



**GEOLOGICAL INVESTIGATIONS OF THE HIDDEN CREEK DEPOSIT,
ANYOX, NORTHWESTERN BRITISH COLUMBIA
(103/P5)**

By **R.W.J. Macdonald, T.J. Barrett, R.L. Sherlock, R.L. Chase, P. Lewis**
Mineral Deposit Research Unit, U.B.C.
and
D. J. Alldrick
B.C. Geological Survey Branch,

(MDRU Contribution 042)

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INTRODUCTION

The Hidden Creek mine is an historic copper producer located within the Anyox pendant, a volcanic-sedimentary succession preserved as a roof pendant along the eastern margin of the Coast Plutonic Complex, approximately 160 kilometres north of Prince Rupert, British Columbia. (Figure 1)

This study is the first phase of a two-year program designed to examine the geological and geochemical relationships of sulphide mineralization in the Anyox pendant. This phase focuses on the volcanic-sedimentary contact at the Hidden Creek mine which is recognized as the main site of massive sulphide deposition in the Anyox camp. In this first year, the project utilized data and drill core from the exploration program completed by TVI Copper Inc. in the fall and winter of 1992-93. Sixteen holes totalling 3202 metres were logged and sampled for lithogeochemistry, fluid inclusion studies and petrographic analysis. Detailed mapping and sampling on a 1:2400-scale were carried out in the immediate area of the Hidden Creek mine with particular emphasis on the footwall metavolcanic sequence and the immediately overlying chemical and clastic sediments.

REGIONAL GEOLOGY

The most recent regional geological mapping in the Anyox pendant was done by Sharp (1980), Grove (1986) and Alldrick (1986). These authors defined a simplified stratigraphy consisting of a basal mafic volcanic unit of primarily tholeiitic, andesitic to basaltic flows and subordinate volcanoclastic layers, and an overlying sequence of siltstone, greywacke and sandstone with minor calcareous and conglomeratic beds. A chert unit crops out discontinuously along the volcanic-sedimentary

contact. Most recently the geochemistry of volcanic rocks in the pendant has been described by Smith (1993).

The structure of the pendant is dominated by large, north-trending, east-verging asymmetric or overturned folds. Superimposed on these are east-trending minor crossfolds that are most clearly recognized along the volcanic sedimentary contact. The area has been cut by several generations of faults. Fox (1989) identified a major décollement zone and tear fault in the Hidden Creek area, and related these to an early fold-thrust deformational event that generated the early north-trending folds. The entire succession is cut by late, mainly northerly trending extensional faults, one of which offsets the No. 2 and No. 3 ore zones at the mine.

Five major copper-rich massive sulphide deposits are recognized in rocks either along or adjacent to the metavolcanic-sedimentary contact (Figure 1).

EXPLORATION AND MINING HISTORY

The Hidden Creek deposit was discovered in 1901 and was operated between 1914 and 1935 by Granby Consolidated Mining and Smelting Company. During this period, 21 681 800 tonnes of ore grading 1.5 % copper, 9.25 grams per tonne silver and 0.17 gram per tonne gold was mined from the Hidden Creek deposit and an additional 647 904 tonnes averaging 1.51 % copper from the Bonanza deposit. The mine was closed on August 1, 1935 and purchased by The Consolidated Mining and Smelting Company of Canada, Limited, now Cominco Ltd. on October 25, 1935 (Davis *et al.*, 1992).

From 1936 to 1989 a number of exploration programs were carried out by Cominco and various joint venture partners. Most of this work was completed on the Hidden Creek, Double Ed and Eden properties. During the course of these programs, 96 holes were drilled for an approximate total of 17 000 metres (Fox, 1989). Detailed geological studies and drilling from 1950-54 resulted in the discovery of the Double Ed and Eder deposits. The

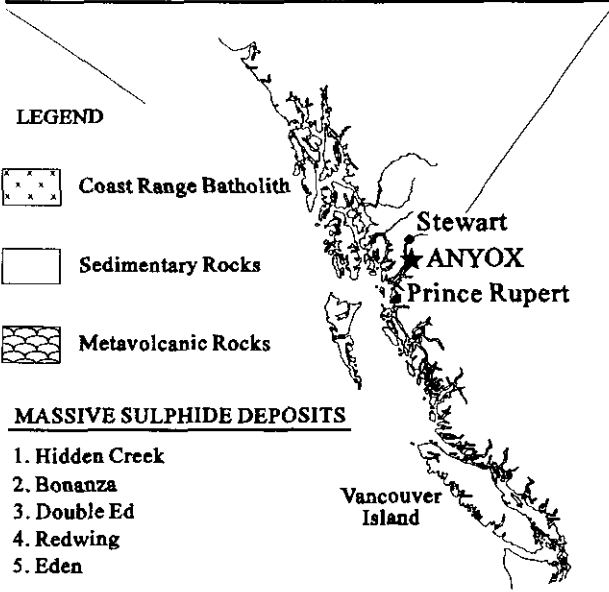
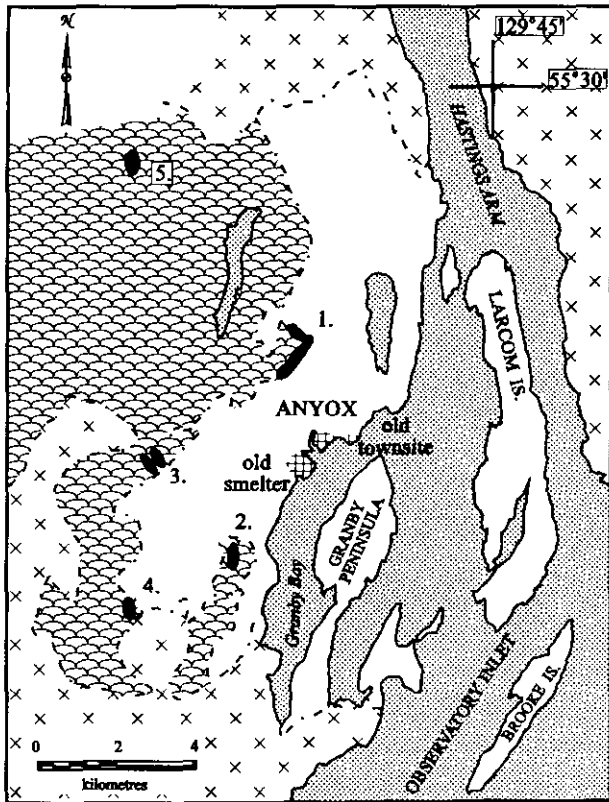


Figure 1. Location and general geology of the east Anyox pendant (after Alldrick, 1986).

work delineated a drill-indicated resource of 1 224 700 tonnes and a drill-inferred resource of 748 427 tonnes grading 1.3 % copper and 0.6 % zinc at Double Ed and a drill-indicated resource of 158 757 tonnes of 1.3 % copper and 1.9 % zinc at Eden (summarized in Davis *et al.*, 1992).

In a 1982 joint venture with Mitsui, 16 drill holes

were completed in the Hidden Creek area. Several new mineralized zones were identified under the No. 1 orebody although values were erratic or low grade. One intersection, obtained from a hole north of the old mine workings and within the sedimentary sequence, graded 2.5 % copper, 0.5% zinc, 100.4 grams per tonne silver and 1.8 grams per tonne gold over 6.1 metres.

From 1987 to 1988 a total of 13 drill holes were completed by Cominco Ltd. and Prospector Airlines Ltd. in the Hidden Creek, Bonanza Creek and Redlight areas, however, no significant mineralization was found. In 1990 Moss Management Ltd. and Boston Financial Corporation acquired the property and retained Glanville Management Ltd. to update the economic assessment of the property. This study indicated a geological reserve of 10.8 to 13.6 million tonnes grading 0.7 % to 0.75 % copper.

In the fall and winter of 1992-93, TVI Copper undertook a comprehensive exploration program that included geological mapping, prospecting, geochemical and geophysical surveys, and 4256 metres of diamond drilling in the Hidden Creek area and on other nearby copper occurrences. The program included eleven definition holes designed to confirm reserves and ten exploratory holes to test a number of targets (Davis *et al.*, 1993).

GEOLOGY OF THE HIDDEN CREEK AREA

The stratigraphy at the mine site consists of a basal metavolcanic unit overlain by a turbiditic sedimentary sequence with an intervening chert horizon of variable thickness. In most drill holes, intersections display consistent stratigraphic relationships across the contact and suggest that the original ocean-floor stratigraphy is, for the most part, preserved in this area (Figure 2)

METAVOLCANIC ROCKS

Massive to pillowed flows, fragmental metavolcanic and bedded volcanoclastic rocks form the footwall to the Hidden Creek sulphide lenses. These rocks are fine grained to porphyritic and have been metamorphosed to a lower greenschist assemblage of chlorite, actinolite, biotite, sericite, clinozoisite and zoisite. A biotite-chlorite assemblage forms a distinct subunit in the upper sections of the volcanic pile and may reflect hydrothermal alteration.

Pillows range from 10 centimetres to 1 metre in longest dimension and typically have length to width ratios of 2:1. Pillow rims are 1 to 2 centimetres thick, aphanitic and darker than the pillow cores. The interpillow fill consists of aphanitic to fine-grained, black to dark green to reddish coloured rock of predominately chlorite and biotite. Locally the pillow rims and interpillow fill are silicified and sulphide bearing in mineralized zones.

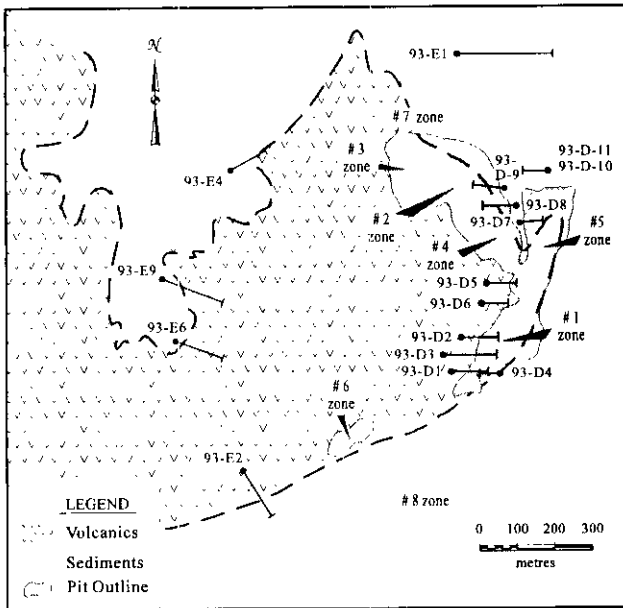


Figure 2. Generalized geology of the Hidden Creek mine area showing the distribution of the ore zones and the location of the drill holes logged during the first phase of this project. The number 7 and 8 zones are small subsurface deposits indicated by drilling (after Davis, 1993).

Fragmental rocks, described by Sharp (1980) as pyroclastic tuff horizons, crop out in several areas throughout the map area and are commonly recognized in drill core. The rocks consist of subangular to tear-shaped, actinolite-rich volcanic clasts, 5 to 30 centimetres long, separated by an anastomosing network of 0.2 to 1-centimetre, aphanitic quartz veins and fine-grained, granular to foliated volcanic rock. Individual clasts appear flattened and vein networks have consistent trends over tens of metres, imparting a banded appearance to these outcrops. The origin of these rocks is still in question as they have a similar appearance, on a small scale, to the silicified pillowed sequences that locally appear to grade into the fragmental rocks across zones of more intense deformation.

Bedded volcaniclastic horizons are readily recognized in drill core but are difficult to distinguish in outcrop. Beds are several centimetres thick, light olive-green in colour, and show normal grading. The distribution of these horizons is not well established within the volcanic stratigraphy, however, they appear most commonly near the top of the volcanic pile.

CHERT

A thin to thickly bedded, foliated, saccharoidal chert unit is found along the volcanic-sedimentary contact at Hidden Creek mine. It varies in thickness from less than a metre to a maximum of about 70 metres (Sharp, 1980). The maximum thickness is in the vicinity of the No. 1

and No.5 orebodies where the chert contains interlayered massive sulphides and volcaniclastic rocks. The chert varies in colour from bone-white to grey, reddish or pale green as a result of impurities. Individual beds vary from less than a centimetre to several centimetres in thickness and are separated by sericitic laminae. At its base the chert is interbedded with a silicified chlorite-biotite-sericitic schist and at its top with silicified siltstone or argillite; transitions between these lithologies are gradational over distances of several metres.

To date no microfossils have been identified within the chert unit. Its variable thickness and close association with exhalative metal sulphides and chemically precipitated carbonate in the mineralized zones suggest that the chert is of exhalative origin.

CLASTIC SEDIMENTARY ROCKS

The sedimentary rocks in the Hidden Creek area comprise laminated to interbedded siltstone, argillite and fine sandstone. Individual beds range from less than a centimetre to tens of centimetres thick, with sharp boundaries and thinly laminated tops and only rarely display good grading. Flame and load structures mark the boundaries of beds. Crosslamination is preserved in finer layers as thin wisps. Small, discontinuous limestone layers, less than a metre thick, occur near the base of the sequence immediately overlying the contact and decrease in frequency up-section.

The sedimentary rocks are variably metamorphosed and deformed, most strongly near the contact with the metavolcanic rocks. Metamorphism has formed phyllosilicates such as biotite, sericite and chlorite, and produced planar and crenulated fabrics through most of the unit. Medium to coarse-grained porphyroblasts of cordierite (Fox, 1989) are developed in pelitic rocks along the contact in the vicinity of the ore zones, and may be related to sub-seafloor hydrothermal alteration.

STRUCTURE

The orebodies sit within the hinge zone and the overturned limb of the Hidden Creek anticline, a northerly trending, easterly verging structure that formed as part of a fold and thrust system that Fox (1989) correlates with the earliest deformation event in the area (Figure 3). Movement along a tear fault, immediately to the south of the deposit, is thought to be responsible for rotating the southern part of the contact to a northeast-southwest orientation, resulting in the arcuate distribution of the orebodies (Fox, 1989; Figure 2).

Deformation is reflected in the rocks as open to tight folding in the sedimentary sequence, as planar flattening fabrics in the alteration assemblages, and as shear fabrics in the metavolcanic rocks. Folds on the scale of metres to tens of metres occur throughout the sedimentary sequence. These are particularly noticeable along the walls of all the open pits and obviously affect the distribution of

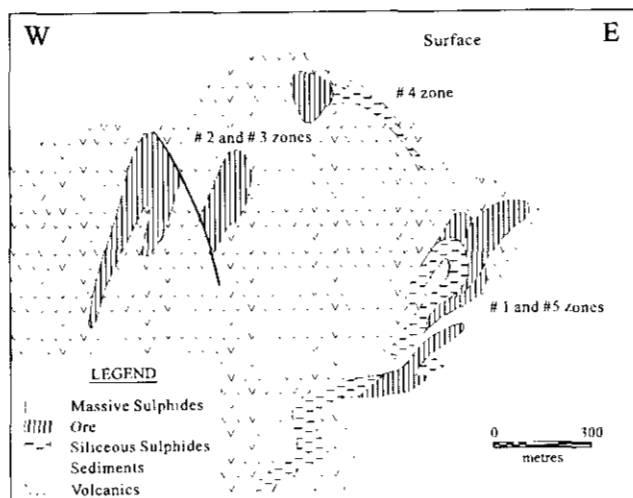


Figure 3. Schematic cross-section, from west to east, through the Hidden Creek mine (after Grove, 1986). Positions of the ore zones are approximate and are inferred from the literature.

mineralization within the larger scale anticline. The development of strong planar and crenulated fabrics adjacent to the volcanic-sedimentary contact suggests that this was a zone of high strain; however, movement along this zone has not been established.

MINERALIZATION

The Hidden Creek orebodies constitute the largest accumulation of known sulphide mineralization in the Anyox district. Eight mineral deposits are known in the Hidden Creek area. Of these, seven contributed to mine production (Table 1; after Davis *et al.*, 1992).

The Nos. 1, 4, 5 and 6 orebodies are located at the contact between footwall metavolcanic rocks and hanging-wall sedimentary rocks and are intimately associated with cherty chemical sediments. The No. 2 and 3 orebodies are west of the contact within the footwall metavolcanic rocks. The Nos. 7 and 8 orebodies occur stratigraphically above the contact in hangingwall turbiditic sedimentary rocks (Sharp 1980; Figure 2). Average production figures for the mine give recovered grades of 1.6% copper, 0.17 gram per tonne gold and 9.25 grams per tonne silver. However, significant portions of the No. 1 and 5 orebodies graded in excess of 3% copper with higher than average gold and silver values. The best copper mineralization was always concentrated in fold closures and the best precious metal grades associated with massive sulphide bodies in proximity to sediments (Rhodes and Jackisch, 1988).

The orebodies are tabular to sheet like (Grove, 1986) and consist mainly of pyrite, pyrrhotite and chalcocopyrite, with minor sphalerite, galena and magnetite. The gangue minerals are principally quartz, calcite, chlorite and sericite. There is a strong association between

chalcocopyrite and pyrrhotite in the massive sulphide lenses and in vein networks in mineralized sections. Mineral zoning in the massive sulphide lenses is observed in drill hole D-9 and along the southern wall of the No. 6 zone pit. In these sections of chemical sediments and sulphides, pyrite dominates the stratigraphically lower horizons, occurring as alternating semimassive to massive bands in a matrix of silica and carbonate. In stratigraphically higher parts of these sections, pyrrhotite-chalcocopyrite forms more discrete and massive layers in a carbonate-dominated matrix. Transitions between the two types of sulphide ore are characterized by large euhedral pyrite crystals within a finer grained pyrrhotite-chalcocopyrite matrix.

TABLE 1
TONNAGE AND GRADE OF HIDDEN CREEK
PRODUCTION

Orebody	Tonnes Shipped	% Copper
1	8 879 803	1.55
2	6 279 157	1.48
3	2 896 192	1.14
4	420 600	1.12
5	2 651 610	2.27
6	485 738	2.19
8	9 022	0.69
slide	59 678	1.13
TOTAL	21,681,800	1.57

Quartz-pyrite-pyrrhotite-chalcocopyrite veins occurring stratigraphically below the sulphide lenses within the chert and the metavolcanic rocks probably represent footwall stockwork mineralization. These veins range from less than 0.2 to several centimetres wide. Associated gangue minerals include quartz, chlorite and biotite.

Fine to medium-grained disseminations of pyrite, pyrrhotite and chalcocopyrite occur throughout the basal units of the clastic sedimentary sequence in siliceous bedding-parallel layers and coarse sandstone layers. These sulphides form in both discrete spaced layers, typically less than 2 centimetres thick, and in more diffuse layers that coalesce into thick semimassive bands.

STRATIGRAPHIC SECTIONS

Two of the sixteen holes logged during this phase of the study are illustrated in Figures 4 and 5. These holes demonstrate some of the stratigraphic relationships observed in the drill core.

Diamond-drill hole 93 D-1 (Figure 4) was collared in the footwall to the south of the No. 1 deposit at an azimuth of 090° and inclination of -60°. The hole was drilled up the stratigraphy, extending 146.3 metres to the hangingwall sedimentary rocks. The hole progresses from an interlayered chert and biotite-sericite schist, to a

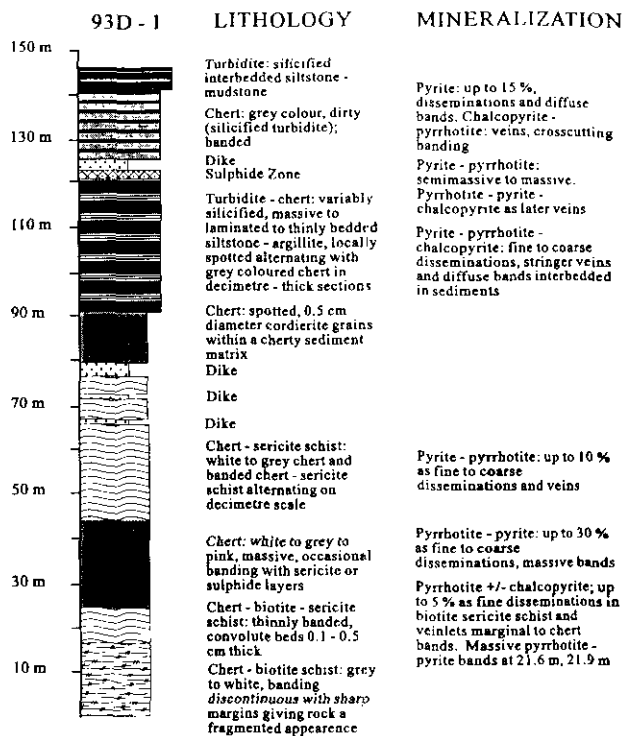


Figure 4. Summary log of diamond-drill hole 93D - 1. The scale on the left represents depth of the drill hole. The thickness of units has not been corrected for drilling angle

massive white to grey chert, to an alternating chert and banded chert-sericite schist, and ends in an interbedded chert and silicified siltstone-mudstone turbidite. Pyrite, pyrrhotite and chalcopyrite occur as fine disseminations, as semimassive to massive bands several centimetres thick, and as anastomosing vein networks throughout the section.

Diamond-drill hole 93 D-9 (Figure 5) was collared in the hangingwall in the north end of the mine, at an azimuth of 270° and inclination of - 60°. The hole was drilled down the stratigraphy, extending 136.6 metres to the footwall metavolcanic rocks. The hole passes stratigraphically upward from a stockwork zone in chlorite, biotite and talc-altered metavolcanic rocks through an intensely biotite-altered zone, and into a 40-metre semimassive to massive sulphide section of primarily pyrite with lesser pyrrhotite and chalcopyrite. The hole ends in laminated siltstone to mudstone turbidite. Pyrrhotite, pyrite and chalcopyrite occur as stockwork veins in the footwall basalts and in banded semimassive to massive layers in a carbonate and silica-rich matrix.

PRELIMINARY CONCLUSIONS

Mineralization occurs at or near the top of a thick,

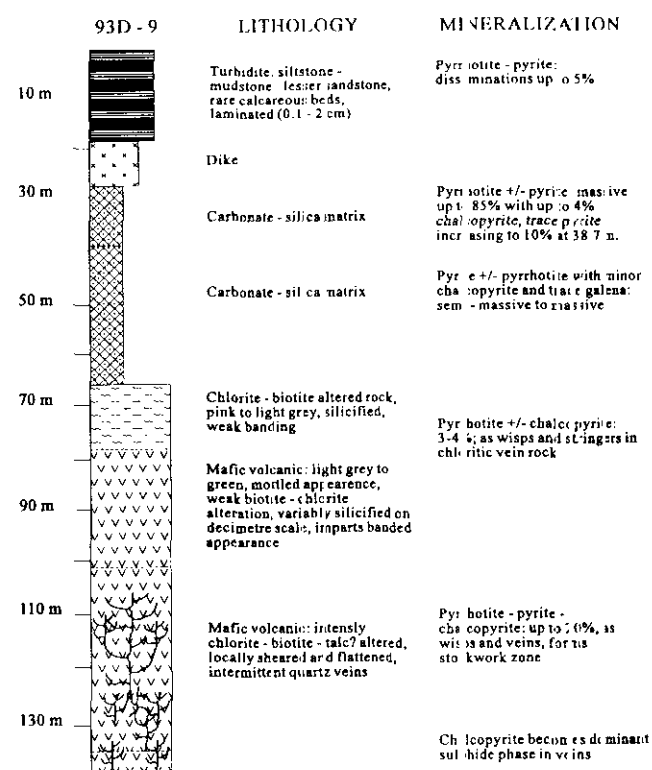


Figure 5. Summary log of diamond-drill hole 93D - 9. The scale on the left represents depth of the drill hole. The thickness of units has not been corrected for drilling angle

mafic volcanic pile which forms the base of the stratigraphic succession in the Anyox area. Although deformation has affected the area the original stratigraphy is still intact in many areas. The ore zones are tabular bodies and are closely associated with a thick chert horizon, and to a lesser extent, with silicified clastic sedimentary rocks at the base of the overlying turbiditic-mudstone sedimentary sequence. Some of the metal-rich chert intervals may represent lateral equivalents of the massive orebodies. These features suggest that the sulphide lenses were formed after volcanism, at the same time as the chert, and for the most part prior to the deposition of the turbiditic sediments.

FUTURE WORK

Future research at the Hidden Creek mine will concentrate on characterizing volcanic and sedimentary stratigraphy, mineralization, intensity and characteristics of the hydrothermal alteration, and geometry of the hydrothermal system. This will utilize whole-rock geochemistry and petrography of various lithologic units and their altered equivalents, trace element and stable isotopic studies of the chert horizon and ores, and fluid inclusion studies of the ores and footwall stringer mineralization.

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