THE MACLEAN EXTENSION OREBODY, BUCHANS, NEWFOUNDLAND[1]

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Abstract

About 53 per cent of the ore mined to date at Buchans, Newfoundland has been from transported volcanogenic massive sulphide deposits. A detailed sedimentological investigation is in progress to determine the source, transport mechanism and deposit lithologies for the MacLean and MacLean Extension orebodies. This report describes briefly lithological and sedimentological features of the MacLean Extension orebody. Two ore units occur in a sequence of felsic pyroclastic rocks of the Lucky Strike Ore Horizon Sequence. Three lithological units: sulphide matrix ore, polylithic breccia-conglomerate and arenaceous conglomerate are distinguished in the lower ore unit. The upper ore unit is exposed at one location in the MacLean Extension workings. Here two sedimentary cycles have been identified. Sedimentological work to date supports the concept of ore emplacement by subaqueous sedimentary gravity flows with deposition in channels. Several individual flows have been recognized based on their distinctive lithologies.

Introduction

From 1928 to 1978, the volcanogenic massive sulphide deposits of the Buchans camp yielded 15 813 000 tonnes of ore with an average grade of 14.62% Zn, 7.60% Pb, 1.34% Cu, 114.77 g Ag/t and 1.34 g Au/t (Thurlow and Swanson, 1981). About 53 per cent of this total was transported ore[5] from the Lucky Strike North, Two Level, Rothermere, MacLean, Oriental #2 and Old Buchans Conglomerate ore deposits (Fig. 43.1). The economically most significant transported ore has been the Rothermere and MacLean orebodies. The MacLean Extension orebody, currently under development in

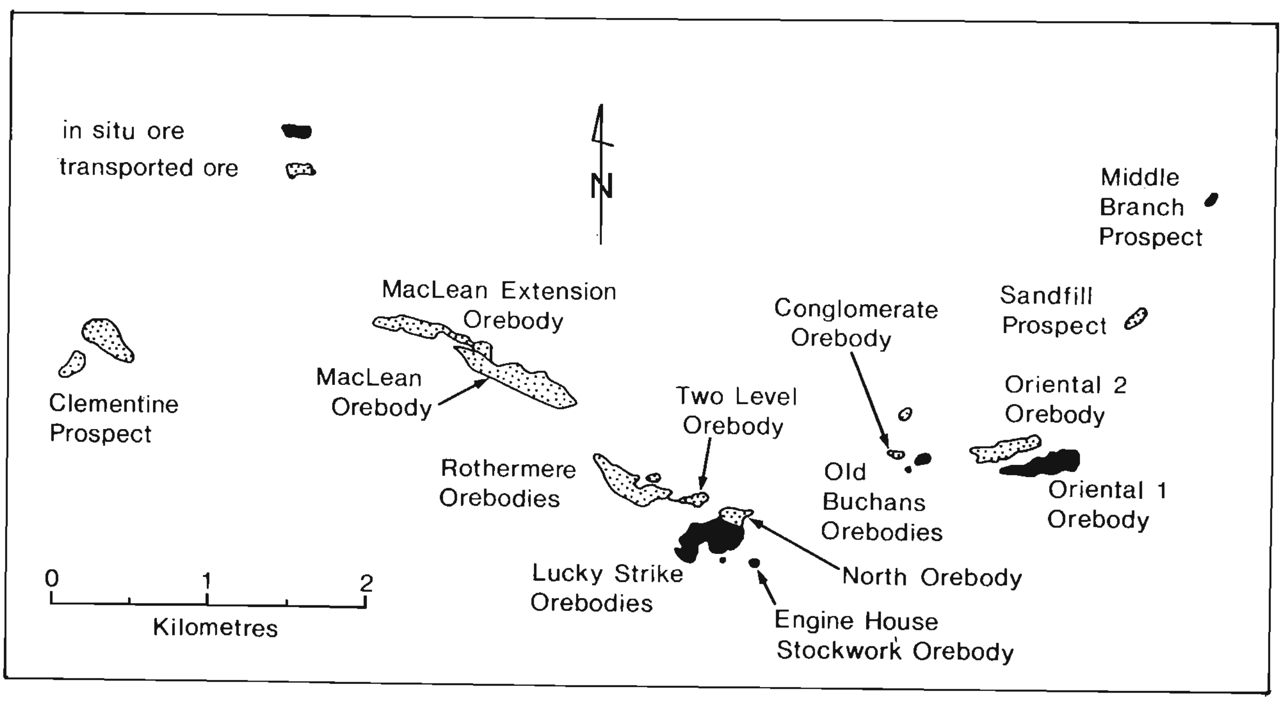

Figure 43.1. Distribution of orebodies and ore types at Buchans, Newfoundland projected to surface. After Thurlow and Swanson (1981) with MacLean Extension orebody added.

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[5] Transported orebodies are elongate-tabular accumulations composed of discrete high grade sulphide fragments and occurring in paleotopographic depressions at and near the same stratigraphic horizon as the major in situ orebodies (Thurlow and Swanson, 1981).

September 1982, is the most northwesterly deposit on the Rothermere-MacLean trend and contains 339 400 tonnes of ore with an average grade of 10.22% Zn, 5.90% Pb, 1.42% Cu, 88.02 g Ag/t and 0.72 g Au/t.

The present study, undertaken by Binney, is an extension of an ongoing study by Thurlow, Swanson and other company personnel. The study emphasizes the nature, origin and exploration guides for transported ore and will be concentrated on the MacLean and MacLean Extension orebodies. This report outlines some stratigraphic and sedimentological relationships of the MacLean Extension orebody.

Acknowledgments

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Geological Setting

The following descriptions of lithology, structure and sedimentological relationships apply only to the MacLean Extension orebody. These are based on observations in underground workings and diamond drill core. For general descriptions of the transported ores of the Buchans camp see Thurlow and Swanson (1981), Walker and Barbour (1981) and Calhoun and Hutchinson (1981).

The mineralization is contained within the Lucky Strike Ore Horizon Sequence, a group of predominantly felsic pyroclastic rocks with interbedded flows, breccias and volcaniclastic sedimentary rocks. The Lucky Strike Ore Horizon Sequence conformably overlies the Intermediate Footwall, a complex assemblage of altered volcanic and volcaniclastic rocks (Thurlow and Swanson, 1981).

Only those portions of the Lucky Strike Ore Horizon Sequence that contain transported sulphides and/or barite have been examined in detail. The lateral distribution of two ore-bearing units in the MacLean Extension orebody is shown in Figure 43.2 and as a schematic idealized cross-section in Figure 43.3. The MacLean Extension orebody adjoins the MacLean deposit but the contact relationships are obscured by faults and a diabase dyke.

The lower ore unit conformably overlies green dacitic tuffaceous rocks along an irregular contact. Mineralization occurs as clasts of sphalerite-galena, sphalerite-galena-chalcopyrite and barite in a matrix which consists of varying proportions of lithic detritus, galena, sphalerite and barite. Overlying the lower ore unit is a sequence of felsic pyroclastic rocks including volcanic breccias.

The upper ore unit, known in mine terminology as the "#4 baritic zone", conformably overlies these felsic pyroclastic rocks. The ore beds within the upper unit are notable for their high content of barite in addition to galena, sphalerite and small lithic fragments. Felsic pyroclastic rocks of the Lucky Strike Ore Horizon Sequence form the hangingwall of the MacLean Extension orebody.

Both major and minor faults occur in the MacLean Extension orebody. A major thrust fault defines the southern margin of the orebody. Thrust and normal faults with small displacements cut the ore beds at numerous locations. Offsets on these faults range from a few centimetres to tens of metres. Felsite and diabase dykes also cut the ore beds, but in most areas little offset of the ore exists across the dykes.

The Lower Ore Unit

The lower ore unit ranges in thickness from 0 to greater than 15 m. Within the unit a virtual continuum exists from high grade sphalerite and galena containing scattered lithic clasts, through sphalerite and galena blocks and lithic

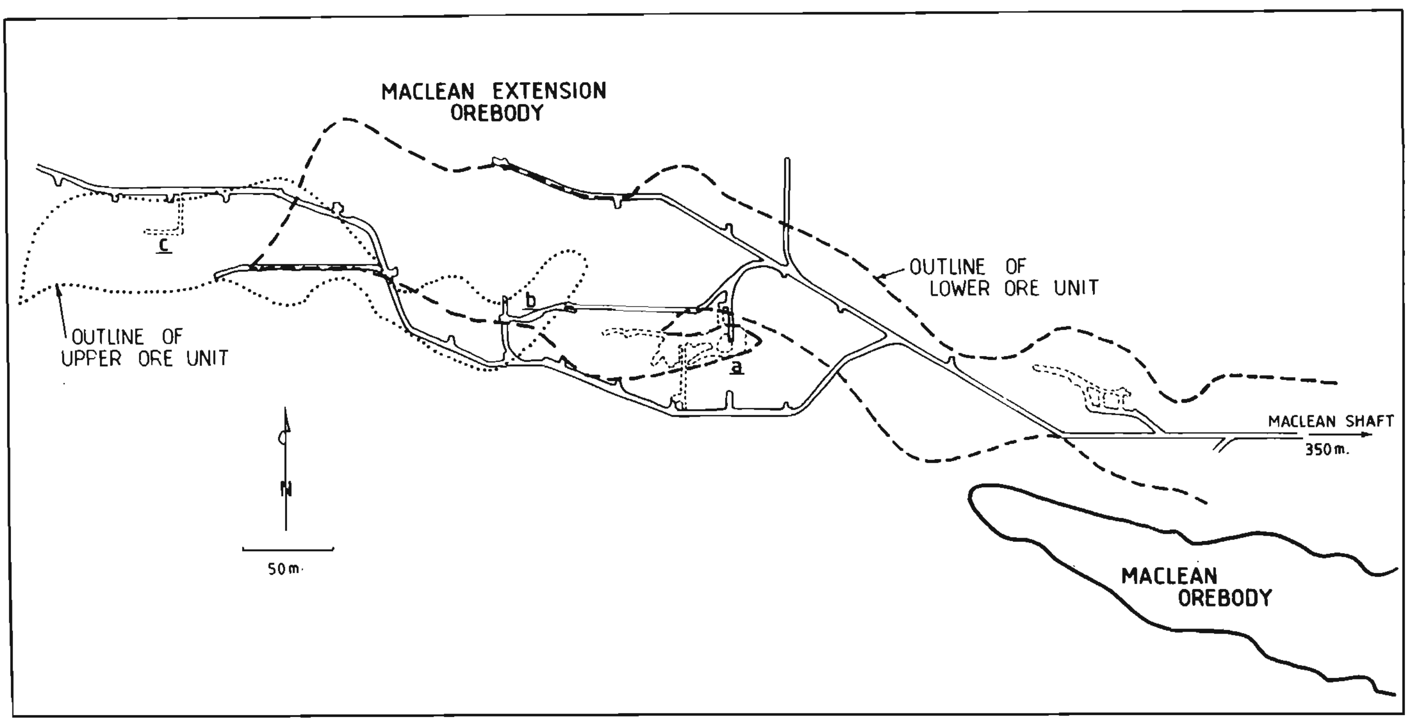

Figure 43.2. Vertical projection of the ore-bearing units of the MacLean Extension orebody to the 20 level, MacLean Shaft. Letters are locations referred to in text.

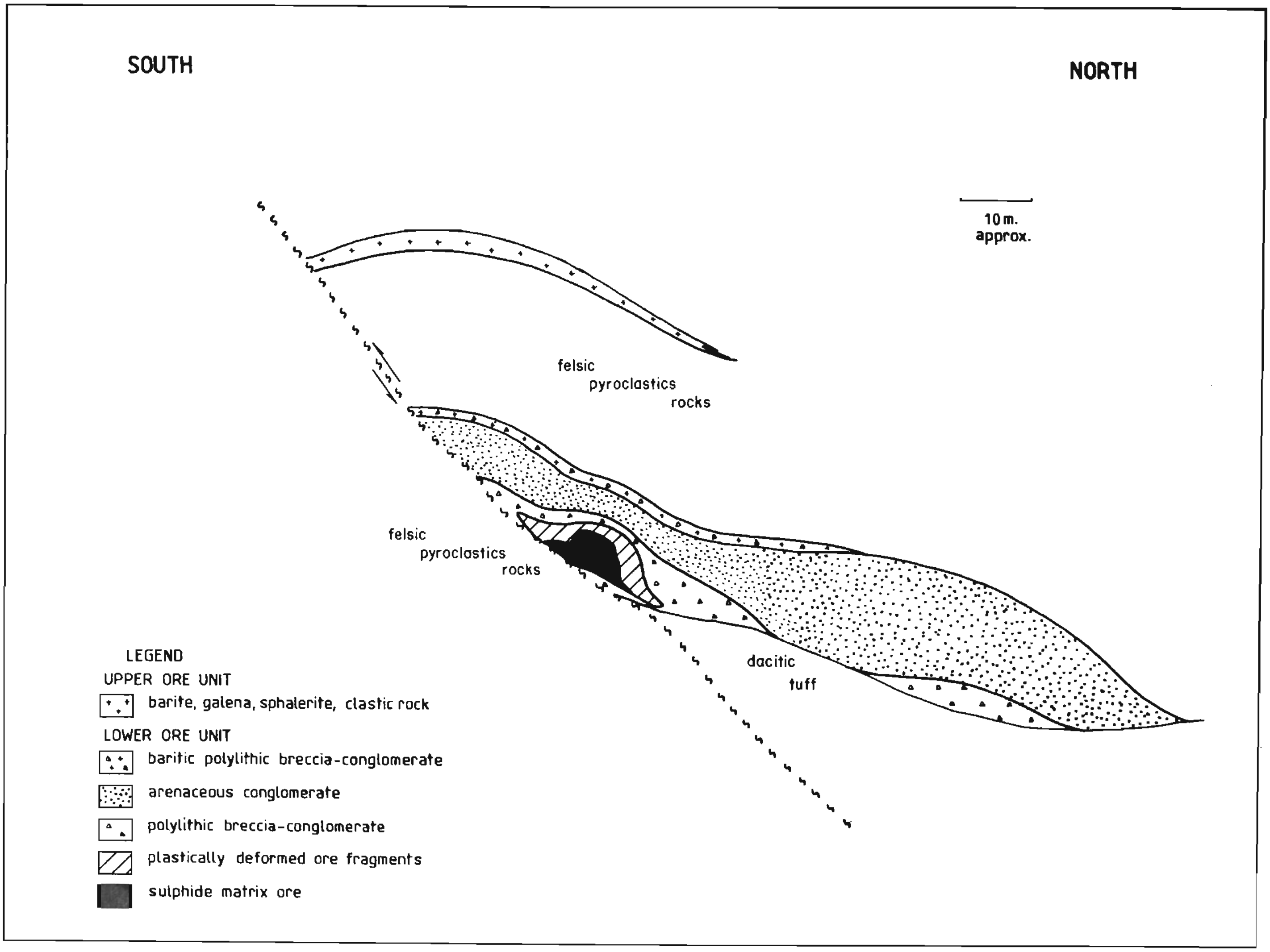

Figure 43.3. *Schematic north-south cross-section of the MacLean Extension orebody showing some generalized lithological units.*

fragments in a clastic matrix, to arenaceous conglomerate with minor pebble-size detritus including rare sphalerite and galena clasts.

Three lithological units have been defined that are believed to be fundamental divisions within this continuum. The divisions are based on the nature and distribution of the sulphide and lithic components of the rock without reference to the grade of the ore. Several intermediate lithologies are of local significance and by adding modifiers to the basic units most beds in the lower ore unit can be described accurately. The three main lithological units will be referred to as sulphide matrix ore, polylithic breccia-conglomerate and arenaceous conglomerate.

Sulphide matrix ore consists of a fine grained matrix of sphalerite, galena and locally barite with a minor amount of admixed lithic detritus. Within the matrix are subangular to subrounded clasts including siltstone, rhyolite, altered Intermediate Footwall, pyritic stockwork and barite (Fig. 43.4). All these clast types occur in the Intermediate Footwall or at the base of the Lucky Strike Ore Horizon Sequence in the vicinity of the Lucky Strike ore deposit or along the Rothermere-MacLean trend, the current suggested source and transport channel for the ore (Walker and Barbour, 1981). The clasts rarely exceed 15 cm in length and comprise less than 15 per cent of the unit. To date no sorting has been indicated by measurement of clast size and type for all clasts more than 1 cm in length in areas 0.5 m wide by the accessible height of the bed (generally 1-3 m). Segregation of clasts into distinct beds within the sulphide matrix ore has been noted.

Sulphide matrix ore occurs in a discontinuous bed at, or near, the base of the lower ore unit. Ore grades in this bed range from 15 to 40 per cent combined zinc and lead. In a sublevel of 20 level (a on Fig. 43.2) thin, laterally continuous layers of chalcopyrite in the matrix define planar zones in the rock. The bed of sulphide matrix ore changes thickness rapidly. Presently available exposures and drill core information suggest that the sulphide matrix ore grades into polylithic breccia-conglomerate with a change in the mode of occurrence of sphalerite and galena from the matrix to distinct clasts of ore.

Polylithic breccia-conglomerate comprises the broad central part of the lithological continuum between sulphide matrix ore and arenaceous conglomerate. It is distinguished from the sulphide matrix ore by its arenaceous matrix and from the arenaceous conglomerate by the number, size and variety of clasts. Breccia-conglomerate is the term chosen to describe this unit due to the angularity of a majority of

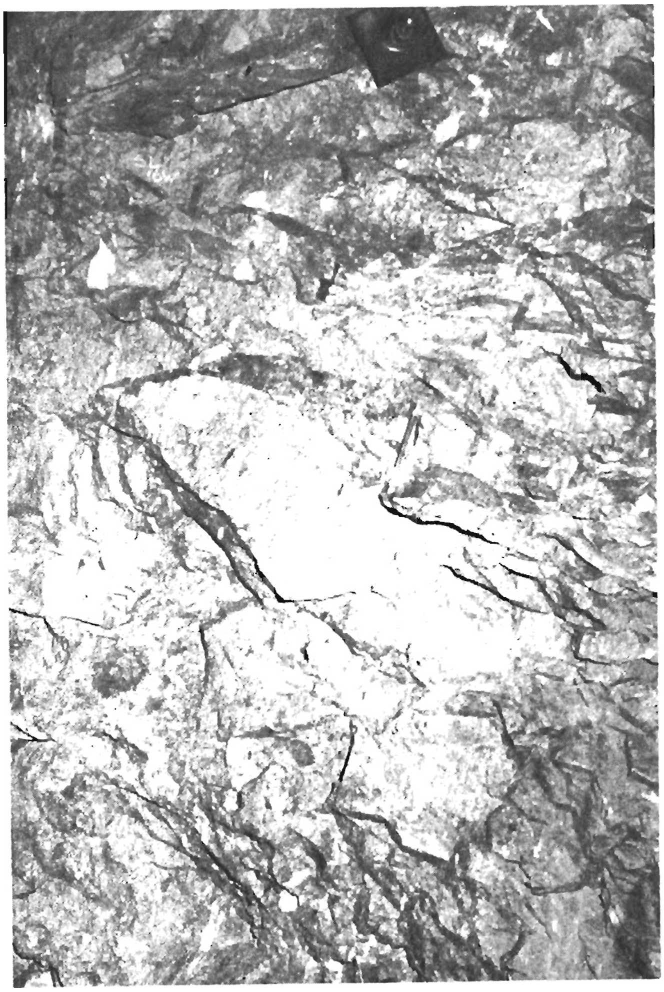

Figure 43.4. High grade sulphide matrix ore with some lithic clasts at location a, Figure 2. Rock bolt is 12.6 cm across.

the clasts. However, polylithic breccia-conglomerate contains subangular to subrounded clasts which include siltstone, rhyolite, altered Intermediate Footwall, stockwork pyrite, mafic volcanic rocks, felsic tuff, jasper, sphalerite-galena-chacopyrite and barite. In addition, sphalerite-galena fragments are common and granitic boulders are present in local concentrations. The granitic boulders, although larger than most other clasts, are subrounded to rounded. They are also the only clast type not recognized in situ in the Intermediate Footwall or the Lucky Strike Ore Horizon Sequence. For further information on granitic clasts the reader should refer to Stewart (1983). The size range of the clasts in the breccia-conglomerate is considerable with large boulders (up to 4.5 by 2.4 by 1.8 m, minimum measurements) in a sand-size matrix. In typical polylithic breccia-conglomerate the clasts range from 1 to 30 cm long and comprise from 15 to 50 per cent of the rock.

Polylithic breccia-conglomerate occurs overlying, underlying and adjacent to sulphide matrix ore, as isolated beds at the base of the lower ore unit, within the arenaceous conglomerate and at the top of the lower ore unit (Fig. 43.3). In the latter case, barite fragments are concentrated in a polylithic breccia-conglomerate. In marginal parts of the lower ore unit this baritic polylithic breccia-conglomerate rests directly on the footwall dacitic tuff and is overlain by felsic pyroclastic rocks.

The relationship between the sulphide matrix ore and polylithic breccia-conglomerate has been documented in several areas of the MacLean Extension workings. Along a drift at location b (Fig. 43.2) sphalerite-galena-barite sulphide matrix ore with less than 5 per cent lithic fragments overlies dacitic tuff or a thin polylithic breccia-conglomerate bed. Above and adjacent to the sulphide matrix ore are large blocks of sphalerite-galena, and sphalerite-galena-chalcopyrite in a clastic matrix (Fig.43. 5). The ore clasts are typically tabular with length-to-width ratios from 3 to 10. They exhibit draping and plastic deformation over and against adjacent lithic detritus (pebbles, cobbles and boulders). Ore clasts are less abundant and matrix more abundant farther away from the sulphide matrix ore, and some granitic clasts are present. The granitic clasts tend to be large (20 to 50 cm in diameter) and are concentrated in a

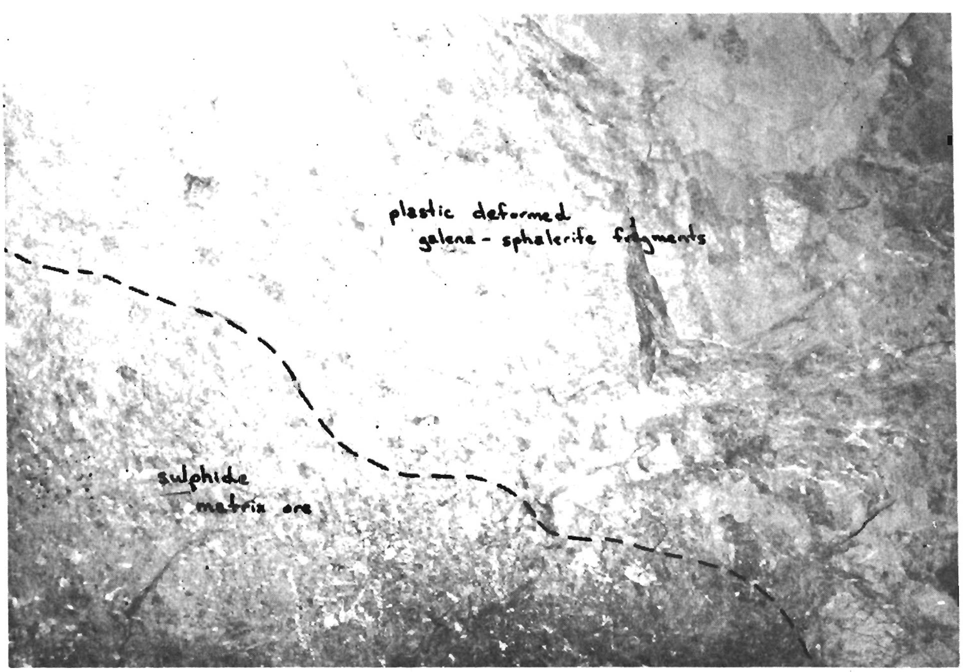

Figure 43.5

Contact of sulphide matrix ore and plastically deformed galena-sphalerite fragments in a matrix of lithic detritus at location b, Figure 2.

distinct stratigraphic unit. This unit is succeeded by a typical polylithic breccia-conglomerate with a wide range of clast lithologies and sizes. The complete sequence is observed in a strike length of 15 m.

A separate lithological unit, arenaceous conglomerate, occurs also in the lower ore unit of the MacLean Extension orebody. This unit has a wide lateral distribution judging from drill intersections but has been found only in one location in the underground workings. The rock consists of an arenaceous matrix with less than 10 per cent subangular to subrounded clasts. Rhyolite and granite comprise two thirds of all the clasts. Other types include siltstone, altered Intermediate Footwall, mafic volcanic rocks, sphalerite-galena and sphalerite-galena-chalcopyrite. Where examined underground, the arenaceous conglomerate overlies footwall dacitic tuffaceous rocks and is overlain by polylithic breccia-conglomerate, but in drill core this unit can be seen to overlie polylithic breccia-conglomerate as well.

The Upper Ore Unit

The upper ore unit is separated from the lower ore unit in the MacLean Extension orebody by 30 to 50 m of felsic pyroclastic rocks (Fig. 43.3). An excellent exposure, undisturbed by faults, exists in a drift above 20 level (location c in Fig. 43.2). Details of the geology of the south wall of this drift are shown in Figure 43.6. Notable features of the exposure are cyclic units of barite-rich transported ore and graded beds of sandy sedimentary rocks at the top of the ore layers.

At the base of the exposure, massive, yellow-green felsic tuff is conformably, but irregularly, overlain by a bed containing single barite crystal clasts (up to 5 cm long) in a matrix of barite, galena, sphalerite and minor lithic detritus. Other clast types include siltstone, rhyolite, altered Intermediate Footwall and basalt. Granitic clasts are absent. This massive bed grades upward into about 10 cm of sandy lithic detritus and barite. Above the sandy bed, and gradational with it, is a thin bed of felsic tuffaceous rock. The combined thickness of the sandy and tuffaceous beds ranges from 5 to 50 cm at location c.

A second cycle consisting of a barite-galena-sphalerite-rich basal portion overlain by arenaceous, polylithic pebble conglomerate grading upward into sandy and tuffaceous rocks rests on the basal graded unit.

The baritic beds contain cobbles and boulders of galena-sphalerite exceeding 30 cm in length as well as other large blocks of siltstone, rhyolite and basalt. These occur in localized areas associated with the barite-rich ore beds and in places have penetrated the fine grained top of the first cycle (Fig. 43.7).

Origin of the Ore Sequence

Earlier work on the genesis of the transported ores by Walker and Barbour (1981) and Calhoun and Hutchinson (1981) was restricted to diamond drill core and a limited number of ore exposures remaining in the MacLean orebody. The MacLean Extension orebody is presently being developed for mining and consequently contains some excellent exposures.

This is an ongoing study but preliminary results indicate several features bearing on the transport and deposition of the ore beds. Thurlow (1977) suggested that the transported ores of the Buchans camp represent deposits from subaqueous sedimentary gravity flows initiated by explosive volcanic eruption or local earthquake. The size and angularity of the clasts, in addition to the types and diversity of lithologies represented by the clasts, all support this hypothesis.

Sedimentary gravity flows can be divided into four main types based on the sediment support mechanisms. These types are turbidity currents, fluidized sediment flow, grain flow and debris flow (Middleton and Hampton, 1976). Each type of flow has specific depositional features.

Within the MacLean Extension orebody, and especially the lower ore unit, a range of depositional features have been observed that suggest complex channel filling from several

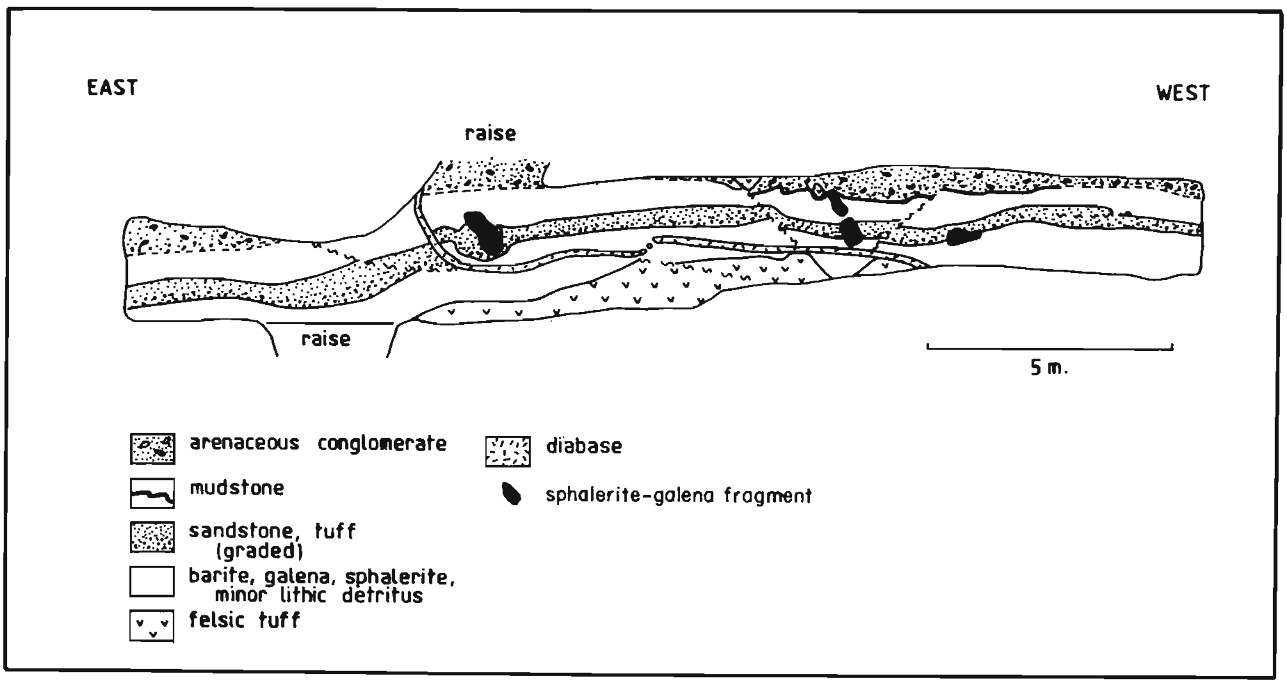

Figure 43.6. Subdivisions of the upper ore unit along the south wall of drift, above 20 level, location c, Figure 2.

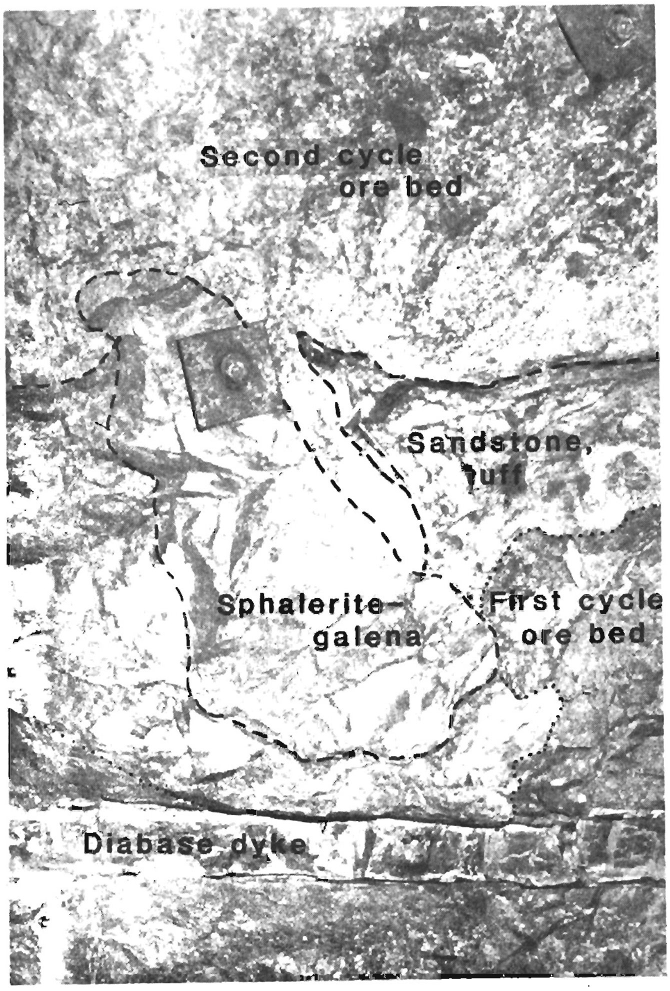

Figure 43.7. *Galena-sphalerite block penetrating the top of the first cycle ore bed of the upper ore unit at location c, Figure 2. Rock bolt is 12.6 cm across.*

episodes and types of sedimentary gravity flows. Individual flows can be separated by their distinct clast lithologies. The most obvious example is the baritic polylithic breccia-conglomerate which is at the top of the lower ore unit in many areas. Underlying the baritic polylithic breccia-conglomerate is a polylithic breccia-conglomerate bed with a distinctive high content of granitic fragments. Both beds are localized, probably in topographic depressions which existed at the time of emplacement.

With the exception of the above beds, most of the lower ore unit is a sequence of beds grading from sulphide matrix ore to coarse sphalerite-galena blocks in a lithic matrix, to sphalerite-galena-bearing polylithic breccia-conglomerate, and to arenaceous conglomerate with few lithic clasts and only rare sphalerite-galena clasts. There is an overall sorting of dense, sulphide-rich material toward the base of the lower ore unit.

The contacts between massive sulphide matrix ore and polylithic breccia-conglomerate beds are quite steep suggesting a subaqueous debris flow with matrix strength as the transport mechanism for some high density, sphalerite-galena-rich material (Middleton and Hampton, 1976). Turbidity currents can account for graded units within arenaceous conglomerate beds.

Several beds were selected for clast counts in the MacLean Extension workings. Modifications were made to Walker's (1975) method to typify grading. Rather than vertical traverse lines, an area was chosen 0.5 m wide through the entire thickness of the bed. Within this area the length and width of all clasts over 1 cm long were recorded, as well as clast type and height in the bed. The length of galena, sphalerite, chalcopyrite and barite clasts was corrected to allow for their greater density. This was done by multiplying clast length by clast density divided by a density of 2.8 gm per cm^3. A plot of clast height in the bed versus length is presented in Figure 43.8 for a polylithic breccia-conglomerate bed that contains granitic clasts. Inverse grading in the lower part of the bed is succeeded by a disorganized to normally graded top. This sequence, duplicated by clast measurements in the bed at a second location, suggests proximal deposition from a high-sediment-concentration turbidity current (Walker, 1975).

The supply of lithic and sulphide detritus to the basin, although intermittent, was not interrupted by long periods of quiescence. This is suggested by the massive nature of the lower ore unit and the recognition of several separate flow deposits. The sedimentary gravity flows would have the capacity to erode any thin intervening pyroclastic units.

The upper ore unit reflects a change in the depositional history. Two discrete cycles of ore deposition are separated by a thin bed of sandy and tuffaceous rocks. The transport mechanism, although similar to that of the lower ore unit, appears to have a greater component of turbulent flow.

Summary and Exploration Guides

The MacLean Extension orebody contains two main ore units, both comprising distinct and interrelated lithologies. The lower ore unit is characterized by pebble and boulder size ore and lithic clasts in a matrix which is predominantly sandy lithic material with the exception of the economically important sulphide matrix ore. In this ore the matrix is galena and sphalerite with or without barite. The upper ore unit is of different character with at least two distinct cycles of deposition. At the base of each cycle is a bed of galena, sphalerite, barite and fine grained lithic detritus.

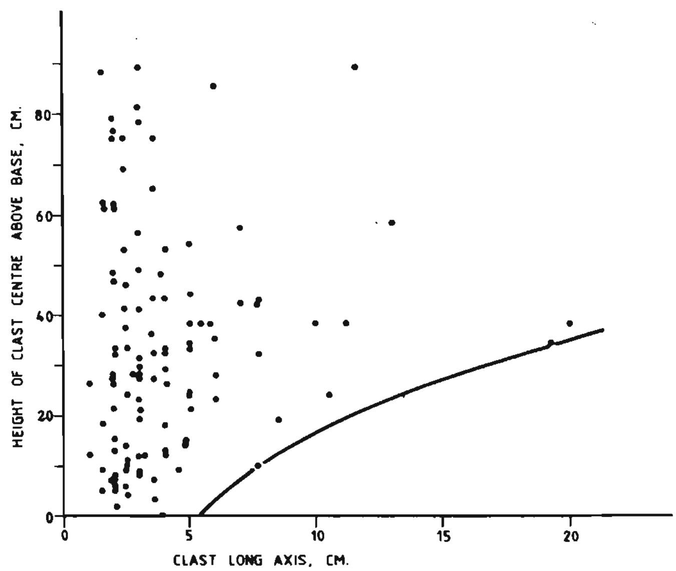

Figure 43.8. *Plot of height of clast centre above base of bed versus corrected clast long axis (cm) for a polylithic breccia-conglomerate bed in the lower ore unit, MacLean Extension workings. The lower 35 cm of the bed is inversely graded. Curve is limit of largest clast.*

Preliminary sedimentological work indicates that the ore-bearing beds are products of subaqueous sedimentary gravity flows. A few clast orientations determined in the MacLean orebody support previous interpretations that the ores were transported down the Rothermere-MacLean channel and could have been derived from the vicinity of the Lucky Strike in situ deposits. Thin, low grade arenaceous conglomerate units, widespread in diamond drill holes, can be traced laterally into thicker and denser gravity flow deposits containing high grade sulphide ores.

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