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SAMATOSUM MINE GEOLOGY UPDATE

INTRODUCTION

Pit mapping over the past several months has provided new geological information on the Sam Deposit area. Apart from providing the mine with much needed data for its interpretive work, the data is also significant enough for consideration in the development of future exploration programs in the vicinity.

any data is

The alteration and structural history of the Sam Deposit is incredibly complex. The following notes represent my current thoughts on the geology and genesis of the Deposit, developed after more than a year of observing, walking over, and mapping the Deposit. This detailed view has led me to conclude that certain geological relationships are visible in the pit which would otherwise be extremely difficult to interpret correctly from diamond drill core examination. In my opinion, good solid geological mapping information should carry the most interpretive weight. Now that good rock exposures are available in the pit, drill core evidence and laboratory data should be used to complement, and confirm or guide geological observation and thought—not necessarily control it. Although much fact–finding remains to be done, the ideas expressed in this report should help us better understand Sam and should be considered for both future exploration planning and in the McGill research program.

GEOLOGY—LITHOLOGY AND ALTERATION

The Sam Orebody is a stratabound quartz vein deposit of probable epithermal or mesothermal origin. In the Deposit area, the original lithologies are mafic pyroclastics structurally overlying a sedimentary package of turbidites—predominately argillites, wackes, and argillaceous "mixed sediments" (mixed sericitic argillite/chert unit at the northern and southern extremeties of the Deposit) and their altered equivalents. Alteration is widespread and complex throughout the Deposit area; so much so that on the basis of scale, it is probable the ore zone is a product of one or more of the widespread alteration events, rather than the other way around. Certain originally interpreted lithologies such as SERT, MUT, quartzites, and cherts are essentially systematically altered equivalents of these original lithologies—such that the area is presently underlain by a **combination** of the original turbidites and their altered equivalents.

?

Protoliths can usually be distinguished. Altered protoliths lead to slightly different alteration products

Although the alteration trends appear conformable, there are local strong discordancies as explained below. There is also the possibility these alteration features with the ore zone follow a low angle crosscutting trend through the original turbidite sequence, from the structural footwall to the north into the structural hangingwall to the south—giving the

This doesn't really hold up on the property scale impression of separate hangingwall and footwall components of unaltered turbidites (argillite "wedges" or remnants).

Contact Relationships of the Deposit Area Lithologies

Of more significance to regional interpretation, the Sam Horizon appears to be "right way up"; as evidenced by the majority of facings in the recent pit drilling in the footwall argillite. In the pit, local overturning of the structural base of the mafic pyroclastics can be explained by drag folding near the sheared contact with the Sam Horizon sediments. However, because of the existence of at least 2 phases of deformation, and the resultant isoclinal style of folding yielding maximum amplitudes of only a **few meters** (producing facings in both directions), final resolution of this problem could be accomplished by a statistical comparison of overturned vs "right way up" observations across the **entire stratigraphic sequence**—with the final decision made on the basis of the numerically dominant facing direction. Detailed examination of Rea Horizon core by Keith Glover indicates it is overturned; however, to my knowledge, Sam has not been similarly examined.

I believe a true understanding of the geology of the area will be achieved with the recognition of the importance of distinguishing altered vs unaltered rocks, and that the altered sedimentary rocks essentially had a common protolith of a predominately argillaceous nature. Thus, altered rocks in the Deposit area should not necessarily be interpreted as totally different lithologies from the unaltered rocks with which they appear to be in contact. This is especially true for the symmetrically synformal interpretation given to the "argillite wedge" and its encompassing MUT immediately northwest of the Deposit. Bedding within the argillite "wedge" could easily be discordant to the contact with its altered counterpart—the hangingwall and footwall MUT; and the interpreted fold axis through it could be at a considerable angle to the remnant.

This has been a fundamental since day 1.
No. Different protolith can be recognized

These relationships reveal a potential diamond drill core interpretation problem:

- On a section with a single argillite intersection in one hole and an argillite and MUT intersection in another down–dip hole, it is almost certain the two argillites will be correlated, with little consideration given to correlating the argillite to the MUT. Yet in the pit, argillites and MUT can be correlated within the same lithological horizon.

Alteration Types and Relationships

Excluding the regional greenschist facies grade and its ubiquitous chlorite alteration in the mafic pyroclastics, pit mapping reveals the significant alteration components to be (in chronological order as per current thinking):

- Pyritization (MUT)
- Silicification (includes ore event) and
- Sericitization/pyritization (SERT)
- Fuchsite ? See Keith's comments Jun 20/90
- Dolomitization (+/-calcite) – some, at least, is very early.

Sorting out the true chronological order of the alteration events is still at best, very confusing due to the presence of conflicting relationships—the result of multiple stages of overprinting and later modification by at least two phases of deformation and thrust faulting. Pyritization is currently thought to be pre–ore, and silicification/sericitization is thought to be ore–related; fuchsite is spatially related to the structural footwall of the ore zone in sheared wallrocks. The major dolomitization event is thought to be a later, possibly post–ore event.

The following subsections discuss these alteration phases in more detail.

Pyritization

In the Deposit area, the light to medium grey MUT dominates the immediate footwall and lower, down–dip hangingwall of the ore zone. The MUT units are interpreted to represent an early, intense "pyritization" form of alteration in the argillites within the Sam Horizon—often containing up to 60% or more very fine grained pyrite. In the mine area, MUT are more extensive, but always intimately associated with their unaltered argillite equivalent. They often contain an argillaceous component as "lithic fragments". Evidence in support of this pyritization process lies in the hangingwall of the Phase 1 ore zone, where a large MUT unit (as an "alteration front"), surrounded by SERT, could be seen to grade **along strike** southwards, into an unaltered argillite, typical of the many "remnants" found along the Sam Horizon.

Evidence of accompanying silica may be explained by a cherty component often associated with the MUT ("cherty MUT").

This alteration event was intense and destructive as in many instances the original turbidite textures have been obliterated.

The reason for believing it to be an early alteration phase is that MUT can be seen to be locally silicified in the footwall of the ore zone.

Silicification and Sericitization/Pyritization

Silicification is common in the Deposit area as localized ore–related silicified wallrocks (eg., former "quartzites") to the orebody and as silicified graphitic argillite/wackes (formerly "black cherts" footwall to the ore zone, and in the hangingwall rocks at or near the mafic pyroclastic/sediment contact). Early, silicification is generally intense but localized as for example, on the Phase 1, 1280 Bench, where only a few meters of the footwall portion of a 20m thick argillite remnant nearest the ore zone is silicified; the rest is unaltered. This event may be directly ore–related, although it is not yet known with certainty when and how many episodes of silicification there have been. Another phase of silicification may be represented by the hangingwall silicified argillites which are riddled with deformed, unmineralized, quartz veins and veinlets.

The altered wallrocks enclosing the orebody consist of SERT on the structural hangingwall side of the ore; and MUT and their unaltered equivalents—the turbidites—on the footwall side. It has been observed numerous times in the pit and in drill core, at all scales, that quartz veining may occur at the contact of two differently altered rocktypes. On the 1280 Bench, the quartz vein ore zone terminates along strike northwards within the sheared contact between the MUT and SERT.

Sericitization is abundant and well–developed in the Deposit area and is regional in proportion. Collectively, any strongly sericitic rock in the Mine area is termed a SERT; however in reality, there are at least two types:

- sericitic mafic pyroclastics—recognizable by the greenish brown colour, and location; which is often in the highly strained, sheared mafic/sediment contact area, and generally surrounding the nearby silicified hangingwall argillite.
- sericitic sediments (argillite/wacke)—recognizable by their yellow to buff colour, and location: in the immediate hangingwall and sometimes footwall of the ore zone and lower down in the footwall of the ore zone. Often, original centimetre scale syngenetic (yes, syngenetic!) pyrite beds from the original argillite/wacke protolith still remain.

Throughout the Deposit area, well developed sericitic alteration (as sericite schists) appear most commonly as a concordant feature; however, local strongly discordant sericitic alteration is also evident (eg. 1330 Bench, Phase 2, in the footwall of the ore zone where there is a substantial crosscutting SERT "alteration front" in the argillite unit).

Disseminated pyrite is a common feature of sericitized rocks, as are thin lenses and beds of cherty silica which may often form a major component of the SERT—indicating a quantity of silica accompanied the sericitization process.

Silica is a natural product of the destruct of feldspar.

As with the other alteration events, not enough is known about the relationship of sericitization to the ore and its timing; however, because sericitic alteration extends structurally upwards into the strained, lower portions of the mafic pyroclastics, some of the sericite may actually have a tectonic origin—during the later thrusting process—in the vicinity of the volcanic/sediment contact.

Sericitic alteration (at least the yellow variety) is thought to be later than MUT and silicification because it is known to "displace" MUT/argillite from the ore zone.

Fuchsite

Fuchsite alteration is very intense for 1–2 meters into the immediate footwall of the ore zone along its entire exposed strike length, regardless whether the footwall rocks are SERT, silicified argillite, argillite, or MUT. I have always held to the belief that by quantity and association, it is a shear–related alteration feature where thrusting and sericitic alteration in contact with MUT and argillite is strong. I realize this is contrary to another belief (e.g. Keith Glover) that by the chemical association with chromium, and the relatively common occurrences (much lesser intensity though) of fuchsite throughout the mafic volcanic units on the property, this footwall fuchsite occurrence represents a highly sheared original mafic volcanic horizon. The problem I have with this interpretation is that I have yet to see any

The mafic volclastic thickens to the N but is not present at Sam.

convincing sign of a significant mafic volcanic unit in footwall contact with the ore zone—it is **all sediment.**

Dolomitization

The major dolomitization event appears to have been late. When at its strongest, it produces a weakly to non–foliated texture, often distinctly mottled. It is most abundant in the mine area within the sheared mafic/sediment contact in the Sam Horizon. Also, recent pit drilling has revealed a distinct zone of dolomitization in the footwall of the ore zone beginning about Section 100+00mW and trending northwards away from the ore. In this latter instance, it is believed most of the protolith was sediment; however, in one instance, a texture resembling dolomitized lapilli was noted; indicating the possible inclusion of a volcanic component in the mine stratigraphy at this end of the Deposit.

Summary

Figure 1 schematically represents the above lithologic and alteration relationships as they now appear in the pit.

The ore body is still an enigma. As a quartz vein, it is well mineralized with tetrahedrite, sphalerite, galena, chalcopyrite, and minor pyrite. It is surrounded by extensively altered rocks described above; yet with all this alteration, including numerous other base metal and pyrite mineralized quartz vein occurrences, we do not yet understand why it is the only quartz vein in the area containing significant tetrahedrite.

STRUCTURAL INTERPRETATION

Regardless of genesis, it is now generally accepted by most who have seen Sam, the orebody is an unusual **stratabound** quartz vein occurrence; generally tabular in shape, and averaging about 5 meters thick, 450 meters long and varying about 100–150 meters in dip length.

Thrust faulting with its associated folding, and cross faulting were thought to be the dominant structural features affecting the ore zone.

Within the last two months however, a more complicated structural picture has emerged. In addition to the abovementioned features, the Deposit area stratigraphy shows increasing evidence of an earlier phase of folding, such that what really occurs is isoclinal or "folded folds". There is also evidence of original ore vein discordancies.

It appears we are mining the thicker, flattened, down–plunge portion of the ore zone which upwards has been caught up in a north plunging fold structure. Figures 2 and 3 schematically illustrates the development of this structure and its effects on the ore zone from the 1330 Bench, upwards to the 1350 and 1370 Bench where the ore vein has been tightly folded and thinned to only a few centimetres. Axial planar cleavage/foliation is very strong. It can be seen that the ore zone is only economic in the limbs and flattened portion of the fold where

I thought things thickened on hinges, thinned on limbs.

it is thickest (possibly original dilatant zones suitable for thickened veins to occur; or more probably, zones of less strain during development of the drag fold and thus are relatively undeformed by this structure). It is significant to note that in the area of the ore zone, the ore horizon (ore and SERT between the mafic volcanics on the hangingwall and the MUT/argillite on the footwall) is 80 to 100 meters thick; whereas on the 1370 Bench, in the area of the tightest occurring fold structure, this same package of rocks is now only 10 meters thick.

This fold structure may be either a large–scale equivalent to the isoclinal style folds which are very well developed in the hangingwall silicified argillite unit on the 1330 Bench, the ore zone itself, and the footwall argillite; or a completely different third phase of folding. Until now, very little has ever been said about folding other than Phase 1 as we have only been able to observe them reliably and consistently in the Phase 2 mining.

Together with the previously recognized folding and thrust faulting, this new structure adds a whole new dimension of structural complexity to the deposit. Isoclinal folding may explain the sudden disappearance of the northern, down-dip portion of the orebody between Sections 100+20mW and 100+40mW; from a 30m+ thick zone of quartz vein, to virtually nothing in the space of 20 meters!

DISCUSSION

So how do these interpretations affect the progress of future geological work at Sam?

I believe the thoughts and interpretations expressed here on alteration and structure should be applied and tested in future exploration ventures in the area. As stated before, we must realize and appreciate the extreme geological complexity of Sam:

- We are being exposed to a deposit with an extremely complex multiple alteration and deformational history.
- The ore zone and alteration are mostly concordant, producing a stratabound effect; however, local strongly discordant ore–related veining and alteration is becoming more apparent.
- As the alteration package (especially sericitization, pyritization and dolomitization) is very complex and extensive, the original argillite/wacke protoliths now form only remnants within the horizon.
- These remnants are common within the Mine Series rocks and probably represent the sole protolith for much, if not all of the Sam Horizon .

The argillite/wacke remnants always have their altered equivalents (MUT) closely associated with them. We must be careful to not always interpret a lithological change simply because two differently altered rocks are in contact with each other. For example, a MUT in contact with a zone of strongly dolomitic alteration may be interpreted to be a MUT/dolomitic mafic volcanic contact. Why? If there is no obvious lithological boundary, or apparent volcanic texture remaining, it could also be a dolomitic MUT or argillite.

The Deposit area—including the ore zone—has been subjected to more than one phase of folding producing isoclinal fold styles with resultant undulatory fold traces within the entire package.

Finally, I believe we can relate the abovementioned fold interpretation in the pit to what may be a **very significant tetrahedrite–bearing intersection** made recently on the Cana Property. We can no longer pass this sort of intersection off as "noise".

We never have done. These are invariably followed up.

As discussed earlier, the 1370 Bench of the open pit reveals the ore vein(s) have been subjected to tight folding and subsequent thinning to only a few centimetres. On the Cana Property, drill hole C90–6, intersected a 2–3 centimetre discordant tetrahedrite/sphalerite–bearing quartz vein in a chert unit. Immediately below this intersection the cherts displayed a well developed cleavage normal to bedding—indicating a fold hinge structure possibly analogous to what is described above at Sam; i.e., this intersection may represent a tightly folded, thinned vein, **high up** in the fold structure. If this is so, we should continue exploring this area (and any other similar occurrences) at depth—trying to follow the limbs of the fold in the hope the vein flattens and produces a thicker vein structure. It would be necessary to work out the orientation of the fold structure as it would not necessarily be the same as occurs at Sam. This may even require some drilling be done off grid azimuth—to the northwest or southeast.

Thin hinges again!

How? Why not?

Bob Friesen

17/10/90

SCHEMATIC PLAN OF SAM ORE HORIZON - SOUTH TO TOP OF MAP.

≈ 1300 ELEVATION.

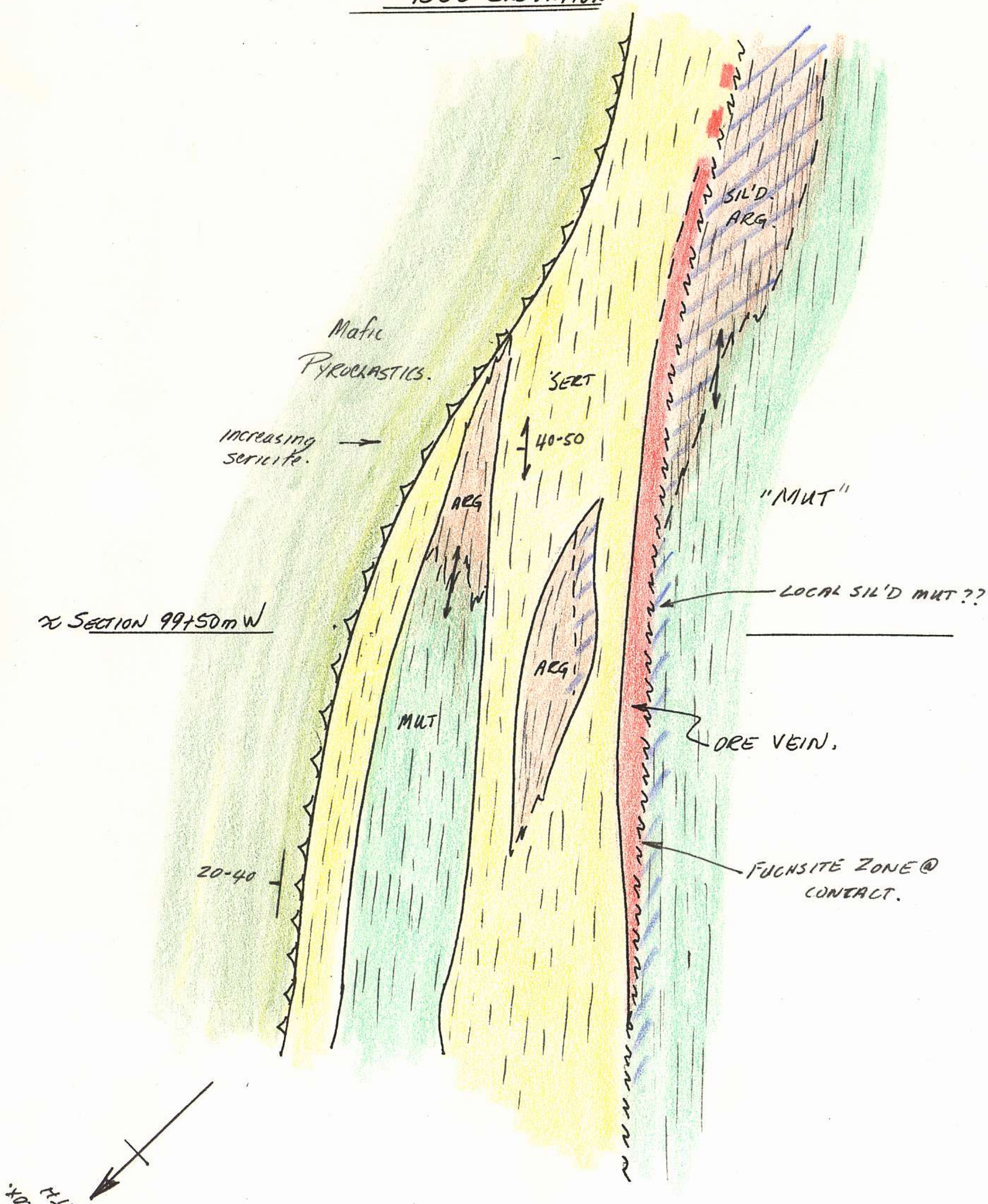


Fig. 1.

B.F. 24/9/90

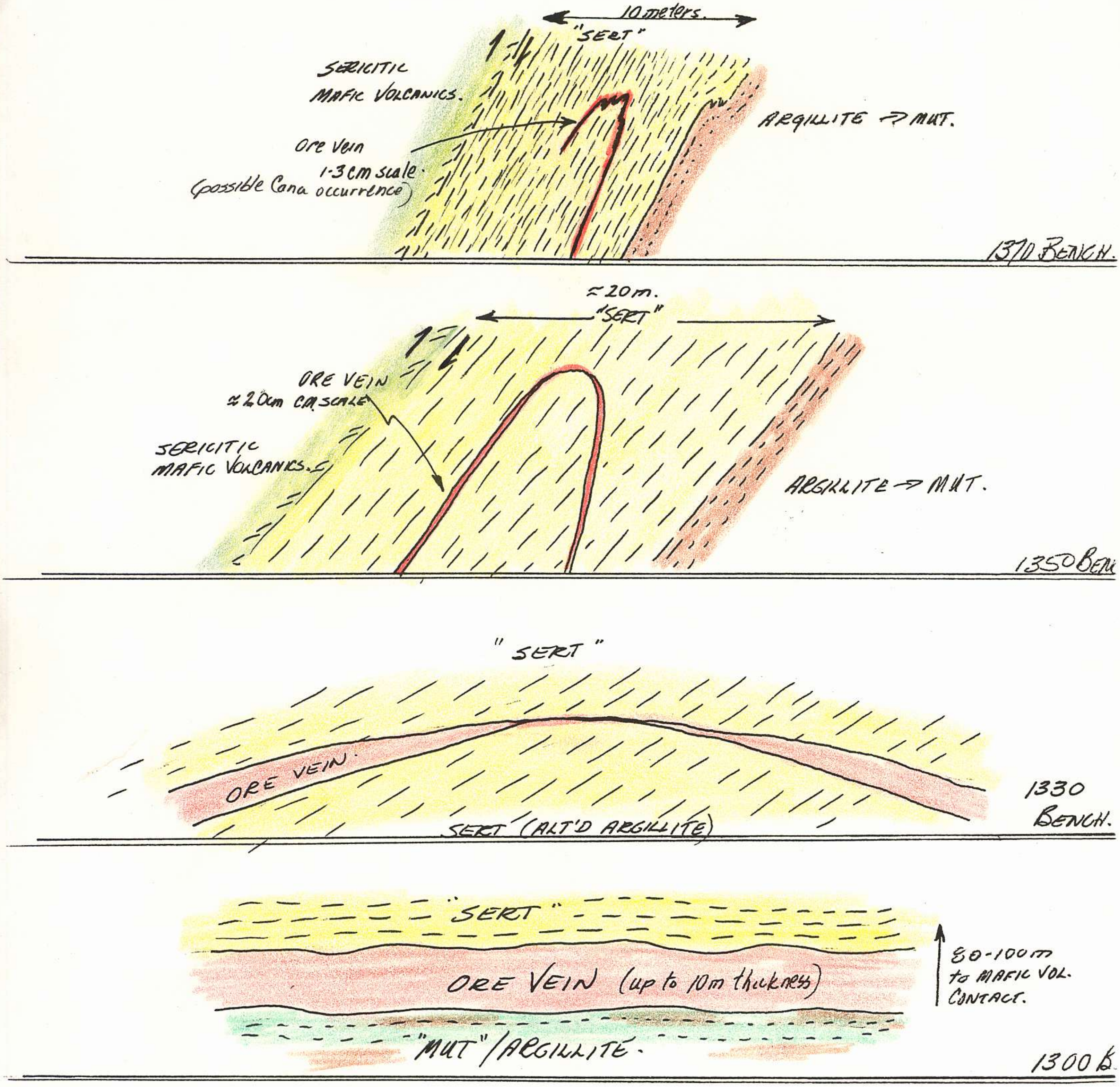
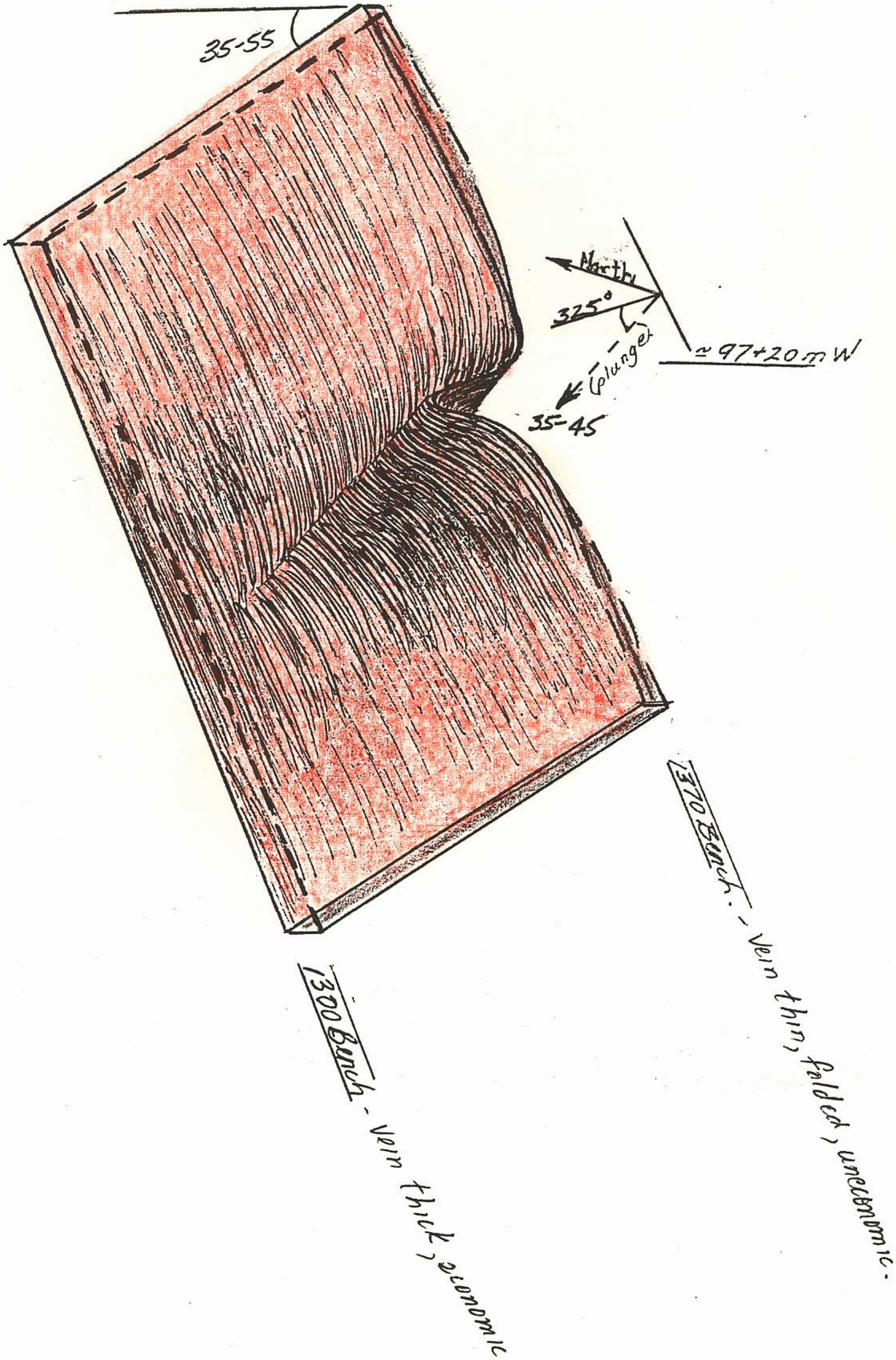


Fig. 3. SCHEMATIC SECTIONS LOOKING WEST.
SHOWING DEVELOPMENT OF FOLD STRUCTURE.

B.F. 24/9/9.

SCHEMATIC PORTRAYAL OF INTERPRETED FOLD GEOMETRY @ SAMI



B.F. 24/9/90

Fig 2.