH THIS FACT IN MIND, A METHOD OF EXTRACTION, ACCOMPANIED BY COMPLETE MOUNTAIN CAVING, COULD BE CARRIED OUT SUCCESSFULLY.

IN BREAKING THE ROOF, IT IS OUR OPINION, THAT ACCUMULATIONS OF DEBRIS BE PREVENTED AS IN CASES WHERE SLUMPING AND SCALING OF THE ROOF IS ALLOWED, OR IN OTHER WORDS, BREAKING THE ROOF 20 OR 30 FEET UP. SEE PLATE XI. IF CONDITIONS LIKE THIS ARE ALLOWED TO ACCUMULATE, FURTHER COMPLICATIONS ARE SET UP. WHAT IS DESIRED, IS ESSENTIALLY THIS, THAT THE ROOF BE SET DOWN INTACT AS NEAR AS POSSIBLE ON THE FLOOR OF THE MINE, WITHOUT ANY ACCUMULATION OF DEBRIS. TO ACCOMPLISH THIS IT IS NECESSARY TO TEMPORARILY HOLD UP THE IMMEDIATE ROOF, THUS PREVENTING LOOSE BLOCKS OR PIECES OF ROCK FROM FALLING UNTIL ENOUGH COAL HAS BEEN EXTRACTED TO ALLOW A VACANT AREA LARGE ENOUGH FOR A BREAKING LEVERAGE TO BE ATTAINED. WITH THIS IN MIND, IT IS RECOMMENDED THAT TIMBERS BE LEFT STANDING, THAT ROOM AND ENTRY GOB BE HAULED OUTSIDE, OR LEVELED DOWN, AND THAT THE PILLARS BE EXTRACTED AS RAPIDLY AS POSSIBLE SO AS NOT TO BE SUBJECTED TO ANY UNNECESSARY SETTLING WEIGHT.

FROM AUTHORITATIVE SOURCES IT WAS LEARNED THAT, FOR VARIOUS ECONOMIC REASONS, PILLARS OF COAL RANGING IN NUMBER FROM ONE TO THIRTEEN HAVE BEEN LEFT AT PARTICULAR POINTS IN THE ROBBED AREAS. SOME OF THE REASONS GIVEN WERE: - UNMERCHANTABLE COAL, THIN COAL, ROLLS, WATER AND BAD ROOF. A GREAT MANY OF THESE ARE NOW INACCESSIBLE DUE TO THE FACT THAT THE APPROACH TO THEM HAS BEEN BLOCKED BY ROOF FALLS. HOWEVER, IT IS RECOMMENDED FOR THE PREVENTION OF BUMPS IN THE FUTURE, THAT ALL SUCH PILLARS IN FUTURE MINING BE REMOVED. REASONS FOR THIS, WHERE WEIGHT IS SHIFTED FORWARD, INSTEAD OF AWAY FROM THE PILLAR LINE, PREVENTING AT THE SAME TIME ROOF FALLS AND BREAKS, ARE EXPLAINED IN CAUSES OF BUMPS. IT MAY COST A LITTLE MORE, AT THE TIME, TO REMOVE ALL SUCH PILLARS, BUT SURELY THIS IS NOT AS EXPENSIVE AS THE LOSS OF LIFE, LOSS OF TIME AND THE DESTRUCTION OF THE MORALE OF THE MINERS. THIS RECOMMENDATION IS NOT MADE FROM A PURELY HYPOTHETICAL POINT OF VIEW, BUT FROM ACTUAL OBSERVATIONS AND STUDIES OF SUCH OPERATIVE METHODS AS ARE PRACTICED IN MINES THAT HAVE EXPERIENCED NO BUMPS.

IN OPENING A NEW MINE, WE RECOMMEND, FIRST, THAT A STUDY OF THE GEOLOGY BE MADE SO AS TO ASCERTAIN THE CONDITION OF THE ASSOCIATED STRATA AND TO DETERMINE WHAT SYSTEM OF MINING COULD BEST BE ADAPTED TO SAME. PLANS FOR WORKING THE COAL SHOULD BE BASED ON THE INFORMATION THUS DETERMINED. SECOND, THAT THE PLAN OF THE PROPOSED WORKINGS BE CO-ORDINATED WITH THE EXISTING WORKINGS OF ADJACENT MINES. THIRD, THAT IT BE CO-ORDINATED WITH THE FUTURE WORKINGS OF THE ADJACENT MINES TO THE END THAT

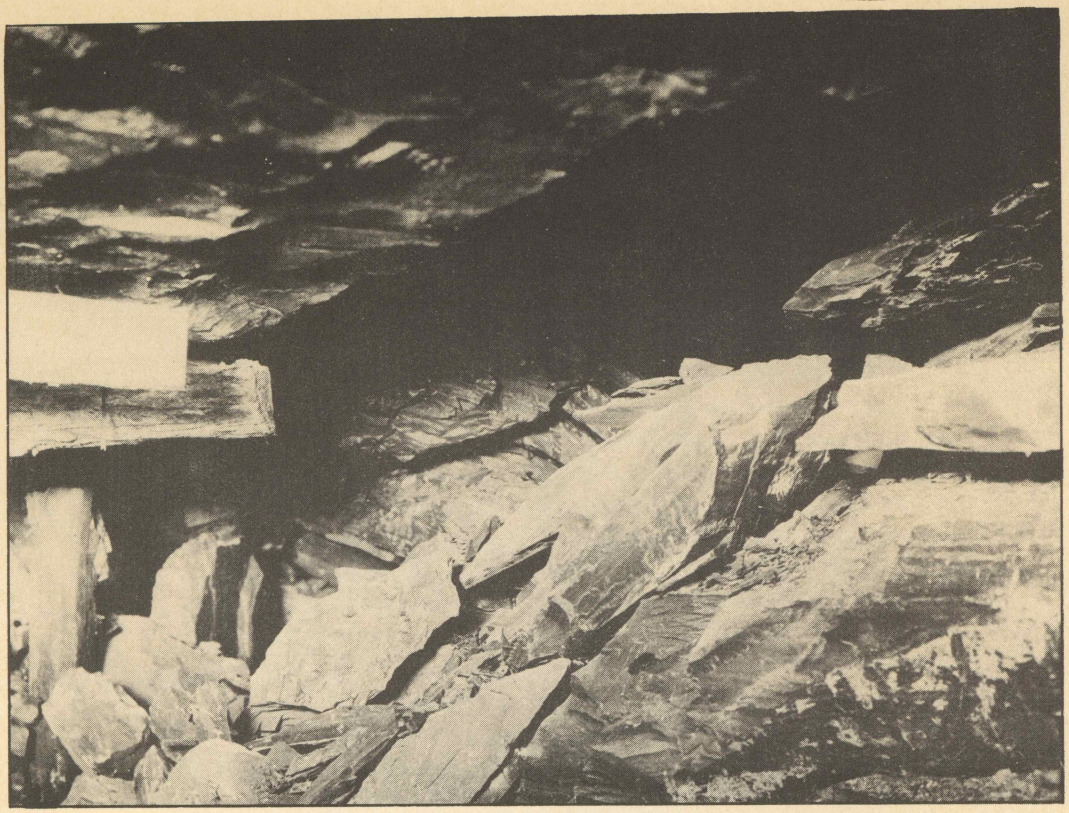


FIG. 1

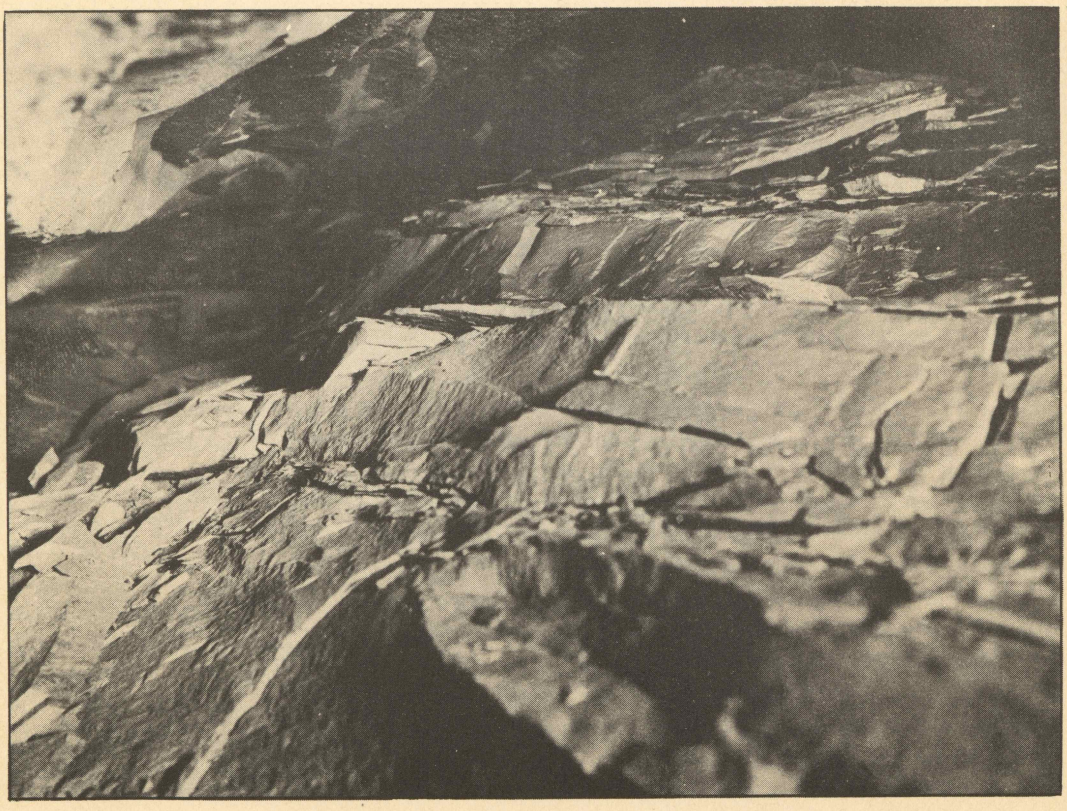


FIG. 2

KENTUCKY DEPARTMENT OF MINES AND MINERALS
GEOLOGICAL DIVISION
Lexington, Kentucky

THE TERRITORY AS A WHOLE MAY BE WORKED FOR THEIR MUTUAL BETTERMENT.

WHEN THE EXPLOITATION OF A COAL PROPERTY IS PLANNED, IT SHOULD BE DECIDED IN THE BEGINNING WHETHER ALL THE COAL IS TO BE EXTRACTED OR ONLY A PART OF IT. IF PLANS ARE ADOPTED WHICH INVOLVE TOTAL EXTRACTION IT IS CUSTOMARY AND ADVISABLE TO TAKE AS LITTLE COAL AS POSSIBLE ON THE ADVANCE UNTIL THE BACK END OF THE PROPERTY IS REACHED. IDEAL PILLAR EXTRACTION SHOULD START ON A CROP LINE WHERE POSSIBLE, AND BREAK LINES SHOULD BE MADE TO CONFORM WITH THE DIRECTION OF JOINTS, OR PLANES OF WEAKNESS, IN THE SUPERINCUMBENT STRATA. IF THIS IS DONE, TOGETHER WITH CLEAN EXTRACTION OF COAL, IT SHOULD BE LESS DIFFICULT TO GET MOUNTAIN BREAKS STARTED. PROGRESSIVE BREAKING OF THE OVERBURDEN TO THE SURFACE CAN BE CARRIED ON THRU OUT THE LIFE OF THE MINE.

IT IS NECESSARY TO KEEP IN MIND HERE THAT THE PILLAR LINE MUST BE KEPT STRAIGHT AND THAT NO PILLAR BE ALLOWED TO PROGRESS ANY FASTER OR SLOWER THAN ANY OF THE OTHERS. TO ACCOMPLISH THIS, WE SUGGEST THAT IN MAKING THE MINE SURVEY, ALL PILLARS BE MARKED AT INTERVALS CLOSE ENOUGH SO THAT THE FOREMAN CAN MAKE AN ACCURATE CHECK OF THE PROGRESS OF HIS SECTION EACH DAY AND COMPARE IT WITH THAT OF THE ADJOINING SECTIONS. THIS HAS BEEN PRACTICED TO SOME EXTENT AND HAS WORKED WITH REASONABLE SUCCESS. AT LEAST, IT IS MUCH BETTER THAN GUESS WORK.

SHORT PILLAR LINES, PILLARS NOT SYSTEMATICALLY EXTRACTED, INEXPERIENCED OFFICIALS AND WORKMEN, BROKEN WORKING TIME, ALL TEND TO MAKE CONDITIONS IDEAL FOR A "BUMP", ESPECIALLY UNDER HEAVY COVER. IN CONSIDERATION OF THESE FACTS IT IS ADVISABLE THAT OPERATING MEN AND ENGINEERS GIVE MORE TIME AND ATTENTION TO THESE MATTERS TO THE END THAT UNDER HEAVY COVER IT WOULD BE MUCH SAFER TO DISCONTINUE PILLAR WORK AS RAPIDLY AS PRACTICABLE AND THE SYSTEM OF DRIVING ENTRIES AND ROOMS, LEAVING A SMALL PILLAR FOR PROTECTION, BE ESTABLISHED.

IN THIS SYSTEM OF MINING ABOUT 20% TO 30% OF THE COAL MUST BE LEFT IN PILLARS OF SUCH SIZE AND IN SUCH LOCATIONS THAT THEY WILL BE SUFFICIENT TO SUPPORT THE OVERBURDEN. PLANS FOR EXTRACTION IN THIS METHOD AND ANY OTHER METHOD SHOULD BE MADE IN ADVANCE, TAKING INTO CONSIDERATION THE AMOUNT AND CHARACTER OF OVERBURDEN EACH SECTION OF THE MINE WILL HAVE TO BEAR.

WHERE PILLARING HAS BEEN IN EFFECT FOR YEARS IT IS SURPRISING TO KNOW THAT IN THE FINAL EXTRACTION MOST MINES AVERAGE FROM 72% TO 81% RECOVERY. THIS AMOUNT OF RECOVERY CAN BE ACQUIRED THRU THE "ENTRY AND ROOM" OR "NO PILLARING" SYSTEM AND WITH GREATER SAFETY TO THE MEN AT THE FACE.

SUMMARY

In this study of Mountain Bumps, we have arrived at such conclusions as might seem to make us offer drastic recommendations in as far as changes in mining methods and economical extraction are concerned. But, we feel that we have been very lenient in this matter and certainly have been unbiased in the formation of our opinions.

The results of our studies have led us to conclude that altho the immediate cause of bumps is probably due to a transmitted blow originating from the sudden subsidence of a higher stratum or to direct pressure on projecting pillars, we believe that the primary causes may be attributed to two factors, namely:

(A) Lack of knowledge of regional geologic structure.

(B) Improper mining, both in detail and in large scale extraction.

Geologic structure has been considered as an important phase in the solution of this problem and again we repeat that more attention be given it and especially so in the development of new sections and new mines.

Attention to pillar lines and detailed pillar extraction, we think has been more or less neglected. Leaving stumps and mining in scattered sections has been common practice. We think most officials concerned will agree with us in this. However unintentional, these causes nevertheless were factors in the development of bumps. Possibly economical conditions, fluctuating prices and markets for coal, in recent years, overshadowed matters pertaining to safety and altered existing plans for future development.

There is nothing mysterious in the occurrence of bumps. Accumulations of gas, if there were any, have had nothing to do with the causes, but it is entirely possible for gas to be released in conjunction with a bump.

BIBLIOGRAPHY

Annual Reports, Kentucky Department of Mines, 1910 to 1933

Ashley, G. H. and Glen, L. C. - Geology and Mineral Resources of Part of the Cumberland Gap Coal Field, Kentucky. U.S.G.S Professional Paper No. 49, 1906

Bryson, J. F. - Coal Bumps. Paper presented to 25th annual convention of Mine Inspectors Institute of America. May, 1934.

Butts, Charles - The Coal Resources and General Geology of the Pound Quadrangle of Virginia and Kentucky. U.S.G.S. Bulletin 541, 1912.

Mississippian Series of Eastern Kentucky, K.G.S. Series VI, Vol. 7, 1922.

Fensters in the Cumberland Overthrust Block in Southwest Virginia, Virginia Geological Survey, Bulletin 28, 1927.

Campbell, Marius R. - Geology and Mineral Resources of Wise County, Virginia, Virginia Geological Survey, Bulletin XXIV, 1923

Cash, F. E. and Allen, C. A. - Coal Losses in Kentucky, K.G.S. Series VI, Vol. 27, 1925.

Giles, Albert W. - Geology and Coal Resources of Dickenson County, Virginia, Virginia Geological Survey, Bul XXI, 1921.

McCall, T. L. - Further Notes on Bumps in No. 2 Mine, Springhill, Nova Scotia., A. I. M. E. Contribution No. 74, 1934.

McKenzie, W. A. - Annual Report of the Minister of Mines of British Columbia, 1932.

Morse, William Clifford - The Pennsylvanian Invertebrate Fauna of Kentucky, Paleontology of Kentucky, K. G. S,, Series VI, Vol. 36, 1931.

Phalen, William Clifton - Coal Resources of the Kenova Quadrangle,, U.S.G.S., Bulletin 285, 1905.

Rice, George S. - Bumps and Outbursts of Gas in the Mines of Crowsnest Pass Coalfield. British Columbia Department of Mines, Bulletin No. 2, 1918.

Occurrence of Bumps in the Springhill No. 2 mine of the Dominion Coal Company, Ltd., Nova Scotia Department of Public Works and Mines, 1924.

Stose, G. W. - Geology and Mineral Resources of Wise County, Virginia, Virginia Geological Survey, Bulletin No. XXIV .1923.

Wentworth, Chester Kenneth - The Geology and Coal Resources of the Middlesboro Basin in Kentucky. K.G.S., Series VI, Vol. 29, 1927.