DETAILED REPORT ON THE TRIUMPH MINE

BLAINE COUNTY, IDAHO

By

C.W. Merriam and C.N. Bozion

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Abstract

The Triumph Mine, an important lead-zinc-silver producer, is located in the Warm Springs Creek mining district, Blaine County, Idaho. The mine lies six and one-half miles by road northeast of Gimlet siding on the Union Pacific branch line to Ketchum. Operations by the Triumph Mining Company include the North Star Mine, one-half mile southeast of the Triumph shaft. From 1936 through 1941 the Triumph and North Star have produced over 500,000 tons of ore. At present a part of the ore is treated at a local mill, the remainder shipped crude.

Important geologic features are a southwesterly dipping homocline of Lower Carboniferous argillites with limestone members and a thrust plate of Pennsylvanian conglomerates, quartzites and limestones cutting across the argillite series. Ores are localized along two major fissures in the argillites; the fissures strike in a northwesterly direction and dip toward the southwest truncating bedding at some points.

The ores are mesothermal silver-lead deposits the origin of which is traceable to granitic stocks emplaced during an orogenic episode which embraced also the major folding and thrusting of the region(post-Pennsylvanian). No appreciable oxidized zone is present and no evidence of important enrichment by descending supergene water is recognized.

Three principal ore types are found: (1) Fissure ore; (2) Bedded siliceous ore; (3) "Complex" bedded ore(high in lead and zinc). Fissure ores consist of galena, sphalerite arsenopyrite and sulphantimonides in a gangue of siderite and quartz. Bedded siliceous ores consist mainly of galena and sphalerite within a gangue including siderite, quartz,unmineralized argillite and limestone. "Complex" bedded ores consist of galena and sphalerite in a pyrite gangue. The ores as mined along the fissures are only in part fissure filling, a large percentage being replacement of limy beds bordering the fissures. The important main "complex" ore body which has in the past been the heart of Triumph production represents replacement where a limestone member is cut by the Triumph fissure.

The estimated reserves are 313,740 tons of which 55,440 tons are measurable, 131,800 indicated and 126,500 inferred. Of the measurable ore less than one-third is the high lead-zinc "complex" which in the past constituted an important part of the Triumph production. On depletion of the "complex", production is expected to be mainly fissure ore with lower lead and zinc tenor and in large part of milling grade. Fissure ore of good grade continues to the northwest on the lower levels of the Triumph Mine; new ore has recently been discovered on the lower level of the North Star. There appears to be no indication of loss of the fissure ore below the lower or 850 level of the Triumph. The large "complex" body of the Triumph does not appear to carry below the 750 level. It is apparently not cut out by postmineral faulting as the fissure ore continues downward in this section of the mine. In general postmineral faulting has not been a serious obstacle to date.

Development on the upper undeveloped projection of the Triumph fissure may be expected to yield ore.

Low capacity of the Triumph shaft is a bottleneck which is expected to be broken on completion(September,1943) of a 6,500-foot haulage tunnel from a point near the reconditioned North Star mill to the Triumph 700 level.

On completion of the new low-level haulage tunnel about September, 1943 tonnage may be expected to increase appreciably with favorable labor and economic conditions. Unless tonnage of fissure ore is considerably increased the zinc and lead production would be expected to fall off with depletion of the "complex" ore. With probable production at the present time(October, 1942) of about 7,500 tons of ore per month of 26 days, it appears reasonable that an increase of 30% is possible to give a monthly output above 9,500 tons(mainly fissure ore) after completion of the new haulage facilities.

It is believed that at least enough ore is in sight for from twelve to fourteen months operations, taking account of expected increase in production rate.

DETAILED REPORT ON THE TRIUMPH MINE

BLAINE COUNTY, IDAHO

Introduction

The Triumph Mine is ~~located~~ in the Warm Springs Creek mining district, Blaine County, Idaho, six and one-half miles by road northeast of Gimlet siding on the Union Pacific branch line to Ketchum. Though Ketchum is nearer the mine, the larger town of Hailey, twelve and one-half miles south by road, is now the business center of this district; most of the mine workers are transported daily from Hailey to the mine by company bus. The mine is operated by the Triumph Mining Company in which the interests of several independent organizations are combined. Operations include the North Star Mine one-half mile southeast of the Triumph shaft. (Figure 1.)

Triumph ore was formerly conveyed from the mine by a four-mile tram to a point on the Union Pacific railroad south of Ketchum; at present the tram is not operated, diesel trucks being used between the mine and the new North Star mill, and from the mine and mill to Gimlet siding. In the past much of the ore was shipped crude to the mill of the Combined Metals Reduction Company, Bauer, Utah. With a new mill now in operation on the site of the old North Star installation, a large part of the ore is concentrated before shipping.

The Triumph was worked in the nineties and earlier, though it did not become an important producer until after

reopeming in 1927. Production records for the first decade are not available at the mine office, having been destroyed by fire. North Star production figures show about 2,661 tons for the period 1883 to 1903 and about 20,686 tons from 1905 to 1918 (U.S.G.S. Bull. 814, p. 179). The following statement provided by the Triumph Mining Company gives tonnage for the six year period 1936-1941:

Tonnage produced from the Triumph and North Star
Period April - 1936 to December - 1941

YEAR	TOTAL TONS ORE	NET SMELTER RETURN	VALUE PER TON
1936 & 1937	107,656.12	$848,871.69	$7.89
1938	105,916.39	809,280.13	7.64
1939	106,185.62	775,776.30	7.31
1940	89,701.01	882,048.19	9.84
TOTAL	409,459.14	$3,315,976.31	$8.10
1941	95,878.00		

Perfection of new methods for the treatment of refractory ("complex") ores in the Triumph and North Star mines is an important factor in success of the present enterprise. (Figures 5 and 10)

Underground workings of the two mines are connected by raises with the Plummer tunnel, and together comprise about 10 linear miles, exclusive of stopes. The deepest drifts are 850 feet below the Triumph shaft collar. The main Triumph shaft reaches the 700-foot level and a new inside shaft extends from the 700-foot to the 850-foot level. As the Triumph shaft is inadequate to handle both ore and waste, a low-level haulage tunnel

is now being driven some ~~6000~~ 6,500 feet from a point near the North Star mill to connect, about ~~January~~ September 1943,* with the 700-foot level of the Triumph. (Figure 1.) North Star ore is removed through the Plummer tunnel but will eventually be taken out through raises from the new haulage tunnel. to from p. 57.

* about 5,000 feet completed in November 1942, approx.

The Independence Mine, somewhat over eight-tenths of a mile north of the Triumph shaft, was shut down in 1923 and most of the workings are now inaccessible. It is generally believed that the known ore bodies were largely exhausted. The Independence, Triumph and North Star mines, on separate lodes, are connected through the Plummer tunnel.

Description of the geology and ore deposits of the Independence, North Star and Triumph mines, with early production figures, is given in U.S.G.S. Bull. 814, 1930, pp. 174-183.

During ~~this~~ the present investigation the surface geology around the Triumph mine was mapped on a topographic sheet (scale; 1" to 100'; contour interval 20') provided by the Triumph Mining Company. (Figure 2.) Airplane photos were also used. Sections were measured along crosscuts; drifts and stopes in the Triumph and North Star were examined. Detailed geology of the underground workings, mapped by M. W. Rankin, geologist and engineer for the company, was checked and used as a guide in underground studies. The Challenger adit, (Figure 1.) now being driven eastward from Triumph gulch toward the North Star lode by an independent operator, was also examined.

To officials of the Triumph Mining Company grateful acknowledgement is made for much helpful information.

Thanks are in particular due Mr. Arthur Jensen, superintendent of the Triumph Mine and Mr. M. W. Rankin, geologist and engineer. Mr. Rankin's intimate knowledge of the Triumph and other lead-zinc mines in the Warm Springs Creek district has been of great value.

Geology

Introduction.- The rocks immediately surrounding the Triumph and North Star mines are mainly Carboniferous sediments penetrated by sills and dikes of probable Mesozoic age. Westward the Paleozoics are overlain by Tertiary lavas consisting of latite and andesite; isolated patches to the north indicate a former more extended distribution of these eruptives.

Two described formations (Figure 2.) are represented in the Carboniferous of this locality: (1) the Milligen below, probably Mississippian; (2) the Wood River above, of Pennsylvanian age. In the vicinity of the mine the two formations are not known to lie in normal depositional relation, the Wood River-Milligen contact being a low-angle thrust fault with the Wood River in general dipping at a lower angle to west or southwest than the underlying Milligen.

Milligen formation.- ~~In the main~~ The Milligen formation consists mainly of dark-gray, argillaceous deposits containing finely divided carbonaceous debris. Certain zones are highly calcareous. The term argillite appears appropriate, for the sediment has suffered mild (regional) alteration. Interbeds of argillaceous limestone are common, ~~while~~ and the formation includes two fairly pure, fine-

grained, bluish gray limestone members 45 and 95 feet in thickness. Throughout the formation alteration has resulted in the development of secondary lime silicates. Some of the argillites show an incipient velvety phyllitic sheen, ~~while~~ and certain of the limy facies contain secondary tremolite or diopside with presumably little free $CaCO_3$ remaining. Fracture cleavage is common in the less competent interbeds of the formations. At several points in the neighborhood of quartz veins the limestones or limy argillites have been almost completely altered to an amphibolitic rock of whitish color consisting of fine needles, blades and rosettes with the appearance of white or colorless tremolite (possibly diopside). Aureoles of silicification occur in the vicinity of quartz bodies; here the resultant granular silicate rock often has the appearance of quartzite. True quartzitic and compact silty-calcareous sediments are apparently common as interbeds in the lower part of the exposed section. Graphitic films are developed in the argillites along surfaces of differential movement.

All commercial mineralization at the Triumph and North Star mines occurs in the Milligen formation. In the Triumph fissure the ore is associated with gougy material and crushed argillite. However, the greater part of the ore high in lead and zinc has evidently been formed as a replacement of Milligen limy argillites and limestones adjacent to fissures through which the mineralizing solutions were introduced. Thus much of the ore is bedded, either replacement of thin limy partings separated by argillite

beds, or as in the case of the large ore bodies with high zinc content ("complex" ore), thick beds of susceptible limestone have locally been mineralized to a large extent. Generally speaking, the lower dense, quartzitic, originally siliceous portion of the formation shows no commercial mineralization, though pyrite is widely disseminated therein.

The Milligen shows a thickness of roughly 2000 feet at this locality though neither the base nor the top of the formation is exposed here. On the basis of surface mapping the formation has been subdivided into five members (see map, ~~fig.~~ Figure 2.) in descending order as follows:

Milligen formation

Upper argillite	1000	feet
Upper tremolite limestone	45	"
Middle argillite	150	"
Lower tremolite limestone	95	"
Quartzitic member	730	" (plus)
	2020	feet

Alteration and silicification of the various members has produced numerous local phases. Within the members no reliable key beds have been recognized which can be employed in detailed correlation of surface structure with that underground. In the Lost River range (Borah Peak quadrangle) the Milligen has yielded plant remains and is directly underlain by Upper Devonian Three Forks limestone. All organic remains at the Triumph locality have been destroyed by recrystallization. The high percentage of carbonaceous debris suggests that the deposits had been plant-bearing and possibly in large part continental, though the thicker lime-

stones may be marine.

The Upper argillite has a probable thickness over 1000 feet, extending westward from the Triumph shaft to the lavas on the west side of Triumph gulch beneath which it extends. This member consists largely of dark-gray argillite showing relatively thin bedding, ~~and~~ it is locally contorted, fractured and iron-stained at the surface of the ground. A few limy layers or lenses are present near the Triumph mine, notably 1600 feet west-northwest of the shaft, where a body of limestone occurs (perhaps faulted in). Locally the Upper argillite is slightly mineralized where cut by quartz veins, but in general commercial values are not known to occur in this member at the Triumph mine. On the ridge southwest and south of the North Star Mine lime beds occur within this member. Along the crest of this ridge local alteration of lime beds to amphibolite was noted near quartz veins. Certain ores on lower levels of the North Star Mine may be replacement of thin lime beds in this unit.

The Upper tremolite limestone is about 45 feet thick at the Triumph Mine. At the North Star exposures of massive limestone assigned to this member show a thickness of about 30 feet. ~~The Upper tremolite limestone~~ it is a dense, fine-grained, bluish-gray limestone, rather massive to well-bedded with layers varying from an inch to more than one foot in thickness. Calcite stringers are numerous both parallel and oblique to the bedding. Certain bands contain ~~an~~ abundance ~~of~~ tremolite needles and blades showing particularly well on weathered surfaces. The outcrop is ~~usually~~ broad north-

of the Triumph Mine owing to development of a dip slope on this member. The member carries southeasterly beneath the Wood River thrust sheet, and over the ridge to the North Star Mine where it forms the hanging wall of an important mineralized fissure. The Upper tremolite limestone is in all probability partly replaced to form one of the larger bodies of high-zinc "complex" ore in this mine. No exposures of this division were recognized in the Triumph workings because of lagging ~~of timbers~~ at the point where the member is inferred to cross the upper levels. Evidently the Upper tremolite limestone lies stratigraphically well above the main mineralized shear zone now being worked at the Triumph and it is not known to ~~have been involved here in development of~~ be the host rock here of any important replacement ore.

The Middle argillite is about 150 feet thick in the No. 3 tunnel of the Triumph which crosses the section normal to the strike (Figure 4). The member consists of dark-gray to almost black argillite with a velvety sheen and an incipient phyllitic cleavage often slightly oblique to bedding planes. Development of secondary minerals is incipient to well-advanced, particularly where the sediment was originally calcareous; in such cases lime silicate (tremolite) blades are abundant and probably little or no free lime remains. All gradations between limy argillite with scattered blades and the tremolite limestone phase are found locally in this member. On the surface good exposures of the Middle argillite are found between North Star Peak and Telephone Peak. A few white quartz outcrops occur at the surface within the Middle argillite,

though in general this division does not appear to show important mineralization except possibly near its base in the old No. 1 and No. 2 tunnels northeast of the Triumph shaft. The Middle argillite is stratigraphically above the main Triumph shear zone.

The Lower tremolite limestone is roughly 95 feet thick as measured in the Triumph No. 3 tunnel (Figure 4) and consists ~~to a~~ largely ~~extent~~ of massive, fine-grained, bluish-gray tremolite limestone with subordinate granular more siliceous limestone facies toward the top and bottom. Limy argillites, some of which carry needles of tremolite, also occur in the upper and lower parts. Calcite is abundant as stringers and pods of varying size. In much of the tremolite limestone facies the lime silicate blades are abundant and often of large size. [On Fig 2, why is the ~~NW~~ boundary of this formation closed around? My guess is that it should have been left open, but if the unit is terminated as depicted, some mention of it should be made here.]

The Quartzitic member is arbitrarily established to include all local Milligen below the Lower tremolite limestone (Figure 4) without reaching about 750 feet was traversed in the No. 3 tunnel; the base of the Milligen ~~was not reached~~ although the lithology seems to change gradually. The most distinctive lithology as seen in the No. 3 tunnel is an extremely dense and finely granular siliceous limestone of dark-gray color. ~~Although~~ no thin sections have been examined but it is probable that this rock contains a high percentage of fine sand or silt grains in which case it might be regarded as a limy quartzite. This ~~observation~~ probability is borne out by surface study; many of the better exposures reveal an altered siliceous rock with the appearance of a fine-grained calcareous quartzite. It is, however, difficult to relate the rocks in this portion of the section un-

derground to the weathered outcrops at the surface in absence of reliable key beds. Much of the granular siliceous rock is sharply banded with lighter gray layers alternating with darker gray. The bands vary from a width of more than one inch to fine laminae. Alternating bands sometimes show slight differences in grain. Fracture cleavage in less competent bands is notable. Within the lower half of this member and also toward the top velvety non-calcareous argillite is abundant and throughout the section are beds of limy argillite, some of which show tremolite needles. Tremolite limestone interbeds are present. The most continuous section of granular siliceous or quartzitic limestone runs through about 200 feet of the member from the middle (as measured in No. 3 tunnel) to a point about 160 feet from the upper boundary. While beds and lenses of similar granular facies are found sporadically in other portions of the Milligen formation this type of rock is observed to be particularly characteristic of the lower member.

Underground the bedding is inclined to be massive in much of the Quartzitic member particularly within the granular siliceous or quartzitic phase. Calcite stringers and pods are numerous within and adjacent to the more calcareous beds. The stringers often roughly parallel the bedding. Tremolite needles and blades are unusually large in limy beds in the lower part of this section.

On the surface the fine granular phases of limy quartzitic appearance frequently show a well-defined banding and fine lamination. These beds weather out light gray. Locally

Locally the limestones of this member, as at Grouse Peak (Figure 2), have been intensely altered to an amphibolitic rock of light color showing rosettes of radiating acicular lime-silicate crystals. Milky quartz bodies are usually associated with highly altered limestone facies. The Triumph shear zone intersects the upper argillitic portion of the Quartzitic member in No. 3 tunnel with resultant commercial mineralization in the uppermost part of the member down to about the 350-foot level of the mine. No commercial mineralization, however, is found in the granular siliceous or quartzitic portion; this zone appears everywhere to underlie the lode. It is thought possible that extreme density of this portion of the Quartzitic member inhibited penetration of mineralizing solutions, though pyrite is widely disseminated.

Wood River formation.- The Wood River formation, (Pennsylvanian) age, normally overlies the Milligen with probable disconformity. In the vicinity of the Triumph and North Star mines it lies in thrust fault contact upon the Milligen, as is well shown in the outcrop extending from North Star Peak westward to Triumph gulch (Figure 2). Small outliers such as that between Telephone Peak and Grouse Peak suggest that this thrust sheet formerly covered a much larger area. The most conspicuous facies of the Wood River formation at this locality is siliceous chert-fragment, breccia-conglomerate, some of it with a limestone matrix. Brownish-gray quartzites of medium to fine grain are intimately associated with the conglomerate. The formation also embraces sandy or pebbly limestones, fine-grained, thin-bedded, bluish-gray limestones

with argillaceous or sericitic partings and medium to coarse-grained crinoidal limestones. In the crinoidal facies, which like the remainder of the formation has suffered some alteration locally, fossils of indeterminate character are found. These include productids, stony bryozoa, tabulate corals and probable fusulinids, though no details of organic structure are visible in the Foraminifera. In mapping, several lithologic types were differentiated but are not represented on the accompanying map (Figure 2). White quartz veins cut the Wood River thrust plate at several points but no important mineralization is known in the formation at the Triumph locality. The main Triumph workings do not cut the thrust or enter the Wood River beds. However, on the American Eagle claim (Figure 2.), old workings at the surface show Wood River and Milligen in contact along a nearly vertical normal fault cutting the thrust. Ore is said to have been removed here. On the ridge-top north of the portal of the new Triumph low-level tunnel (Figure 1.) is an outlier of contorted Wood River thin-bedded limestone dipping steeply eastward. More argillaceous phases in this outlier contain crinoid stems, stony bryozoa, corals and large numbers of probable fusulinids preserved only in outline.

Igneous rocks.- The igneous rocks of the Triumph-North Star area comprise Tertiary andesitic flows with interbedded tuffs and numerous porphyritic sills and dikes varying from acid to basic. The andesites and tuffs cover a large area west of the Triumph Mine. In view of probable irregularity of the basal contact of these extrusives it is likely that they may be encountered unexpectedly in future drifting to

the northwest on lower levels of the mine. The intrusive bodies are mainly of sill character though truncation of bedding at low angles is common. They are probably complementary petrologic types derived from plutonic masses emplaced during an orogeny of either late Jurassic (Nevadan) or late Cretaceous (Laramide) age. The sills vary in ~~width~~ thickness from a few inches to over 5 feet and are for the greater part restricted to more argillaceous thinly bedded zones of the Milligen. They are not common in lower and denser sediments as seen in the No. 3 tunnel. The majority of the intrusives are of light color and intensely altered, with introduction of secondary silica. The darker intrusives ~~seem to be somewhat less numerous than the lighter ones. They~~ are usually aphanitic and possibly referrable to the lamprophyres. Some of the less altered lighter porphyritic sills and dikes possess euhedral quartz~~es~~; certain of these suggest a quartz porphyry while others may be aplitic. In general the more basic sills appear to be the latest and are usually the least altered.

Porphyritic sills are very common in the main shear zones where they are intensely crushed and altered to whitish gougy material which stands out sharply from the black graphitic gouge derived from carbonaceous argillites. The magma evidently followed zones of weakness in the argillites which subsequently or perhaps at roughly the same time served also as paths for mineralizing solutions. The

lighter altered sills usually show disseminated pyrite and locally contain some galena with other sulphides. Sills of varyimg ~~width~~ thickness are closely associated with larger ore bod ies, as f or example the "complex" on the 500 to 750-foot levels.

It is evident that some fissure movement followed invasion of the sills where they are intensely crushed and dragged to a gouge. Post-mineral movement in the shear zones is f urther reflected in shearing and granularity of ores.

Note Old drifts in the North Star Mine following sills suggest that early mining operations were possibly governed in part by the conception that the sills were directly responsible for mineralization which is not surprising in view of the common association of sills and ore shoots in this locality.

Geologic structure (Figures 2, 3, 4, 5–9).- The more important structural features of the Triumph-North Star locality are as follows:

(1) A homoclinal block of Lower Carboniferous (Milligen) sediments with strike from about N. 55° W. to N. 65° W. (with local minor variations) and dipping southwest with average of about 37° (departures in local minor warpings).

(2) Major thrust with upper plate of Wood River sediments inclined in general about 20° to southwest resting with notable discordance upon Lower Carboniferous Milligen.

(3) Two major shear zones (fissures), the Triumph and

North Star, ~~shear zones~~ largely localizing the ore; Origin pre-mineral, perhaps related to the stresses causing thrusting.

Minor structural features:

(1) Local flexures in country rock; departures from normal dip and strike of the homocline; small drag folds associated with shear zone, some recumbent.

(2) Minor shear zones or fissures more or less parallel to main shear zones; may be somewhat mineralized as, for example, minor fissures on West Shore claim and American Eagle claim.

(3) Normal faults of post-thrusting, post-mineral age. Two directions; (a) northeasterly strike, northerly dip; (b) more or less parallel to northwesterly strike of bedding with southwesterly dip.

(4) Fracture cleavage; common in argillite partings between more competent beds; locally suggests overturning of section, though this not supported by other criteria.

It is assumed that the southwesterly dipping Carboniferous section within which the ore bodies lie is a portion of a limb of a broad open fold, though there is no indication of axial planes. Thrusting of Wood River beds is thought to have followed folding though the two events may not have been separated by any great time interval. The major folding is almost certainly post-Pennsylvanian, perhaps either late Jurassic (Nevadan) or late Cretaceous (Laramide).

The thrust sheet consists almost entirely of relatively competent Wood River sediments, including silicified conglomerates, quartzites and crystalline limestones. The upper plate has an average thickness of about 150 feet and is inclined to the west about 17 degrees suggesting that movement was from west to east. Outliers of this or a similar thrust are fairly numerous in the surrounding territory, though it was not in every case possible to eliminate a stratigraphically unconformable relation of certain of the outliers on normally underlying Milligen. Probable thrust remnants of the Wood River formation are found directly north and above the portal of the new Triumph low-level adit and southeast of the Challenger adit on the east side of Triumph gulch.

Barren white quartz veins cut the thrust Wood River at several points, notably southwest of North Star Peak. Though the thrusting is thus in all probability pre-mineral there is no indication of commercial mineralization in the upper thrust plate or along the thrust surface.

The Triumph and North Star shear zones or fissures were formerly regarded as parts of the same structure (U.S.G.S. Bull. 814, p. 182). Recent development in the mines indicates that the two are probably distinct, differing in attitude and ~~elevation~~ position. The strikes of the Triumph fissure (Fig. 5) vary at different levels roughly from N. 35 W. to N. 50 W. on the southeast, swinging to a more westerly direction on the lower northwest levels of the Triumph Mine. The southwesterly dip in places appears to follow bedding of the Milligen formation, but in actuality

probably departs from this throughout ~~most~~ much of the fissure, (Figure 4.) being in general less steep than the bedding. Toward the northwest on the lower levels a decided flattening of the fissure dip is likewise noted. The North Star fissure appears to dip at a somewhat steeper angle than the Triumph. ~~Elevations of Triumph and~~ North Star fissure workings indicate that ~~the North Star fissure~~ it lies in general above the Triumph but may well intersect it at one or more points. (Figure 4) The two fissures are evidently not simple planes but show many irregularities. Earlier operators of these mines regarded the two fissures as the same, with down-faulting of the Triumph portion along a northeast-southwest normal fault such as those known to exist between the two properties. Later development does not appear to confirm this interpretation. (Figure 3.)

The width of the Triumph fissure zone varies. On the 700-foot and 800-foot levels widths of 13 to 30 feet were noted, while in the No. 3 tunnel the argillites are severely crushed for a width of 40 feet at one point. No accurate figures are available for the North Star fissure zone, but on the whole the shear zone is believed to be somewhat narrower.

Crushing is intense with large amounts of dark gray or black clay-like gouge showing multiple slikensided surfaces within the soft gouge itself. The fissure contains much fractured argillite and graphitic or carbonaceous flour. The hanging wall surface is locally well defined, often being a rather massive argillite showing

~~showing~~ mullion structure. The principal component of movement along the shear zones is thought to be reverse dip-slip (reverse faulting) though there is local evidence of movement in various directions; some of this movement is clearly post-mineral and perhaps in part gravitational adjustment.

Local departures from the normal southwesterly dip of the Milligen homocline are widespread. Within and adjacent to the shear zones underground, numerous warpings and complex drag folds occur, many of which are essentially recumbent or with axial planes dipping at a low angle in several directions. Some of these flexures are a result of differential movement of more competent massive beds on underlying or intervening thinly bedded argillites. On the surface reversals of dip are numerous but localized in nearly all instances. However, on the east side of the canyon at the head of which lies the North Star Mine, the dip of the Quartzitic member of the Milligen is reversed for a distance of several hundred yards, the beds inclined steeply eastward. It is thought possible that these larger reversals are a result of drag beneath a thrust plate now stripped by erosion, for on the opposite or west side of this gulch a remnant of thrust Wood River limestone lies on the ridge crest directly north of the new Triumph low-level tunnel portal. Within the new tunnel numerous small more or less recumbent drag folds were encountered.

Post-thrusting, post-mineral normal faults of relative-

ly short vertical displacement are numerous throughout the Triumph-North Star mining area. Because of the shortness of the throw these do not appear to have greatly hindered mining operations. Minor slips with strike and dip roughly concordant with bedding of the southwesterly dipping Milligen are common. These often show a thin gouge or calcite filling. It is possible that some of the high-angle surfaces may be reverse rather than normal faults, or that a reversal of movement on the hanging wall may have followed thrust displacement, after relaxation of compressional stress.

The more important normal faults recognizable at the surface and in the mine workings of the Triumph have a more or less northeasterly strike and dip to the north or northwest. One of these, actually a fault zone with two or more planes of movement, is particularly well shown northwest of North Star peak (Figure 2); the arcuate trace is mainly topographic. The downdropped side to the north shows a probable net throw of not over 100 feet. This fault zone is expressed in the topography, showing well on the airplane photos. It cuts the Wood River thrust plate, a slice of which has been preserved by downfaulting immediately north of Telephone Peak. In the Triumph workings - from the 200' down to the 800' level - minor high angle faults, presumably gravitational, are numerous, with strikes ranging from about north-northeast to nearly east in a few cases. These surfaces have a northerly dip ranging from

about 30° to 80° with an average of about 45°. Several of these appear to line up reasonably well with those in the zone at the surface, discussed above. In the mine workings offsets of ore bodies more than 25 feet by post-mineral faulting are uncommon and in general these faults have been no serious obstacle. In the new development on the lower levels of the North Star an offset of about 100 feet was encountered. (Figure 10) One fault of unknown throw in these workings is unusually flat.

Additional remarks concerning structure are, on the basis of available data, speculative. Points worthy of consideration involve possible pre-mineralization fault movement cutting out the susceptible Lower tremolite limestone which was later partly replaced to form the large "complex" ore shoot carrying down from the 400 to the 750-foot level. (Figures 5, 7) Though the thick "complex" ore body pinches off abruptly below the 750 level, the fissure ore continues on down, indicating that possible structural removal of the susceptible lime probably did not follow mineralization. Other explanations of the loss of this lime and its replacement ore involve a pulling away of the limestone in question from the fissure on a synclinal flexure or alternatively actual lensing out of the limestone. It is significant that the same limestone on the surface cannot be followed as a discrete member beyond the gulch north of the Triumph shaft. (Figure 2.) Here either faulting or lensing out is possible; no evidence of the required fault is found on the

surface or in the workings.

In view of the known reverse faulting in this area and lithologic similarity between the Upper and Lower tremolite limestones on the surface the possibility of actual pre-mineral repetition of the lower lime by a rather high-angle reverse fault has also been entertained. This explanation, however, would not explain the apparent northward disappearance of the lower lime on the surface (Figure 2). In any case, diamond drilling from the lower levels of the mine upward at various angles has, according to data of the Triumph Mining Company (M. W. Rankin) failed to find a continuation of the ~~ore~~ big "complex" ore body or of the important lower lime member.

Ore Deposits

Introduction.- The ore bodies of the Triumph-North Star area occur along silver-lead veins of the fissure type. The major fissures localizing the ore are shear zones where intense crushing has taken place. Only a part of the ore is actual fissure filling, a larger percentage being replacement of calcareous sediments adjacent to and entering the shear zone. Galena and sphalerite are the more important ore minerals; arsenopyrite and sulphantimonides occupy a position of secondary importance. Gangue minerals vary with the situation and include siderite (with other iron-bearing carbonates of calcium and magnesium) and quartz; in certain replacement ore shoots pyrite is the

important gangue mineral. Some of the characteristic minerals are tetrahedrite, boulangerite ($Pb_5Sb_4S_{11}$) and pyrrhotite. Rarer species include stibnite and kermesite (Sb_2S_2O). According to M. W. Rankin, geologist for the company, tin has been reported. Locally pods of coarse galena occur, but in general the ores are inclined to be massive and granular, possibly due to post-mineral movement in the fissures.

The Triumph and North Star fissure and siliceous ores are comparable with those included in Lindgren's Wood River type veins (tetrahedrite-galena-siderite). They appear to differ somewhat in carrying a higher percentage of arsenopyrite and a relatively smaller amount of tetrahedrite. Certain of the valuable bedded replacement ore bodies in the hanging wall of the fissure depart strongly from the Wood River type; these consist mainly of galena and sphalerite in a pyrite gangue.

The wall rock of the fissures is mainly argillite and calcareous argillite ordinarily showing only a mild degree of (regional) alteration. Near the vein unmineralized limestone phases have locally been completely recrystallized to a lime silicate rock or amphibolite. Quartz-bearing fissure ore is associated on the margins with bedded replacement ore and is mined with much of the accompanying dark gouge and unreplaced crushed argillite. Where bedded ores occur the replaced layers appear to have been the highly calcareous strata and are often separated by weakly mineralized or unmineralized argillite bands. Evidently

certain types of limy beds were more susceptible to replacement than others. Porphyritic sills are common in the fissure and are locally somewhat mineralized.

The fissure ores extend from the surface to the greatest depths yet penetrated below the 850-foot level. Some of the more valuable ore bodies are, however, limited to intermediate levels.

Within the past few years much of the production has been non-siliceous pyritic replacement ore which is rich in zinc and carries lead and silver values above average for the locality; gold values, for the quartz-bearing fissure ores, are, in general, somewhat higher. (See assays under reserves)

The greater part of the ore is localized by the Triumph and North Star fissures which strike in a northwesterly direction and dip to the southwest. While the attitude of each approaches that of the bedding in the country rock, the fissure dips are frequently observed to be less, such that this structure locally truncates the bedding at a slight angle. Truncation of the bedding by the fissure has been noted to favor local development of ore shoots. In terms of structural geology the fissures are regarded as shear zones. Reverse fault movement along the shear zones is probable (see geologic structure). Above the 700-foot level the Triumph fissure underlies the Lower tremolite limestone while from the 750-foot level upward for some distance the large body of replacement ore ("complex" ore) is apparently developed in the hanging wall as

a result of intersection of fissure and this limestone member. Below the 750-foot level no ore of this particular type has been found. Whether the susceptible limestone member projects below the 750-foot level is not indicated by diamond drill records, according to M. W. Rankin.

The Triumph fissure was earlier regarded as a northwestward continuation of the North Star fissure which is mainly developed to the southeast. An assumed projection of the North Star fissure, however, seems to overly the Triumph, but may intersect it at one or more ~~points~~ places, as above the 800 and 850 levels of the Triumph Mine (see structural geology). Some older workings of the Triumph Mine appear to be in the North Star fissure. At least two minor fissures in this area show mineralization. These occur on the West Shore and American Eagle claims. Some ore has been produced from the West Shore in the past. (see assays under reserves)

Character of the Ores.- Three general types of ores may be recognized in the Triumph-North Star group:

(1) Fissure ores

(2) Bedded siliceous ores

(3) "Complex" bedded ores (high in zinc)

The fissure ores consist of galena, sphalerite, arsenopyrite and sulphantimonides (tetrahedrite, boulangerite) in a gangue of siderite (with ~~intermediate Ca, Mg and Fe carbonates~~ ankeritic phases) and quartz. Some pyrite is present. Large amounts of gouge and partially replaced or unreplaced crushed argillitic rock ~~is~~ are removed with the ore. Fissure ores are spotty,

occurring in pods and lenses varying in size from a few inches to many feet. Lenticularity makes estimation of these ores difficult. Fissure ore shoots have been worked throughout the mine and occur in the lowest levels yet reached. The principal values are gold and silver, with appreciable ~~though minor~~ amounts of lead and zinc (see assays under reserves). The fissure ore is intimately associated with bedded ores which represent replacement of susceptible lime beds at points of contact with the fissure or where fractured limy beds are included in the fissure.

Bedded siliceous ores consist mainly of galena and sphalerite in a gangue of siderite and other carbonates with quartz, unmineralized argillite and limestone. They are particularly well developed from the 200-foot level upward in the upper eastern workings of the mine where appreciable reserves remain. The gold, silver and lead values are below average for the mine with zinc near the average (see reserves). These siliceous bedded ores may, in part, be regarded as marginal ores, workable under favorable economic conditions. In part they represent replacement of susceptible limy beds with accompanying introduction of quartz and siderite.

The "complex" bedded ores usually occur in the hanging wall of the fissure. They consist largely of sphalerite and galena in a pyritic gangue. The term "complex" was originally applied at the Triumph because of metallurgical complications previous to perfection of zinc concentration.

These ores are not, as a rule, accompanied by quartz or siderite and locally represent almost complete replacement of limestone beds by sulphides. The "complex" may show a fine lamination or banding parallel to original bedding planes. Dark carbonaceous or graphitic debris is associated with the "complex" ore and some of the gangue is partly or little replaced limestone or limy argillite. The "complex" ore carries a high percentage of sphalerite with appreciable lead and silver and has in the past constituted the "heart" of the Triumph production. The largest Triumph ore shoot, now approaching exhaustion, is "complex" bedded ore, in places 50 feet thick, occupying an area roughly 700 feet wide by 170 feet long and with thickness varying from six feet in the upper part to fifty feet below. This body now largely outlined by stoping lies between the 700 and 750 foot levels (see stope plan II ~~diagram~~). The big "complex" shoot is apparently developed by replacement of the Lower tremolite limestone where it is intersected in its lower portion by the Triumph fissure (Figure 7). This shoot does not extend below the 750 foot level, apparently terminating rather abruptly below. There is apparently no evidence of post-mineral faulting off as the associated normal fissure ore continues downward to the lowest workings (see structural geology).

Paragenesis.- No detailed study of paragenesis has been possible during the present study of the Triumph properties. The following preliminary conclusions have been reached regarding the order of succession in the more or less banded fissure ore; quartz and siderite (or intermediate carbonates), pyrite, sphalerite and galena, arsenopyrite, quartz. Two generations of quartz have been noted at several points. Stibnite and other antimonial minerals are said to have formed late (~~see~~ U.S.G.S. 8th, Bull. p. 181).

Mode of origin.- The Triumph-North Star ores are mesothermal silver-lead deposits, the origin of which is traceable to intrusion of granite and quartz monzonite stocks. No exposures of these plutonics occur at the surface in the neighborhood of the Triumph and North Star mines, but are found within ten miles in a southwesterly direction. Considering the partially altered nature of argillites forming much of the country rock, plutonics are believed to underlie the entire area at no great depth. The monzonite and granite intrusion presumably took place either in late Jurassic or late Cretaceous time. A general orogenic disturbance concommitant with or antedating the granitic intrusion resulted in folding of the Carboniferous and older rocks. Compressional stresses set up during later stages of or following folding resulted in low-angle thrusting of younger beds over older. Shearing stresses (perhaps caused by actual emplacement of the granitic bodies) acting at about this stage, are probably responsible for the formation of

the important southeasterly ~~southeasterly~~ dipping fissures or shear zones in which most of the ore is localized. Crushing and shattering along these zones is intense with notable evidence of differential movement, though there is no actual measure of probable reverse fault displacement. The low-angle thrust, also dipping westerly, gives evidence of considerable movement of the upper plate, presumably from west to east (see geologic structure). No mineralization has been found along the thrust sole, where the brecciated zone may be negligible or relatively tight ~~tight~~. Mineralizing solutions from the cooling grahitic magma found a ready path along the fissures. Sills of complementary acid (quartz porphyry) and basic (lamprophyric) character also followed these weak zones. The igneous rocks are, as a rule, highly altered and themselves sometimes partly replaced by mineralizing solutions. The lamprophyric types seem to be the latest and least common in this locality and are locally unmineralized and not greatly altered. Certain susceptible limestones and limy argillites within and bordering the fissure were replaced in varying degree by the ascending solutions to form valuable bodies of bedded ore. Movement along the fissures following invasion of the sills has locally dragged and intensely crushed them to a gouge, while post-mineral fissure movement is evident where the ores are finely crushed and granulated.

Where post-mineral faulting has not cut of f the fissure zone it has not been clearly demonstrated in this area that

~~commercial mineralization does not carry down to depths greater than those yet penetrated (850' in Triumph Mine).~~ Absence of an appreciable oxidized zone suggests very extensive and continuous erosion of rocks which formerly overlay the present surface. There appears to be no evidence that enrichment by descending supergene water has been a factor of any importance within this particular area

RESERVES

A tabular statement of reserves of the Triumph Mining Company compiled from a recent survey by company engineers and geologist M. W. Rankin follows. Insofar as possible the reliability of these data has been checked by the present party. It should be noted that the report was prepared for submittal to the War Production Board some months previous to date in a request for reduction of the lead and zinc quota set by the board. The figures have been brought up to date - October 1, 1942 - by calculation of recent tonnage depletion.

Measurable Ore

Triumph "complex" ore ~~(Fig. 1)~~ (see stope plan II)

Outlined by stoping and development; assay values based on previous tonnages shipped combined with cut samples taken at regular intervals.

Block	Tonnage	Assay			
		Au	Ag	Pb	Zn
A	5,200	0.02	6.70	6.10	12.90
B	4,690	0.02	6.30	5.70	13.30

C	1,800	0.02	6.40	5.50	12.50
D	2,955	0.02	6.20	5.60	13.10
E	2,200	0.02	6.70	6.30	12.60
Total	16,845	0.02	6.50	5.90	13.00

North Star "complex" ore

	10,000	0.01	4.05	3.39	6.48

Triumph siliceous-bedded ore (above 200' level - ~~Fig. 8~~) Stope plan I)

Partly outlined by development; assay values based on cut samples taken at five foot intervals along all accessible exposures.

Block	Tonnage	Assay			
		Au	Ag	Pb	Zn
A	2,490	0.01	2.99	2.68	6.37
B	1,125	0.01	3.31	3.20	5.46
C	4,200	0.01	3.30	3.12	6.55
D	3,150	0.01	3.21	3.43	5.10
E	10,780	0.01	3.16	2.72	6.39
F	3,290	0.01	4.60	4.22	7.15
G	3,000	0.01	4.43	3.93	6.51
H	560	0.01	3.66	3.23	7.17
Total	28,595	0.01	3.48	3.18	6.35

Total Measurable Ore 55,440 tons

Indicated Ore

Triumph fissure ore

Method used in determining tonnage consists in assuming that the ore occurs for a distance of 25 feet from any exposure except where the block is exposed on all sides when the total tonnage is computed; assay values based on previous tonnages shipped combined with cut samples taken at regular intervals.

Tonnage	Assay			
	Au	Ag	Pb	Zn
106,800	0.16	9.29	4.12	4.94

North Star fissure ore

Method of determining tonnage and assay values as above

25,000	0.18	9.20	5.80	9.30

Total Indicated Ore 131,800 tons

Inferred Ore

	Tonnage	Assay			
		Au	Ag	Pb	Zn
Triumph fissure ore	46,500	0.13	6.70	3.30	3.30
Triumph siliceous-bedded ore	30,000	0.01	3.46	3.16	6.36
North Star fissure ore	20,000	0.18	9.20	5.80	9.30
North Star Complex	30,000	0.01	4.05	3.39	6.48

Total Inferred Ore 126,500 tons

TOTAL MEASURABLE ORE	55,440 tons
TOTAL INDICATED ORE	131,800 "
TOTAL INFERRED ORE	126,500 "
TOTAL RESERVES	313,740 tons.

Present operations of the Triumph Mining Company are conditioned by premium prices for base metals. This should encourage mining of the marginal siliceous ores, while intensive working of the reserves of high-zinc "complex" ore may be expected to exhaust these in a relatively short time. Previous to the war the "complex" ore constituted a large percentage of Triumph production.

Until recently all ores were shipped crude. With de-

pletion of the "complex" ore in view, concentration to shipping grade became desirable. At the present time (October, 1942) about 50% of the ore including the "complex" is shipped crude and the remainder treated at the North Star mill (recently reconditioned) employing gravitational methods with bulk flotation of slimes. The mill is designed for about 300 tons per day and is expected to be operating at capacity in the near future.

Under peacetime conditions the fissure ores would presumably be workable at the mill as they carry the highest percentage of gold and good silver values though, in general, the lead and zinc tenor is considerably below the "complex" standards. It seems likely, however, that some of the fissure and marginal bedded siliceous ores would fall below grade. Assuming changed conditions with further increase in base metal prices (or subsidy) it is possible that larger amounts of fissure ores could be shipped crude and the capacity of the mill increased, labor and economic conditions permitting.

In several sections of the Triumph the ores are now mined to an assay boundary and might be worked beyond under emergency conditions to considerably increase the output.

It should be pointed out that the measurable reserves of high-zinc "complex" ore in the Triumph are largely pillars within sections already stoped over a large area (see Stope Plan II). Mining operations would presumably become increasingly hazardous in this ground.

Completion of the low-level haulage tunnel (length 6,500

~~feet) about September, 1943 is expected to remove several ob-~~ stacles and make possible haulage of the bulk of the ore directly from the 700-foot level of the Triumph to the mill without use of the Triumph shaft. (Figure 1.) At present the small capacity of the main shaft is the real bottleneck, as it probably cannot raise more than about 300 tons of ore per day. Mine waste must also be taken out through the shaft, as a consequence of which only a minimum of waste has been removed. The hoist is operated almost continuously three shifts a day with Sundays off for repairs.

Cost of driving the new tunnel and sinking of a new inside shaft from the 700-foot to the ~~800~~ 850-foot level is said to have reduced the amount of exploration and prospecting which the company would probably otherwise have carried out in the Triumph Mine.

Present operations include continued drifting to the northwest along the Triumph fissure on the 800', 700' and 400' levels. (Figure 5) On the 800' and 700' levels development is favorable, with the fissure ore continuing at normal grade. It is possible that the base of the Tertiary lavas may be encountered in this direction in view of either expected irregularity of the basal contact of these overlying extrusives or of downfaulting. On the lower levels, some developments to the southeast on the Triumph fissure are in ore, though to a lesser extent than to the northwest. In driving the new 6,500-foot haulage tunnel from a point near the North Star mill on the south-south-

east to the Triumph 700-foot level ore has been discovered at only one point, though about 1300 feet remains to be completed.

To the northwest of the Triumph shaft (Figure 5), a large section between the 400-foot and 700-foot levels remains largely unworked. With mineralization on three sides this assumed projection of the fissure should yield ore.

There appears to be no indication that the Triumph fissure ore does not continue down below the lowest or 850-foot level of the Triumph Mine. Mineralization was found in the 852 winze extending down along the fissure for a vertical distance of 40 feet below the 850-level.

Extensive diamond drilling was carried out from the lower levels in an attempt to locate a continuation of the "complex" ore shoot. No success was had and it appears unlikely that this high zinc-lead "complex" ore continues below the 750 level, though the fissure ore carries down to the greatest depths yet penetrated.

In general, diamond drilling has not in the past been successful at the Triumph due to extremely poor core recovery in the fissure where soft, claylike gouge is extensive. Marked lenticularity of the fissure ore is a further factor leading to unsatisfactory results where a few inches in one direction or another may be the difference between striking or missing an ore pod. The company would prefer to explore from present workings by raises and crosscuts and thus be in a position to take out ore if discovered without further development. At one point above the face of the No. 3 tunnel in

(At northeast end of section D-D', Fig. 3)
the upper workings of the Triumph it might be profitable to drill from the surface in expectation of finding a continuation of Triumph fissure ore, or intersecting mineral on the North Star fissure which is thought to continue through above (Figures 3, 4.)
the Triumph fissure here. Roughly 600 feet of hole would be required. Ore is found in the No. 3 within this extension and appears to project upward along the fissure.

It appears reasonable to expect that surface exploration of the upper undeveloped projection of the Triumph fissure might be profitable (see Figs. 3 and 4). As outcrops are very poor, cuts might be made with a bulldozer in hope of finding gossans. This type of exploration has been carried on in the past by the company to a limited extent.

Development in depth on the North Star fissure is very favorable with recent discovery of an excellent ore shoot on the lower or 300 north drift (see Fig. 10). The shoot is believed to pinch out upward but is continuing on the face of the drift in a northwesterly direction. In the upper levels of the old North Star the limited amount of ore remaining is reasonably well estimated or blocked out by stoping in the case of the "complex" shoot. The new 6500-foot haulage tunnel (Figure 1.) from the North Star mill to the Triumph 700-foot level is being driven in the footwall of the North Star fissure with raises to the fissure. As mentioned above only one ore body (Venus claim) has been found in this development.

Forecast of Future Production

On completion of the low-level haulage tunnel about Sept-

ember 1943, tonnage may be expected to increase appreciably with favorable labor and economic conditions. Unless tonnage of fissure ore is considerably increased the zinc and lead production would be expected to fall off with depletion of the high-zinc "complex" ore (reserves in Triumph 16,845 tons).

With probable production at the present time (October, 1942) of about 7,500 tons of ore per month of 26 days, it appears reasonable that an increase of 30% is possible to give a monthly output above 9,500 tons, (mainly fissure ore), after completion of the new haulage facilities.

It is believed that at least enough ore is in sight for from twelve to fourteen months operations, taking account of expected increase in production rate.