Leichhardt Colliery Outbursts and Signs
John Hanes

Leichhardt Colliery was notorious for its outbursts during the 1970's. The details of the outbursts and the gas have been adequately covered in other publications. This presentation mainly aims to pictorially show some of the associated signs to help today's miners recognise outburst precursors.

The first outburst recognized after BHP took over mining occurred from the coal roof. The Gemini seam was 6 m thick and the bottom 3 m was being mined at the time. The outburst cone was about 1.5 m deep and was elliptical in plan with the long axis about 1.5 m and the short axis 1 m. The long axis was interpreted perpendicular to the maximum horizontal principal stress direction. In the overlying sandstone, the maximum principal stress was of the order of 35 MPa and the intermediate stress 20 MPa. Minimum stress was vertical and equal to overburden at around 15 MPa.

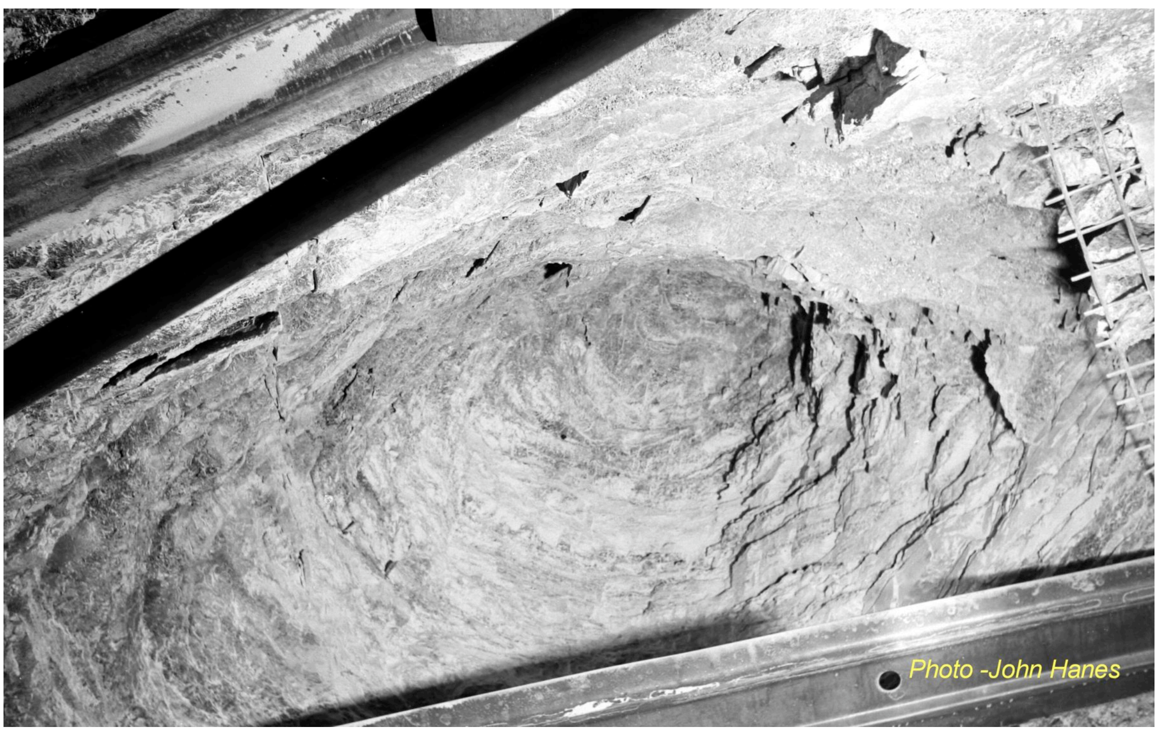

Figure 1
The first outburst recorded. Looking up into cone from roof coal. Note elliptical shape.

In the eastern part of the mine, outbursts occurred frequently (daily) from the rib. They were typically small and occurred as the violent buckling of a few tonnes of the cleated coal into the opening. At times, the miner driver could “turn on” an outburst for visitors.

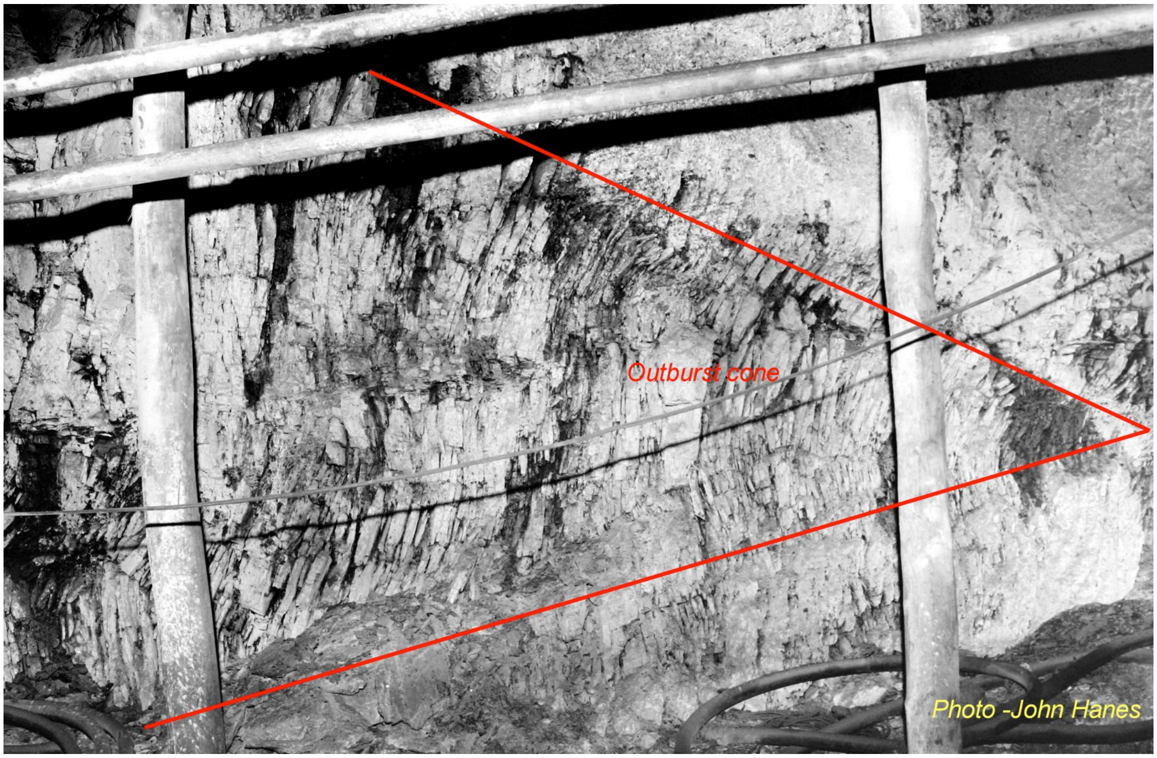

Figure 2
Small outburst from lower part of left rib. Advance to right.

Figure 3
Buckled coal in the core of
a small outburst

Some outbursts were larger with one outburst in the east ejecting over 300 tonnes, burying the cable hand and miner driver to their waists (Figure 4).

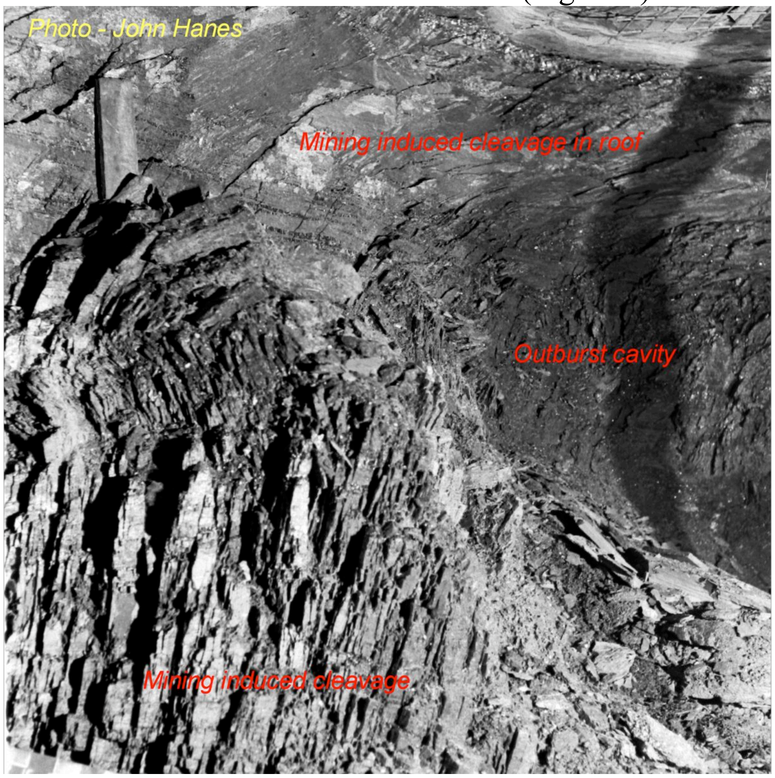

Figure 4a
Tail end of 300 tonne outburst from top right hand side of face, looking into the corner of the face at about 45 degrees to the cone axis. Mining to the sandstone roof. Note the buckled cleaved coal sheets below the cone.

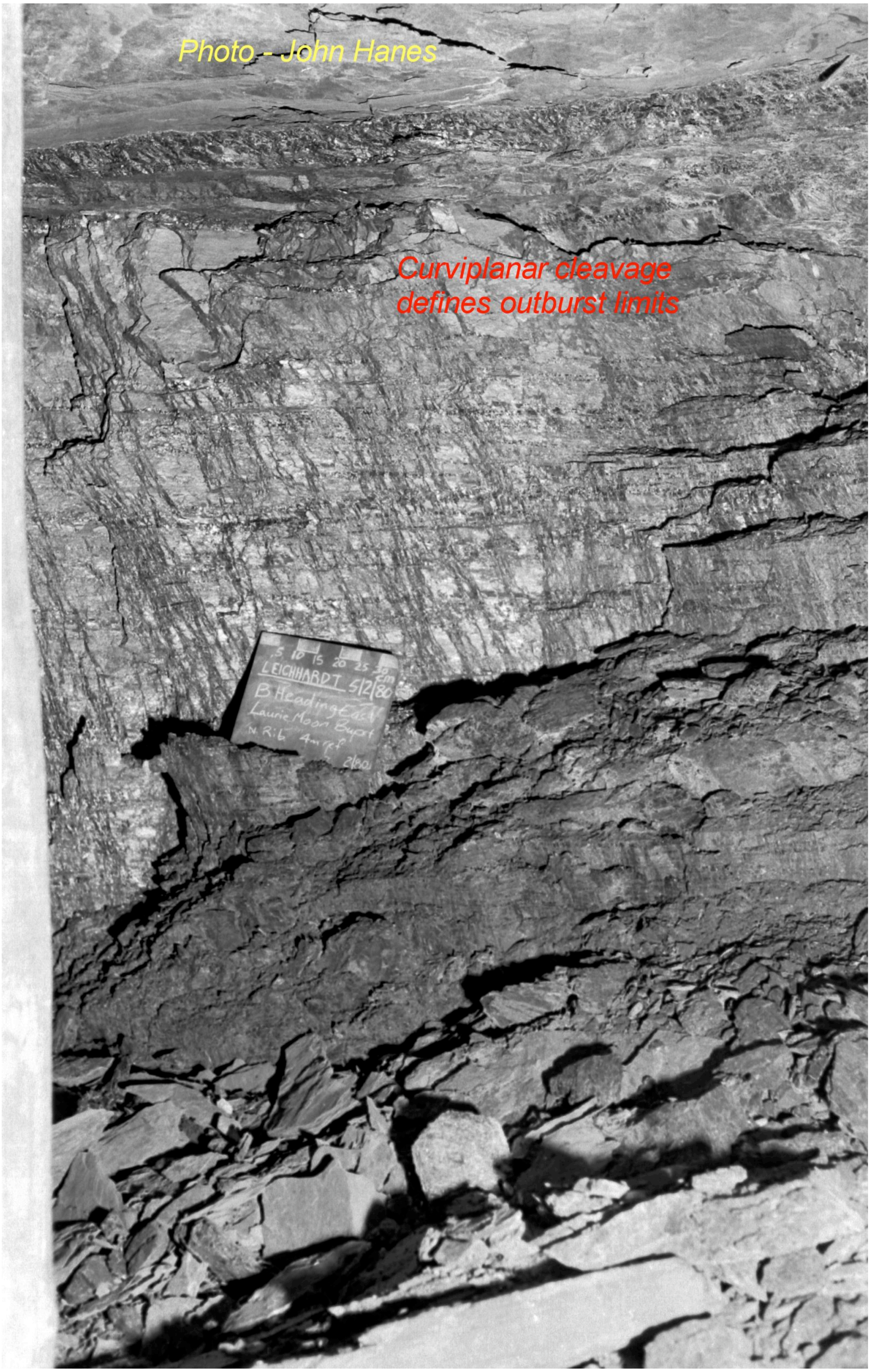

Figure 4b
Right rib about 4 m outbye the face. Photo approximately parallel to the large curviplanar sheets of coal, produced by the local stress pattern, and partly ejected.

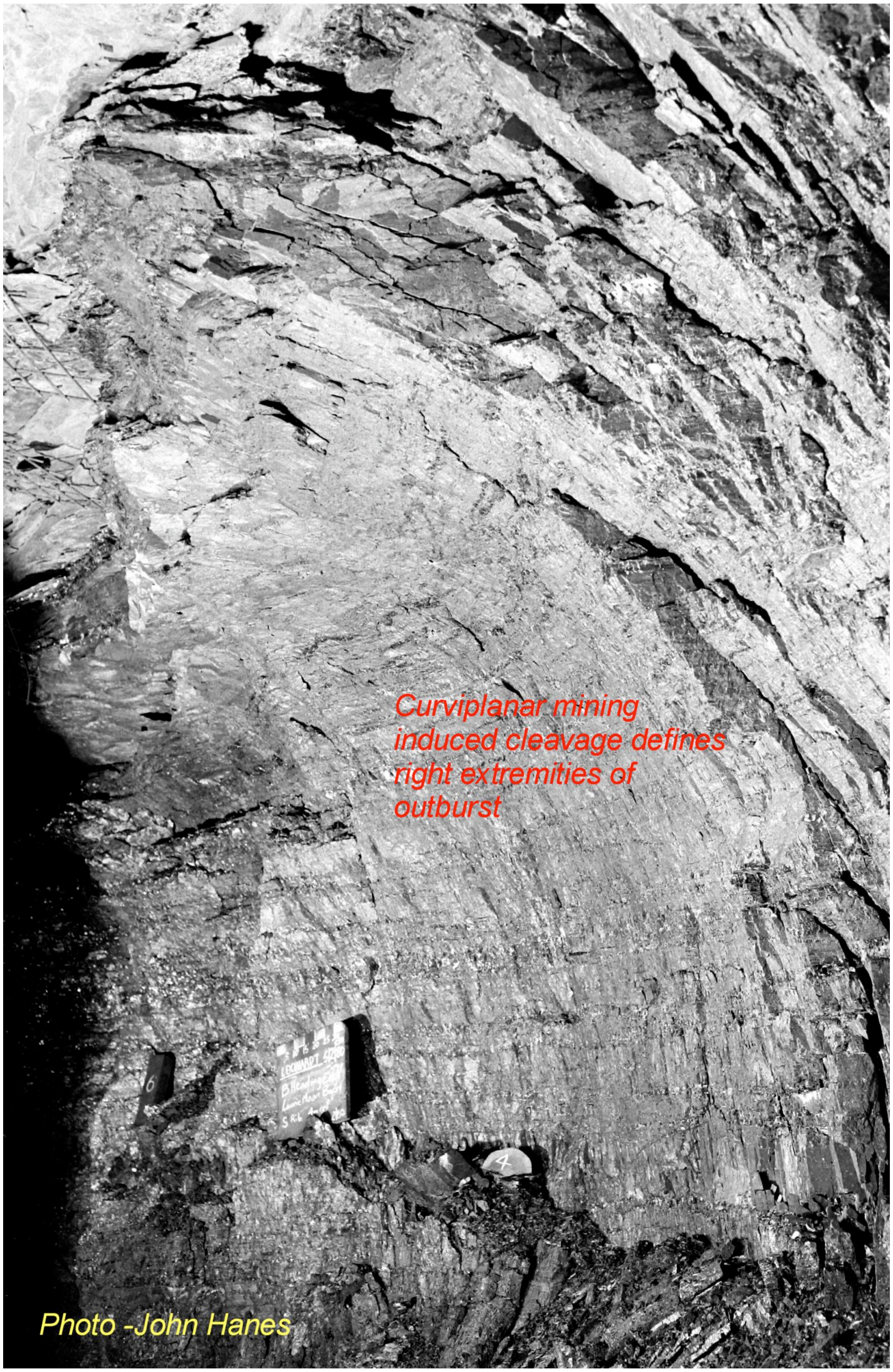

Figure 4c
Same location as 4b but looking sub parallel to the rib. Note the curviplanar mining induced cleavage.

Cleats were prominent in the seam at 3 sizes. There were small butt cleats in the vitrinite layers. These were mainly filled with clay. There were minor cleats spaced at 1 cm to 2 cm, extending around 10 cm horizontally and oriented parallel to the major cleats.

The major cleats extended from 1 m to in excess of 6 m horizontally and vertically. They were spaced at about 1 m. The major cleats showed as prominent lineations on the partings in the seam where many displayed a centimetre or so of vertical displacement and a centimetre of mylonite.

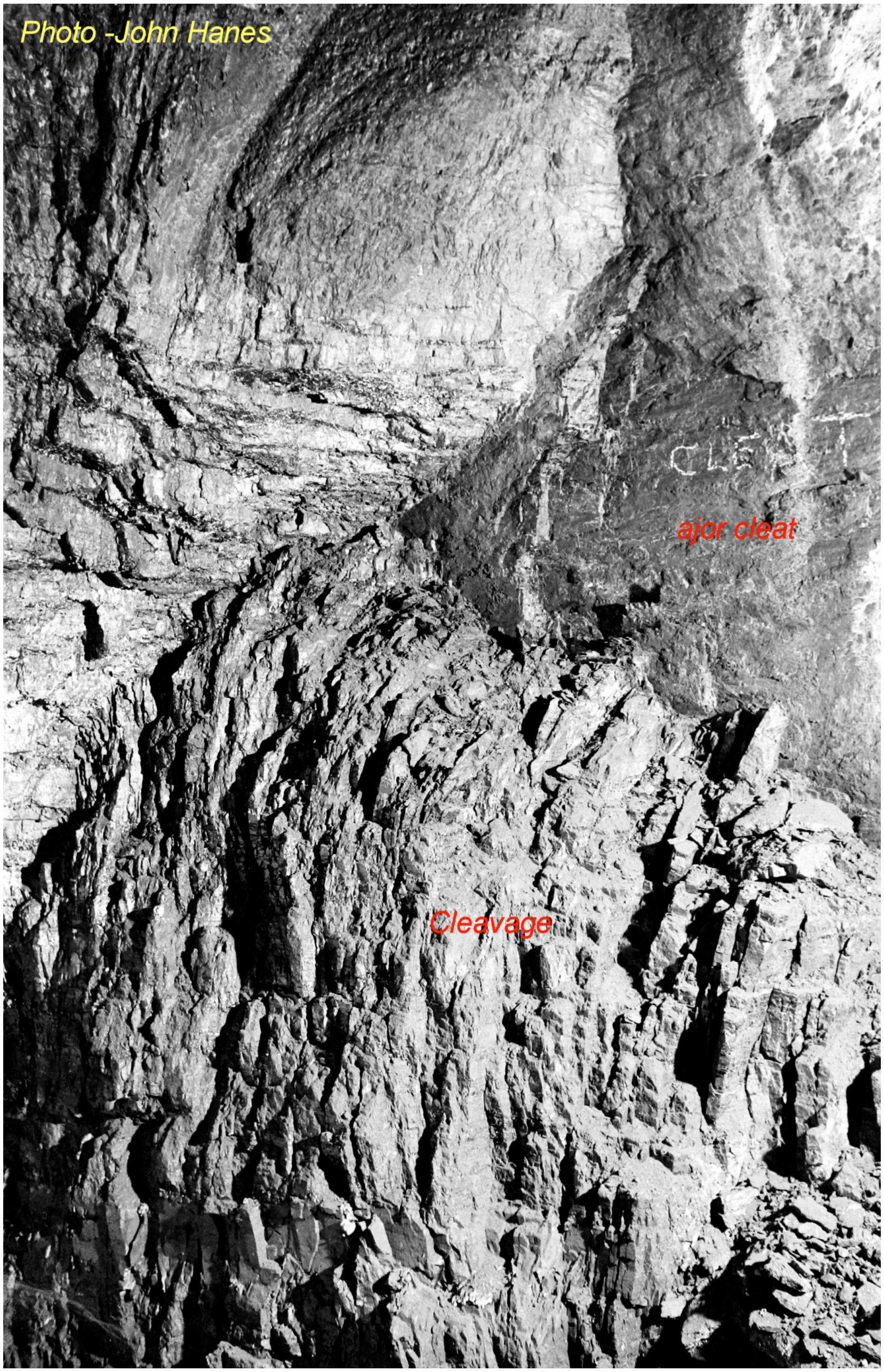

Figure 5
Part of a major cleat plane (mid right) and curviplanar mining induced cleavage (bottom centre) in right rib.

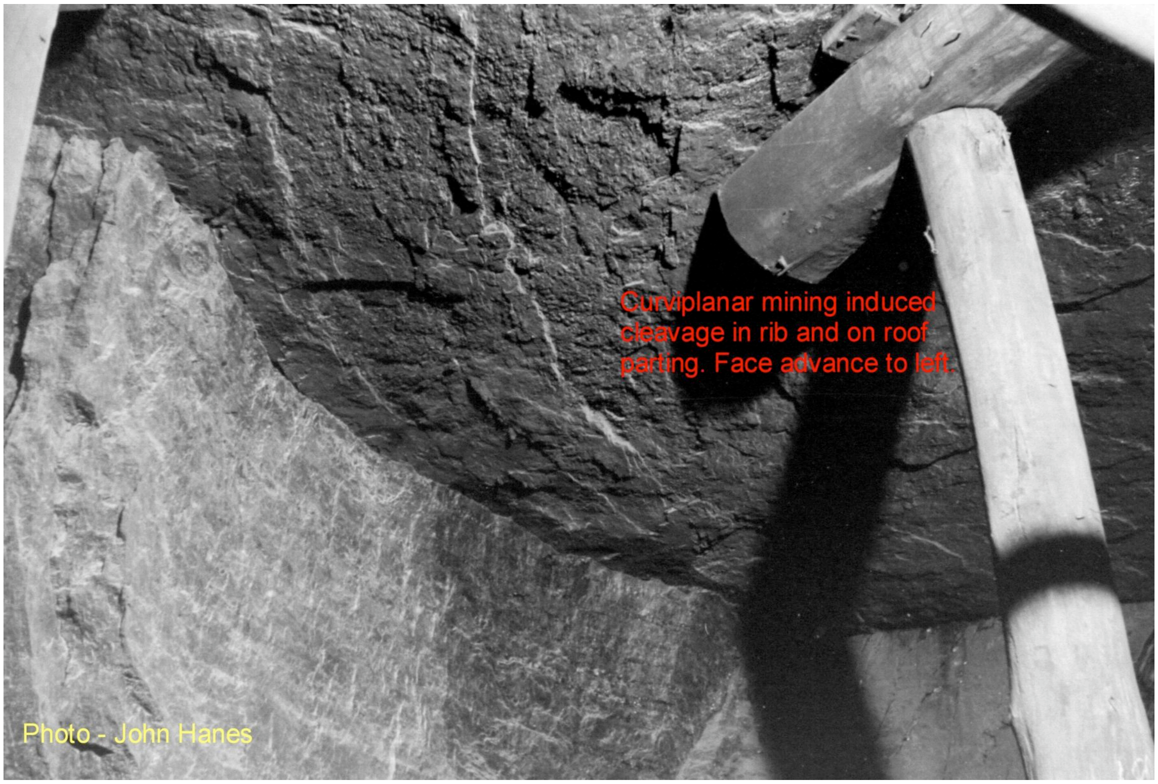

Figure 6
The tracings of mining induced cleavage on the 3 m parting

Mining induced cleavage was typical in the coal at Leichhardt. It curved around the face forming large sheets of coal which easily spalled or at times, burst. Spacing was as close as 1 mm in the brittle, very dull coal at the top of the seam. **Where the dull coal lacked cleavage, outbursts did not occur.**

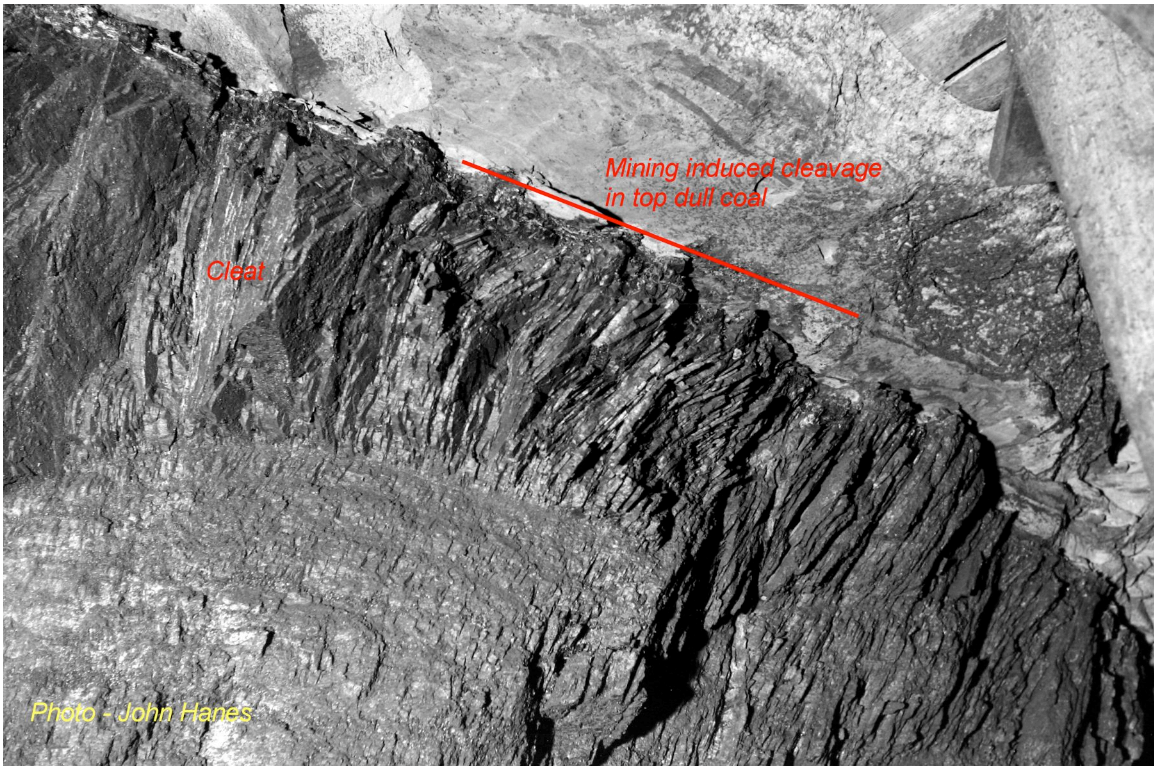

Figure 7
Very closely spaced (1 mm) induced cleavage in top dull coal.

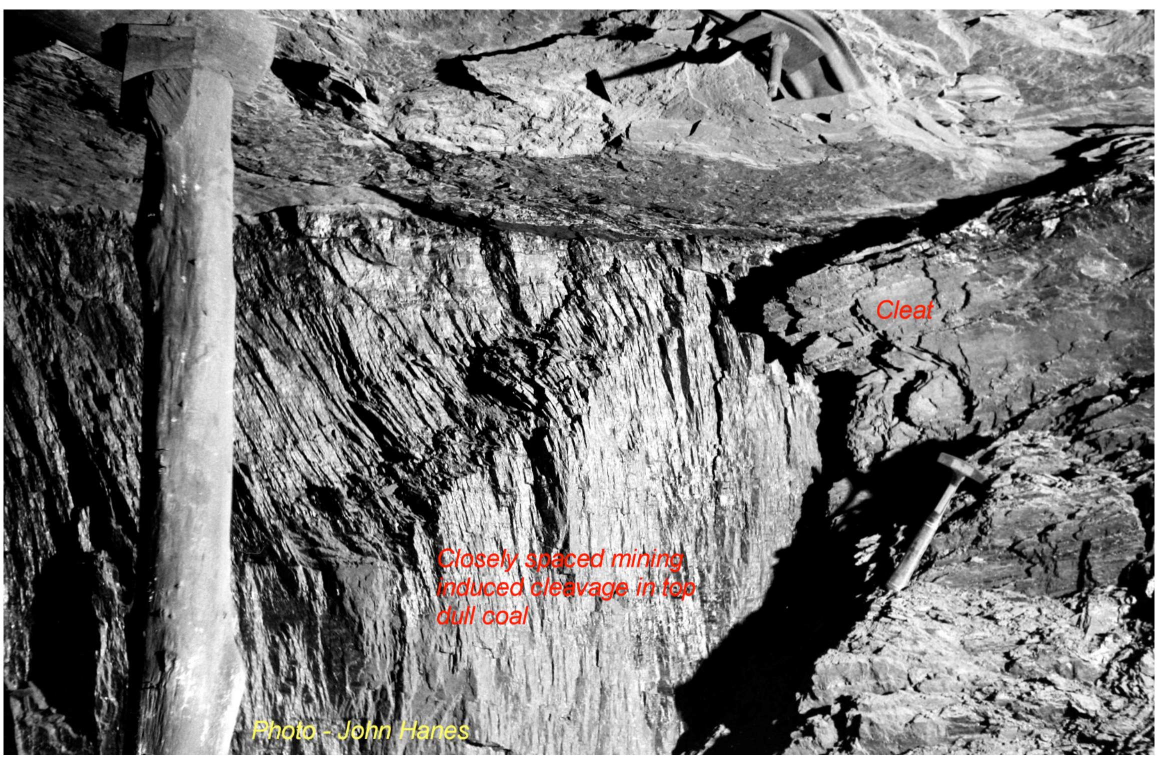

Figure 8
Closely spaced mining induced cleavage in top dull coal

Figure 9
Large scale mining induced cleavage slabs in left rib

The mining induced cleavage was prominent in the coal roof and in the stone roof. The roof strained considerably and assisted the interpretation of stress directions. Roof support was with timbers and chemically point anchored 2.1 m bolts which were tightened to 40 ft lbs torque due to the limitations of the available bolters. Mining strain increased the torque to well over 400 ft lb. The bolts did not prevent roof strain. In many cases the bolts held the roof together even when the roof fell and sat on the floor.

Figure 10
Typical roof fall

Figure 11
Mining induced cleavage 2 – 3 m above seam roof

Figure 12
Mining induced cleavage (perpendicular to photo plane) in roof coal outburst. Mining roof at strap bottom right. Mining direction left to right.

Tight ribs preceded most outbursts. Pick marks were obvious for the full height of the seam. The face at the fatal 1978 outburst had very hard coal ribs which “rang” when hit with a hammer. Similar hard ribs have been associated with outbursts in other collieries. I saw the same signs at an outburst at Appin and several cases of hard coal preceding outbursts have been recorded in the literature on Illawarra outbursts (Harvey, 2002: PhD thesis).

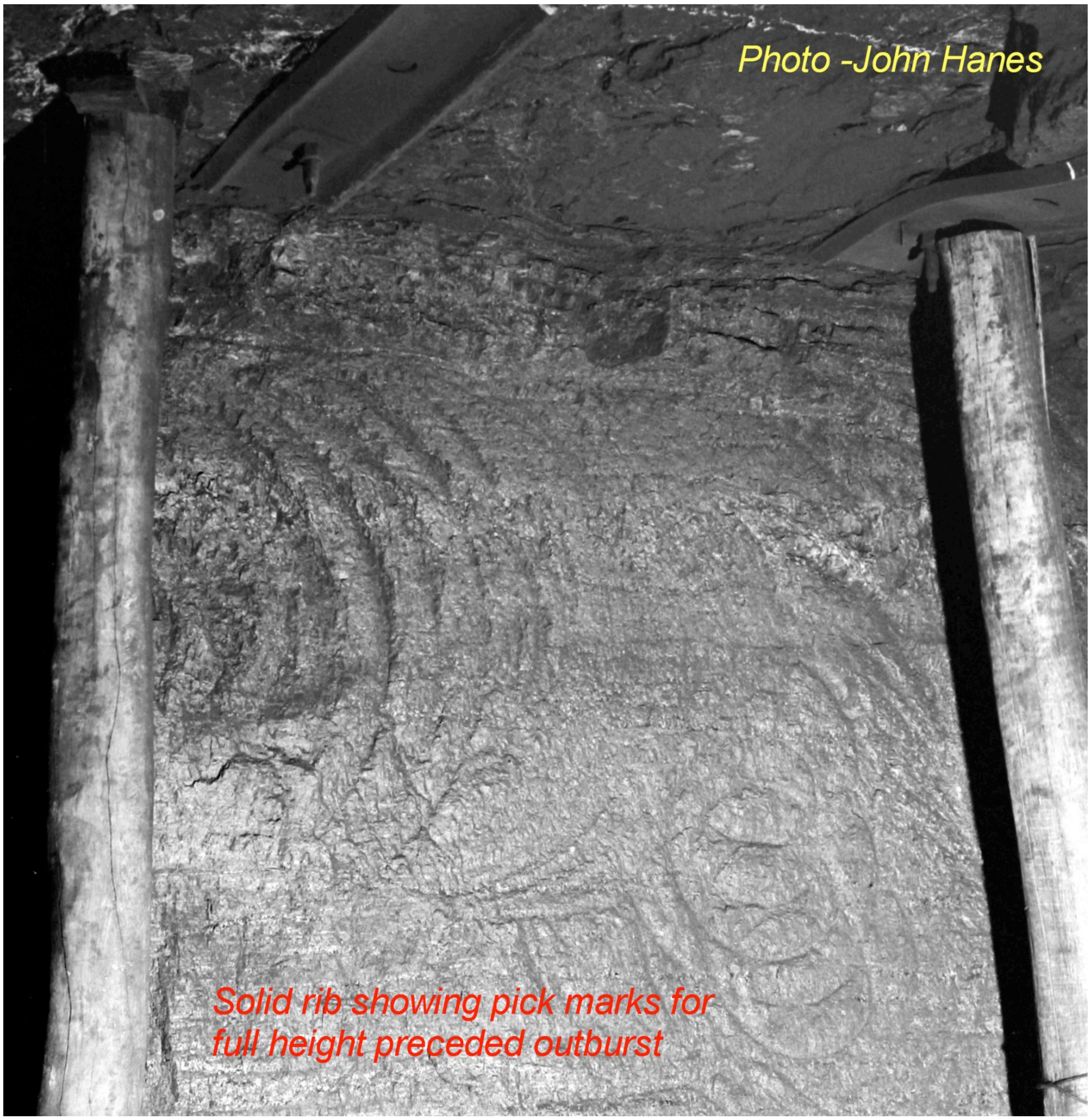

Figure 13
Solid rib showing pickmarks for full height typically preceded an outburst

In December, 1978, a major outburst occurred and killed two men. The ejected coal completely covered the miner and half covered the shuttle car.

The resultant cavity was more than 20 m long. Around 500 tonnes of coal was involved. After this outburst, mechanized mining was stopped and the mine effectively became a research laboratory for a couple of years. The extensive gas investigations have been reported elsewhere.

Figure 14
The situation of the fatal 1978 outburst after the coal debris, which half covered the shuttle car was sufficiently removed to permit recovery of the bodies of the miner driver and cable hand.

Figure 15
The cavity of the 1978 outburst after all loose coal was loaded out

Outbursts were only recognised at Leichhardt Colliery outside circles of about 175 m radius from the two shafts. Outbursts probably occurred in the pit bottom area, but they were only recognised retrospectively and were not reported by the contract miners. The initial mining away from pit bottom followed a period of around two years of no mining. The first pillar in any direction was in excellent mining conditions. Once the degassed coal was mined and steep gas pressure gradients were encountered, conditions deteriorated and outbursts commenced. More than 200 outbursts occurred between 1973 and 1978. They did not occur in the western workings. I do not know the reason. Perhaps the gas regime was different. The structural regime was certainly different. The western part of the mine bordered a major zone of thrust faulting which was associated with sedimentary changes. Mining induced cleavage did not occur in the dull coal indicating that the stress was less and/or the gas was absent or reduced. Measurements were not conducted and, as mine geologist, I was tied up conducting seismic surveys and surface drilling during most of the time the section was mined, so I did not experience the conditions first hand. The mine geologist (who should have good training in structural geology and mining support) can obtain valuable experience by observing even subtle changes in mining conditions and trying to determine the causes.

In the Illawarra, outbursts are mainly associated with sheared coal or mylonite. At Central Colliery, the outburst which occurred in about 2003 was associated with prominent major cleats. At Leichhardt, major cleats were the norm and sheared coal and mylonite were common.

Cleat and other structural mapping contribute to the analysis of the palaeostresses which produced the cleats and other structures. Palaeostress analysis is critical to the understanding of the structures and their contribution to outbursts.

Stress directions which were current in the mine at Leichhardt differed from the palaeostresses. Current stress directions were determined from analyses of mining strain and from overcoring. Mining strain indications included orientation of roof falls, and rib and roof sag relative to mining direction. Stress measurements can be easily conducted today in surface boreholes using Sigra's stress measurement device.

The main message I received from my 10 years at Leichhardt was that there is a need for continual vigilance. There is a need to know what is happening. Guessing is not good enough. There is a need to measure (gas, stress, strength, structure, etc) and understand. This takes dedication and time, and therefore costs money. But the money can be recuperated through prevention of disasters.

The first line of defense against outbursts has been well demonstrated as gas drainage, followed by measurement of the success of drainage for every metre of face advance. The failures of the gas drainage barrier to outbursts mainly occur where personnel assume that the gas is drained based on their experience.

The next line of defense is through thorough training and retraining of all face personnel to recognise any changes in structure, moisture, noises etc. Any change should cause mining to cease while the causes of the changes are investigated. It is better to have many false alarms than to lose a life.

John Hanes
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