

MEMORANDUM



**PASMINCO
EXPLORATION**

24 December 1999

TO Andrew McNeill, Kim Denwer

FROM Marcus Hope

SUBJECT Beatrice Prospect - Similarities and Suggestions

MS10 and MS11 comparisons with other holes.

MS10 displays many similarities with MS8: not surprising due to their position at the northern end of the MSAZ . The stratigraphy of MS4, although also drilled in the northern portion of the MSAZ, shows a greater affinity towards MS1 but contains only minor base metal grades. The closest similarity between MS4 and MS10 and MS1 is the presence of the “typical” coarse limestone/lava clast - pumiceous breccia which appears as less extensive within MS4 with it intersected from 58 to 100m. The presence of mass flows with grading both up and down hole and a diffuse repetition of stratigraphy may indicate that the hole was drilled through the top of anticline, explaining the limited thickness of the coarse volcanoclastic mass flow sequence.

<u>MS10</u>	<u>MS8</u>	<u>Description</u>
350	561.9	Black shale unit with finely bedded and replacement pyrrhotite, creating an interval of elevated mag susc readings. This zone also contains elevated BMS in both MS8 and MS10. Although minor (60-120ppm Cu) in thin section (from MS8) chalcopyrite appears commonly intergrown with anhedral pyrrhotite, with minor galena and sphalerite. Typically more abundant galena and sphalerite exist as fine cross cutting veinlets.
389	582-582.4	Coarser volcanic derived mass flows, with sphalerite replacement of clasts consisting of fine grained quartz sericite.

The sedimentary sequence consisting of the base of the shale unit and top of the volcanoclastic units which can be correlated between MS10 and MS8 is interrupted in MS8 by a Quartz Feldspar Porphyry sill from 583.4-651.7m. This interruption between these likely correlates is somewhat expected due to the inconsistent nature of the porphyry and its irregular intrusion into the black shale

403-416.25 425.9-433.5		680-689.9	Coarse, quartz phyric, sericitic pumice/limestone dominated breccia, in a strongly sericite altered groundmass. An associated sequence, such as the interval between 464.9 and 472.3 in MS10 contains abundant large shale clasts together with medium to large limestone clasts. This unit may possibly correlate to the volcanic shale breccia observed on the access track north of MS3. The unit in MS10 has an underlying sequence of mass flows dominated by limestone and sericitic pumice. This “couplet” of shale clast rich volcanoclastic overlying a limestone - pumice unit may also correlate with a thin limestone/sericitic pumice interval at 20 to 34.6m in MS3.
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<u>MS-10</u> 497.2-632.7		<u>MS-8</u> 696.5-787.3	Interbedded true black shale with blue green grey volcanic siltstone. Black shale is typically pyritic whereas the ashy siltstone contains only minor pyrite. Unlike MS8, this lower sequence in MS10 also contains moderate fine grained interstitial and rare coarse vein related pyrrhotite. Both units contain intervals of moderate BMS mineralisation. At 620.5m in MS10 1.8m @ 4.6%Zn, 0.6%Pb and 22ppm Ag manifested as discordant veins within a black shale unit containing a fine, ashy volcanic component. Sphalerite present within this interval displaying colour variations from dark red/brown in the centre of veinlets to a pale brown orange selvage. Between 517 -519.2m in MS10 similar veinlet mineralisation in black shale assays 2.2m @ 2.4%Zn, 0.37%Pb and 13.5ppm Ag. In MS8 this shale/volcanic siltstone also contains anomalous mineralisation, where BMS exist as replacements of large carbonate clasts such as between 707.6 - 709.65m. Discordant veinlet sphalerite mineralisation very similar to 620.5m in MS10 also exists in MS8 at 735.1m where randomly orientated, veinlet sphalerite has more subtle colour variations from dark red/brown to pale brown/orange sphalerite.
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volcaniclastic units correlate to elevated BMS tenor. Also obvious within the mineralised interval: 111.5- 118.6m in MS3 are pink aphyric lava clasts that are similar to those in both MS1 and MS11. However the second BMS intervals found in both MS1 and MS11 are hosted in coarser volcanic sandstone/grit, with localised strong pervasive chlorite alteration but do not display associated chlorite spotting.

The coarse volcaniclastic mass flow sequence in MS11 (151.6 - 440.3m) appears similar to the usual coarse limestone - lava lithic, pumiceous mass flow units observed in the majority of holes with this unit most similar to the coarse volcaniclastic mass flow units intersected in MS1, MS7, MS4 and between 51.2 - 111.5m in MS3. Several small beds/units within this sequence may possibly be correlated to other holes, particularly the coarse limestone / quartz aphyric pumice breccias observed at 216, 254.3-254.7, and 345-345.65m. This coarse volcaniclastic mass flow sequence in MS11, however, exhibits stronger potassic alteration within the centre of the sequence as opposed to at depth. As the inclination of this hole was much steeper than MS1 this Kspar - chlorite alteration may be intersected earlier and pass down and out of the potassic alteration.

Down hole of this potassic alteration zone, located between 518.2 and 528.3 in MS11 are a series of massive magnetite veins <3cm thick. At 521.6m 1-2mm carbonate veins containing galena cross cut (ie postdate) these veins. If this magnetite veining is associated with the alteration inferred from the high K magnetite series Granites that lie east of the prospect. Then it would appear that the carbonate vein hosted galena is a late feature, possibly supporting the idea of remobilised sulfides. The presence of alteration zonation may also be a possibility, with the potassic alteration passing down into magnetite alteration, perhaps an alteration assemblage more proximal to the inferred granites.

Chemostratigraphy

Black shale units are characterised by high Mg, Sb, Co, Sn, Cd and Ni

Quartz Feldspar Porphyry units contain high Na and are also slightly enriched in Ba.

Volcaniclastic units are typically strongly depleted in Na, with generally high K, reflecting the destruction of primary feldspar and the formation of sericite. Potassium and Ba show localised higher concentrations in the fine volcaniclastic units, evident in both MS7 and in MS8. This addition of Ba would most likely result from the formation of sericite, as Ba may occur as a trace component with the crystal lattice of white mica (Maclean and Hoy 1991). Potassium increases at depth in MS7, possibly attributed to the increase in K feldspar - chlorite alteration. Sodium also shows a notable increase at depth within MS7 and MS10 however this may possibly be lithologically controlled and associated with the fine felspathic volcanic siltstone.

Coarse volcaniclastics show localised increases in Ca and hence a matching reduction in AI (due to CaO being in the denominator of this equation). These intervals, prominent in MS7 at ~385-390m and ~425m are associated with coarse limestone/sericite breccias. A similar feature is observed in MS10 at ~405 and 470-485m. This interval between 470-485m in MS10 also contains approximately 3% sphalerite within the matrix. Indicating that zones of mineralisation do not always have a matching increase in AI.

AI $[100 * (\text{MgO} + \text{K}_2\text{O}) / (\text{MgO} + \text{K}_2\text{O} + \text{CaO} + \text{Na}_2\text{O})]$ also shows a somewhat inverse relationship to mineralisation within some of the shale units due to the preferential mineralisation of carbonate beds such as 560m in MS8 and also due to mineralisation associated with abundant carbonate \pm quartz veins. Due to the localised increase in Ca incorporated as CaCO_3 within these areas AI is reduced. As a result, it would therefore appear that the AI has limited applications as a geochemical vector. However CCPI $[100 * (\text{MgO} + \text{FeO}) / (\text{MgO} + \text{FeO} + \text{Na}_2\text{O} + \text{K}_2\text{O})]$ shows localised increases correlating with zones of base metal mineralisation, particularly within the shale units. This increase in CCPI may be explained by the Fe rich sulfide species (both pyrite and pyrrhotite) associated with base metal mineralisation within these intervals.

Elements associated with mineralisation include: **Mn, Cd, Sb, Co As and to a lesser extent Bi**

Antimony has been used as a vector at Rosebery, Hellyer and Thalanga with values up to ~100ppm proximal to ore. Lentz et al. (1997) also show an increase in As, Sb with S, Cu and Co at Heath Steele North America. Localised increases in antimony associated with

mineralisation exist in MS8, MS10 and a broad increase in MS7. Within MS7 antimony shows a broad high, associated with the shale unit but Sb increases at the base of the shale unit associated with an interval of minor Zn mineralisation and elevated arsenic values. Within MS8 and MS10 at 565m and 460m respectively elevated Sb (and Cd) closely correlates with Pb, Zn, Ag mineralisation. In MS8 antimony increases to ~65ppm associated with elevated Pb, Zn, Ag mineralisation typically manifested as veinlets that cross cut pyrrhotite, pyrite and arsenopyrite replacement and veining of carbonate banded black shale. As expected from the weak magnetism generated from pyrrhotite this interval is also defined by elevated magnetic susceptibility readings. The weaker base metal mineralisation at 345 -375m in MS10 and higher grade intervals between 560 -690m is defined by increased magnetic susceptibility readings also attributed to fine grained pyrrhotite-pyrite mineralisation.

The mineralisation between 560 - 583.4 m in MS8 (23.4m @ 0.9%Zn, 0.4%Pb, 85ppm Cu and 12.6ppm Ag) corresponds to the carbonate bedded black shale (mahope unicalogue 112983) Where Pb - Zn veinlets cross - cut earlier pyrrhotite arsenopyrite and pyrite veins and replacements. Anomalous manganese occurs within this section however As and Bi is absent or minor. (However, it is clearly evident in thin section that Arsenopyrite is present).

Interestingly at depth (779.2 - 782.4m in MS8) elemental associations are somewhat reversed. Pb, Zn, Ag and Au mineralisation (3.2m @ 0.9%Zn, 0.2%Pb, 156ppm Cu, 10.4ppm Ag and 0.08ppm Au) is associated with very high As, Bi and minor Cd and Co but low Mn. The mineralisation within this interval exists typically within discordant quartz carbonate chlorite veins containing coarse arsenopyrite.

It would therefore appear that Mn is a useful indicator to mineralisation, even though it is notably absence from some intersections, such as the above mentioned interval between 779.2 - 782.4m in MS8. As this (possibly late stage?) vein style of mineralisation is not of the preferred target style, the use of Mn as a vector and possible mechanism to differentiate between

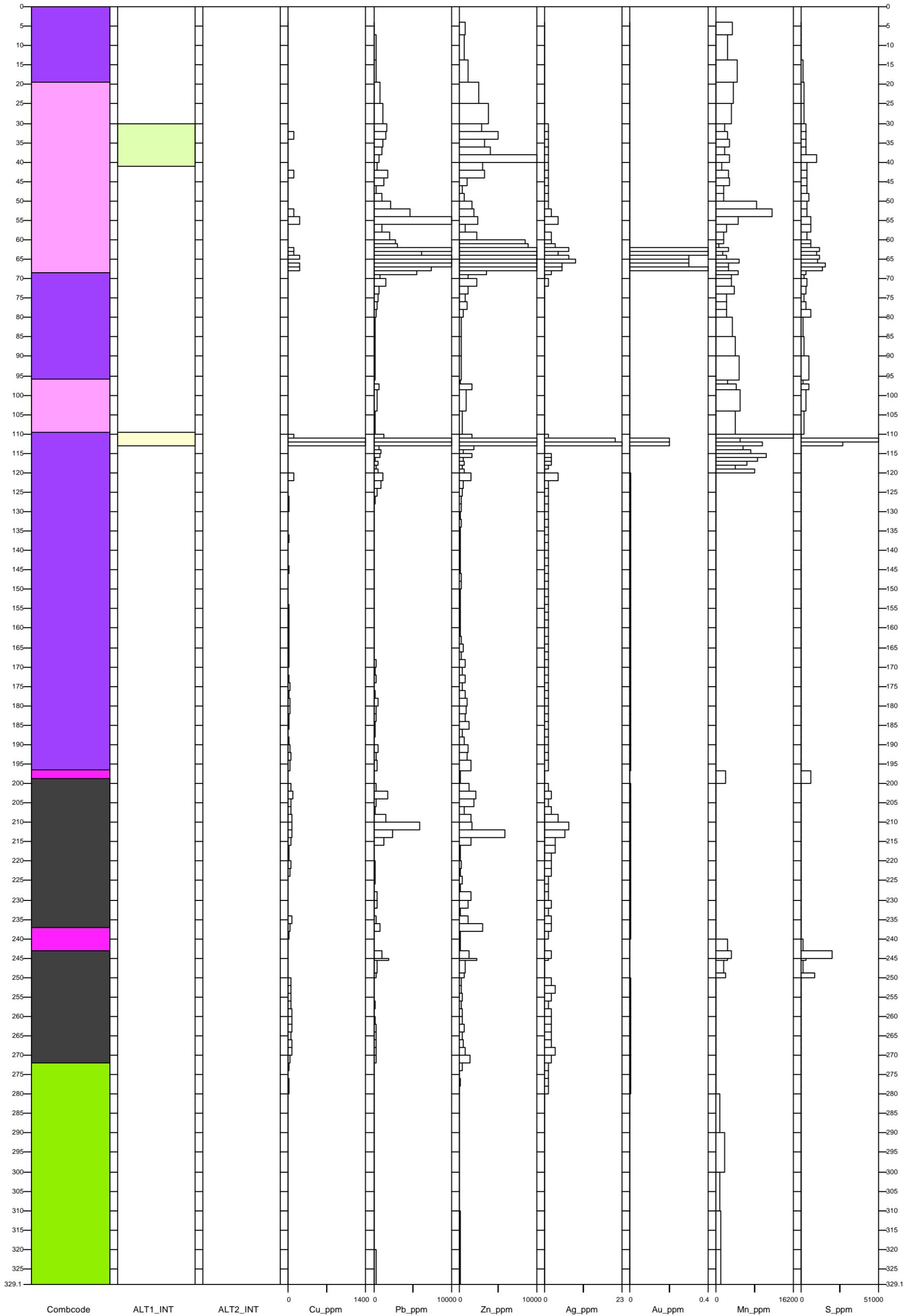
The sharp antimony peak (104.5ppm) observed at ~460m depth in MS10 has a matching Cd anomaly and is associated with Pb, Zn, Cu and Ag mineralisation of a light green sericitic quartz crystal, pumiceous volcanoclastic rock.

Suggestions for further study on the genesis of mineralisation.

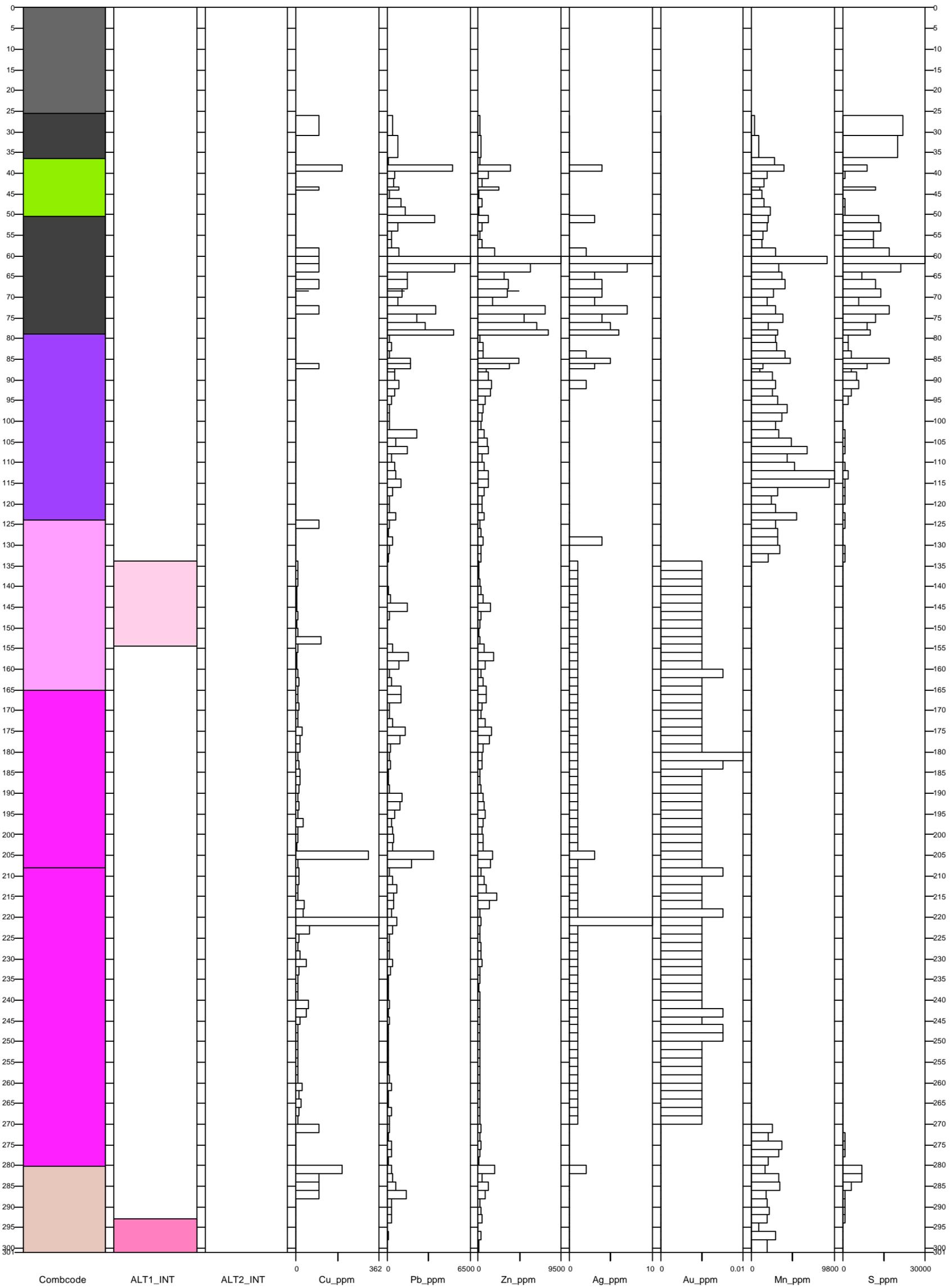
Further examination of primary type 3 fluid inclusions in sphalerite (such as field sample MH3-16 rock catalogue no. 112956), and possible microprobe analysis on various shades of sphalerite colour. My analyses were limited with no obvious colour differences between my samples but the veinlet mineralisation in MS10 at 620.5m may indicate a change in sulfide composition resulting in the obvious colour differences between sphalerite on the edge and central portions of these veinlets.

A downhole traverse of $\delta^{34}\text{S}$ values of pyrite may be beneficial in identifying the spatial distribution and effect of granite derived fluids. It is evident from my research that sulfides do display a wide range of $\delta^{34}\text{S}$ values, with values consistent with VHMS style mineralisation and also the effects of evaporite minerals. However no evidence for a magmatic fluid responsible for the potassic - chlorite - magnetite alteration has been found apart from the characteristic granitic mineralogical assemblage. I would imagine that a down hole traverse of a hole such as MS11 or MS8 would show a systematic change in $\delta^{34}\text{S}$ values, from low $\delta^{34}\text{S}$ values within the K feldspar - chlorite - magnetite zone, indicative of a magmatic source through to heavy $\delta^{34}\text{S}$ values associated with diagenetic pyrite (and sulfides formed from the in situ reduction of sulfate minerals). Also expected would be intermediate values associated with the various higher grade sulfide intervals such as at 58.7 and 149.9m in MS11 due to the mixing of sulfur derived from the underlying volcanic rocks and the reduction of seawater sulfate.

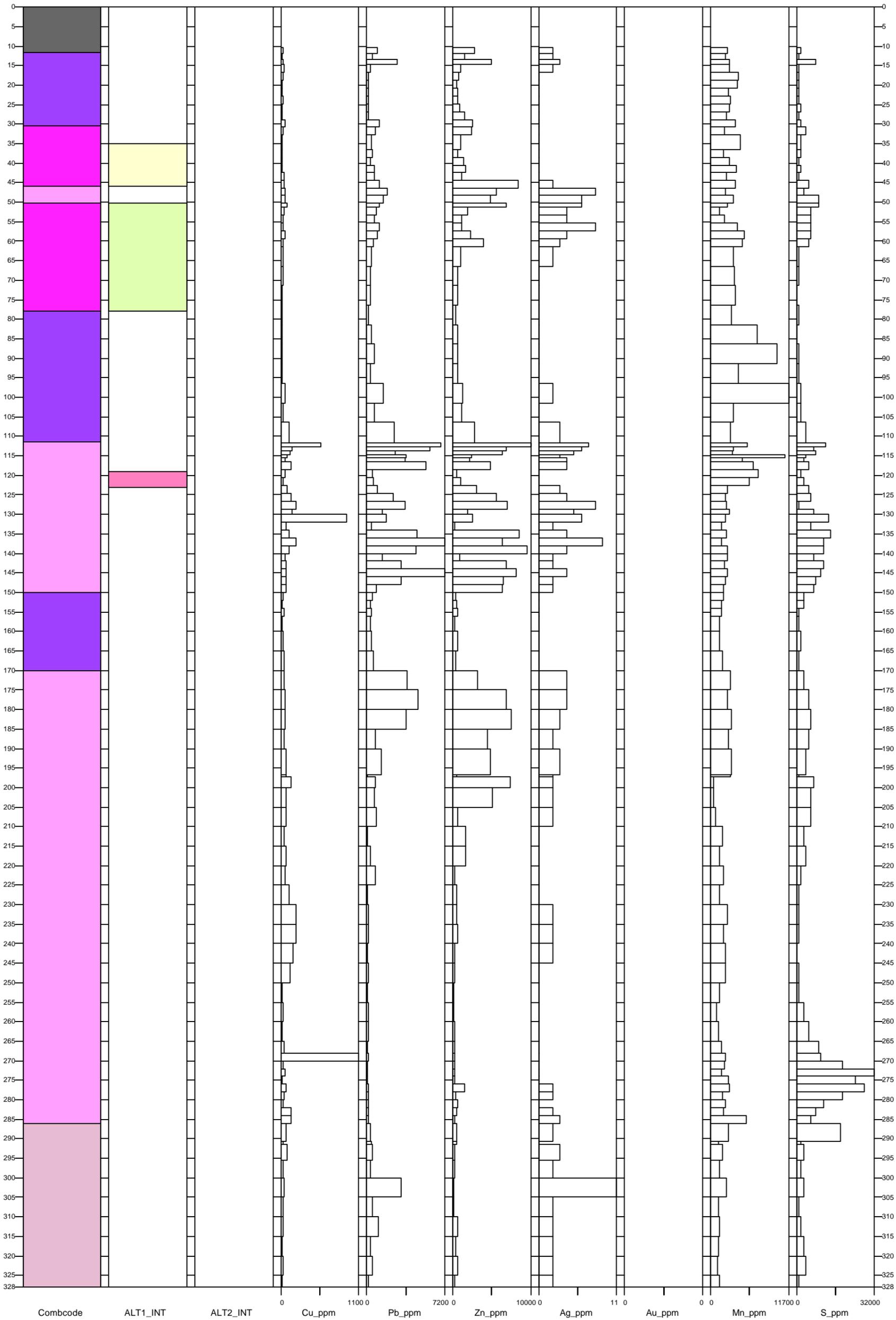
Log for MS1



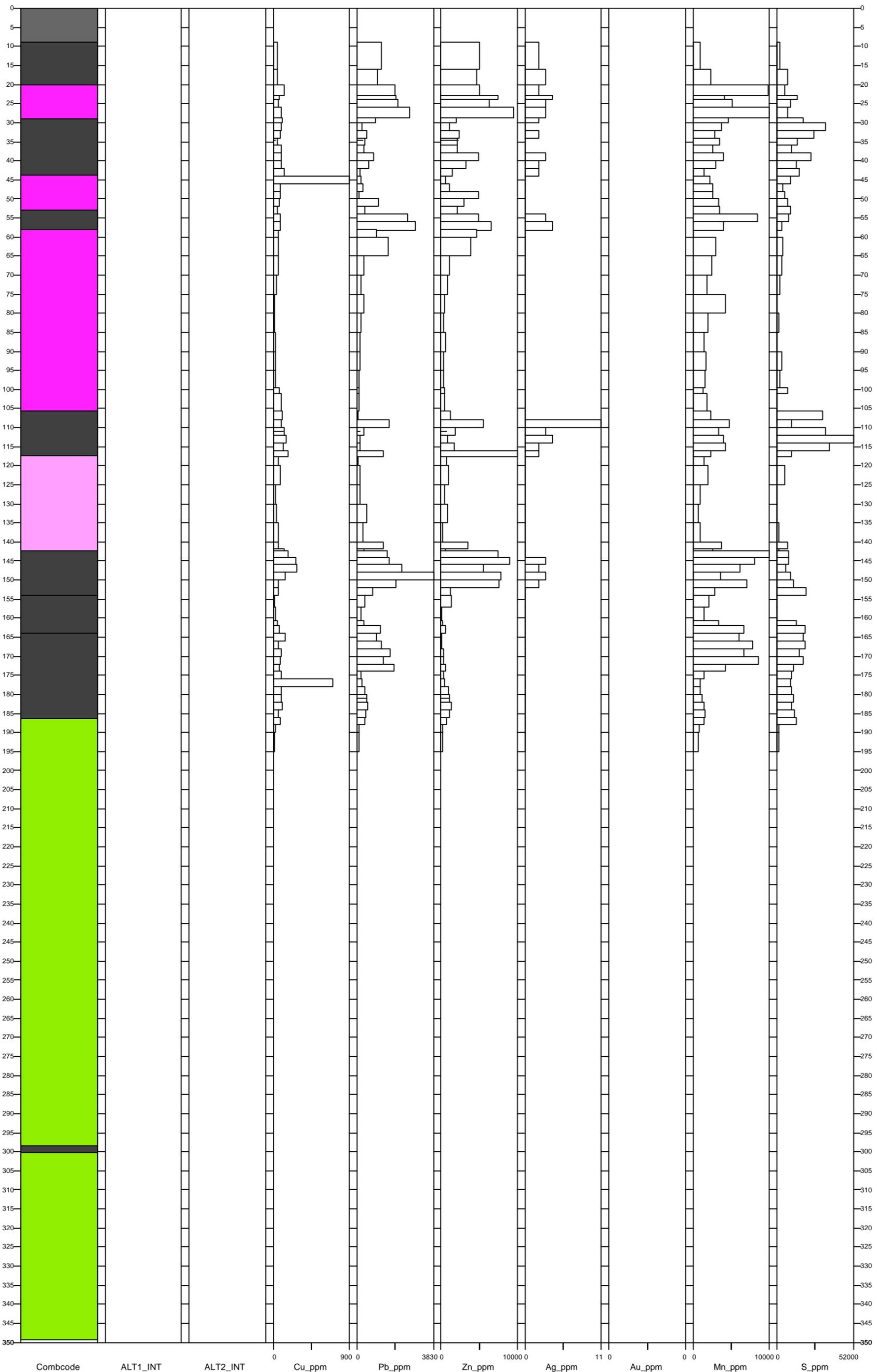
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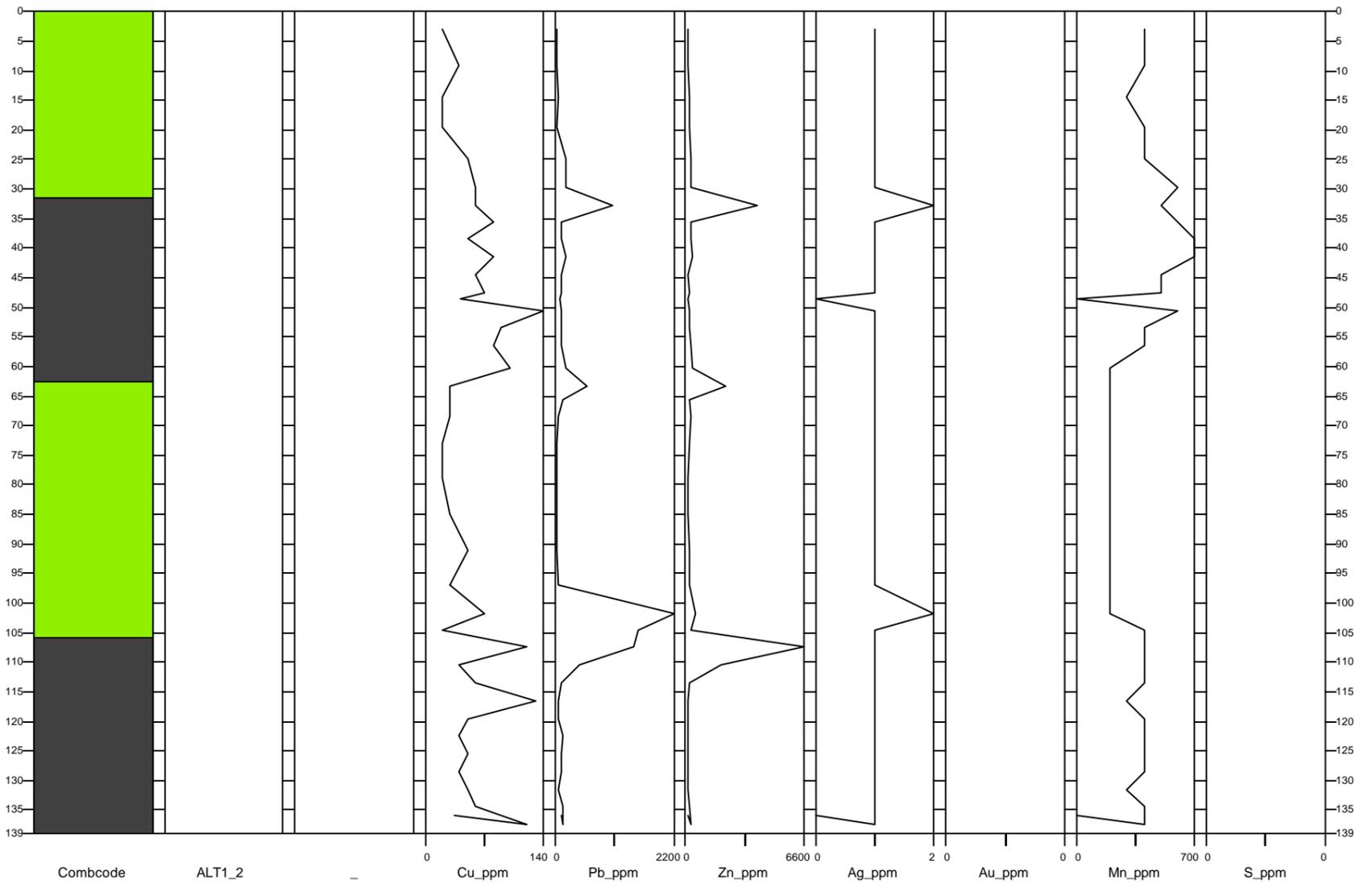
Log for MS3



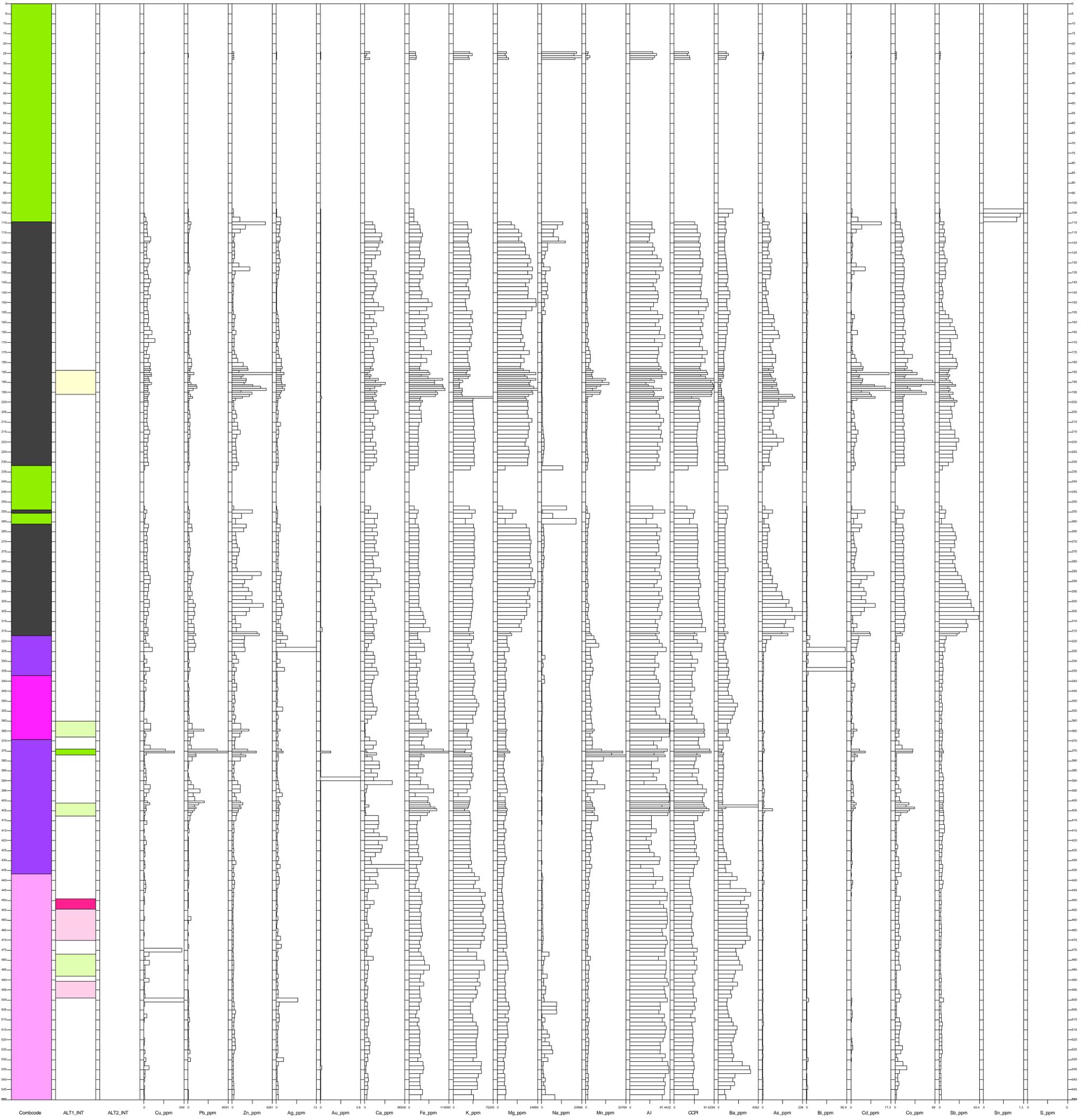
Log for MS4

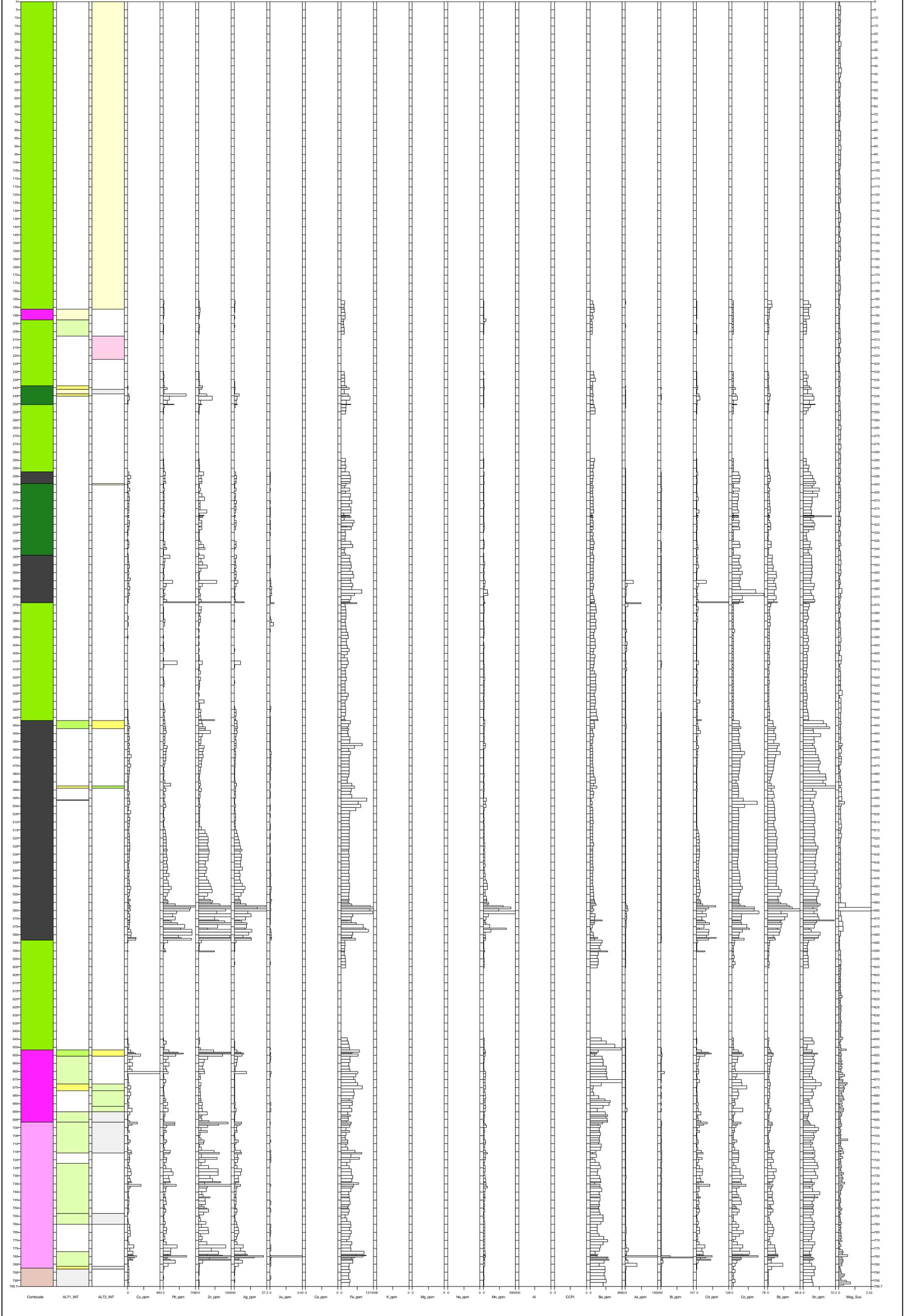


Log for MS5



Log for MS7





Log for MS11

