

MANGANESE HILL, ZEEHANby R. JackIntroduction

In 1962 A.H. Blissett recommended drilling at Manganese Hill, approximately three quarters of a mile South West of Zeehan. The object of the drilling was to test below the zone of oxidization Balstrups lode the large gossanous formation capping the hill.

Two holes were drilled by the Department of Mines in 1962-63; their positions are shown on the accompanying map and a summary of the drilling is as follows.

HOLE NO. 1	Bearing 227°	Dip 50°	Final Depth 525'
0' - 75'	Soft brown weathered shale		
75' - 194'	Dark grey arenaceous shale, weakly sheared and veined with siderite. Bedding at from 20° to 45° to the drill core.		
194' - 370'	Light grey shale with some darker shale bands, local shearing and brecciation. Bedding at from 40° to 80° to the drill core. Shearing generally at 20° - 30° to the core.		
370' - 404'	Sheared zone of siderite and shale, few blebs of pyrite and flecks of galena.		
404' - 525'	Light grey shale with some darker bands moderately sheared and veined with siderite.		
HOLE NO. 2	Bearing 197°	Dip 45°	Final Depth 556'6"
0' - 124'	Broken soft brown weathered shale.		
124' - 301'	Dark grey shale, weakly sheared and veined with siderite. Bedding at from 15° - 30° to the core.		
301' - 320'	Altered dolerite, weakly veined with siderite.		
320' - 321'6"	Siliceous shale.		
321'6" - 322"	Mixed siderite and galena, estimated to contain 30% Pb.		
322' - 335'	Grey siliceous shale.		
335' - 406'	Altered dolerite, weakly sheared with a thin coating of pyrite on some of the shears.		
406' - 556'6"	Light and dark grey shale, bedding at from 30° to 60° to the core. Local strong fracturing and infilling with siderite, fractures generally at 10° to the core.		

## GEOLOGY

The country rocks as exposed in the drill core are light to dark grey shale and siltstone assigned to the Cambrian Crimson Creek Formation. The igneous rock encountered in No. 2 drill hole has been described by G. Everard as follows. "The hand specimen is a fine grained greenish grey rock with occasional spherules and veinlets of chloritic material. In thin section the texture is ophitic with laths of completely saussuritized feldspar enclosed by chlorite. The chlorite, along with patches of very fine grained purplish rhodocrosite and manganosiderite, forms a kind of matrix, the saussurite laths and subhedral crystals and crystalline aggregates of ilmenite partly altered to leucoxene. The rock is an altered manganese bearing dolerite or diabase". The diabase occurs both as flows and intrusions and belongs to the spilitic group of rocks of Cambrian age.

In the old workings the rocks are yellow and brownish clays resulting from the weathering of argillaceous shale. Further in the adit where it is up to 300 feet below surface level the rocks are unweathered light to dark grey shale and siltstone. The strike and dip of the shale is very variable, no one preferred direction being seen. The rocks are sheared throughout the workings and are locally highly sheared and disturbed, some folding has occurred, probably associated with the shearing.

The prominent gossan which caps Manganese Hill consists mainly of limonite with some pyrolusite and it is thought that this is derived from the oxidization of pyrite and manganiferous siderite. The western cross-cut off the main adit cuts the area vertically below the surface gossan and here the shale is seen to be very highly sheared. Pyrite is present as a coating on some of the shears, as blebs and veinlets in the shale, and also in the siderite venation criss-crossing the highly sheared area. Due to the high degree of shearing this zone is very porous and the cross cut is thickly coated and partially filled with a thick sludge of oxide.

Detailed mapping of the old workings was hindered by the accumulation of slime on the walls and back and by the staining and masking of details resulting from the oxidization of pyrite and siderite. However, the main fractures and mineralized area were clearly seen. The most prominent fracture is probably a wrench fault called a "slide" by the early miners. This steeply dipping fault has extensively brecciated the shale. Subsequent leaching of the brecciated zone and the deposition of iron oxide and a little silica have given to this zone which is 1 - 8 feet wide. Tilley (1891, p. 49) described the zone as being 6 to 8 feet wide, increasing when 245 feet from the the cross cut, to 15 feet, containing iron and manganese oxides, and occasional crystals of cerussite. Although the fault zone contains no primary minerals it has been erroneously known as the "lode". During the present mapping of the mine, cerussite only was found in the fault zone and it is thought that this was derived from the oxidation of primary galena found in the tension shear associated with the wrench fault. Elsewhere on the Zeehan field Twelvetrees and Ward (1910, p.82) described lodes which penetrate and occasionally cross the "slide". However, no lodes were seen to cross or penetrate the wrench fault in the Manganese Hill workings.

It was considered by Twelvetrees and Ward (1910, p. 83 - 88) that the "slides" were of a somewhat earlier age than the lode fissures and that the period of ore depositions post-dated both series of fractures.

Twelvetrees and Ward (1910, p. 83) considered that modification of the latter fissures by the pre-existing fractures is shown by

- (1) The "Bending" or "Drag" of the lode fissure as it approaches the slide.
- (2) The "Splintering". As the lode approaches the slide it tends to split into a number of stringers which diverge as they approach the slide.
- (3) "Dying-Out". In many cases the lode fissure on reaching the slide terminates abruptly.

These three points can be explained equally as well ~~as~~ by wrench faulting. De Sitter (1956, p. 172) quoting Riedel's Clay cake experiment showed that in a plastic medium such as wet clay a shearing motion originating at the bottom had a tendency to propagate itself upwards, in a wedge shaped zone widening towards the surface. The first cracks that were observed made a  $45^{\circ}$  -  $47^{\circ}$  angle with the shear plane and were obviously tension cracks (gash fractures) which rotated with the movements the angle increasing to  $50^{\circ}$  or  $60^{\circ}$ . New cracks with a  $45^{\circ}$  angle were then formed and they in turn rotated in accordance with the shearing movement.

It was found that in competent beds the wrench fault was developed as a narrow zone of shearing, and in semi-competent beds as a complicated set of wrench, normal and thrust faults combined with fold.

The "Drag" or Bending of the lode fissures as they approach the slide is explained by the rotation of the tension fractures as shearing continues giving sigmoidal ~~outline to~~ *outline* the fractures. The "splintering" of the lode by the new series of tension fractures which appear as shearing progresses, the "dying out" of the lode on reaching the sheared zone and the occasional development of the lode across the shear zone are in accordance with experimental evidence, which shows that most tension fractures are developed along the shear but occasionally some develop within the shear. (De Sitter, 1956, p. 172)

Wrench faulting also explains the narrowing of the brecciated zone, either when the shear traverses competent beds or when a competent bed forms either the hanging or footwall of the shear. (~~See diagram~~)

The wrench fault tends to propagate itself upwards in a widening wedge shaped zone, and this is in accordance with the observation of Twelvetrees and Ward

(1910, p. 104) who stated that "The principal slide (No. 1) in the (Zeehan) Montana mine is a belt of disturbed and crushed shale descending in a wedge-like form, being 200 feet wide at surface and contracting to 100 feet at 500 feet below the surface".

A similar situation to this was found in the drilling at Manganese Hill where the drill hole intersection of the downward projection of the fault zone was found to contain no one zone of shearing more intense than that found elsewhere in the core. It is probable that the fault zone has decreased from the 6 to 8 feet seen in the adit and is now represented by a much smaller zone of shears.

It is thought that ore formation occurred concurrently with the faulting and that subsequent rotation of the ore bodies during further shearing is not shown as brecciation of the ore (and brecciation of the ore was observed at Manganese Hill) but as slippage of the minerals along the cleavage planes.

Elsewhere on the Zeehan field, at the Montana Silver-Lead Mine, post-Permian thrust faulting has been described by Campana and King (1958). This later fault is in no way connected with the mineralization except where it may have displaced already mineralized structures.

~~Blissett (1962), in describing the Conah (p. 45), Montana Silver Lead Mine (p. 41) and more particularly the Zeehan Montana (p. 141) stated that "the N.W. trending faults ("Slides") were taken previously to be ore channels. There is much evidence that they are post mineralization and that the ore bodies have been dislocated. Waller (1904, p. 41) noted that No. 4 lode, which generally strikes N.N.E. changed direction to N.N.W. within 6 feet of the "slide" on several levels in the mine, showing that the relative movement was north block west. The writer would suggest that by comparison with the thrusting near the Montana Silver-lead Mine, faults in the Montana workings may be Tertiary thrusts on which transcurrent movement has also taken place: Their movement may have been north block up and west. However, it appears to the present writer that, from the description given by Waller (1904, p. 41) that slide is a thrust fault associated with and parallel to the main "slide", and it part of a complex set of Wrench~~

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The fact noted by all previous writers on this area that the same productive lode has never with certainty been found on both sides of a "slide" is significant. If the lodes are in tension shears associated with wrench faulting there would be no connection between lodes on opposite sides of a "slide", whereas if the slides are in fact Tertiary thrusts then with many underground exposures observed, it should have been possible to correlate some of the lodes on either side of the slides.

It seems likely that the known example of post-Permian thrusting near the Montana Silver-Lead Mine is not an isolated case and more post-Permian faulting may be present. However to infer from this one example that all "slides" in the Zeehan Montana, Montana Silver Lead and the Oonah Mines are post-Permian is unwarranted.

#### Workings

The Manganese Hill workings were cleaned out and drained as far as practicable to assist the mapping of the essential features of the ore body.

The information of the section of workings not accessible was obtained from an old mine plan.

The Main Adit was driven for 980 feet S.E from the N.E slope of Manganese Hill. At 370 feet No. 1 cross-cut was put into the N.E and the "slide" or fault was cut at from 14 feet to 19 feet from the adit. This cross cut was later extended to approximately 260 feet. The "slide", where cut, carried low secondary lead values. Driving was done both ways on the slide, for approximately 30 feet N.W and 680 feet S.E. No. 2 cross-cut to connected the drive to the adit was put in at 240 feet from No. 1 cross-cut, and was apparently used to tram out the mined ore. No. 3 cross-cut, 210 feet south from No. 2 was also used as a connection between the adit and the drive and was later driven N.E for approximately 380 feet. This was presumably purely exploratory. At 70 feet from the adit in No. 3 cross-cut a drive to the south was put in to follow weak fractures. At 860 feet from the portal of the adit, No. 4 cross-cut was driven 110 feet to the S.W and was probably designed to test the ground beneath the gossanous surface outcrop. The last 100 feet of the main adit veers to the east, probably the result of driving along the fractures.

The workings are inaccessible from the intersection of the drive and No. 3 cross-cut, and it is probable that no ore was found in the working beyond where the falls occur.

Adjacent to No. 1 cross-cut there is an air shaft to the surface (130 feet) from the main drive. This was presumably extended to No. 2 adit level through a rise or winze (No. 2). At 70 feet from the adit entrance No. 1 winze or rise was driven probably partly for ventilation and partly for exploration of the strong fractures there. Two other winzes No. 3 and No. 4 are shown on the plan, these apparently do not connect with No. 2 adit level and are filled with water.

It seems likely that Tilley (1891, p.49) was referring to No. 4 winze when he reported that "a winze has been sunk in the floor of the drive to a depth of 45 feet, and the following are stated results of assays of material taken from this winze: Canary ore, 888 ozs. silver, 59 per cent lead. Waller (1904, p.78) was probably describing No. 3 winze when he stated that in a winze sunk on the lode "nothing very rich was found, but the lode was worked for some distance by a party of tributors".

The cut and fill stope above No. 4 winze was taken up approximately 30 feet on a narrow vein of galena. The probable stope length is 30 feet and width 3 feet. The vein in the end of the stope shows  $\frac{1}{2}$  inch of galena. No attempt has been made to stope the vein below drive level. Small exploratory stoping occurred above No. 3 winze and to the south of No. 4 winze but production if any from these areas would be very small. From an examination of the stoped area it is thought that total production from the mine would be less than 100 tons of hand picked ore.

*information*  
No. 2 Level Adit This level is inaccessible and was taken from the old plans. The adit was driven from the lower N.E slope of Manganese Hill approximately 50 feet below the main adit level. It was driven in a southerly direction for 250 feet, then in a S.E. direction for 580 feet. At 330 feet from the portal a cross cut was driven easterly for 80 feet to connect with a shaft to surface. Apparently no ore was found on this level as Waller (1904, p.78) commented that "The lode was cut at No.2 level and driven for over 1,000 feet in a S.W direction and Waller (1904, p.78) stated that "though a number of gossan formations were cut, none of these has been definitely recognised as Balstrup's lode". This adit is now blocked and inaccessible.

On for a considerable distance without much result.  
From lower down at the ...

CONCLUSIONS

Drilling of Balstrup's Manganese Hill Mine has shown that the "slide" or wrench fault is very difficult to define at depth. The fault zone containing secondary mineralization was incorrectly termed the "lode" by Tilley (1891, p.49) and Waller (1910, p.78) the primary mineralization being in tension fractures at an angle to the fault. No ore was intersected in the drill holes that could be correlated with the ore bodies seen in the workings. As a result of the confusion existing in the description of the workings and lode in previous reports the drill holes were possibly not sited in the most advantageous positions, however, there is little hope that alternative siting of the drill holes further to the south would have found any economic ore. The gossan capping of Manganese Hill has resulted from the oxidization of pyrite and manganiferous siderite in a highly sheared zone in the sediments. The gossan is not indicative of a large underlying ore body. In future drilling of deposits of this type it may be worthwhile considering drilling holes in a direction semi parallel to the faulting. This would give the maximum number of intersections of tension fractures associated with the faulting.

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