BIMODAL VOLCANISM ALONG THE TINTINA TRENCH, NEAR FARO AND ROSS RIVER

Monica J. Pride

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ABSTRACT

Bimodal Tertiary volcanic rocks are exposed along the Tintina Trench in central Yukon in the Glenlyon, Grew Creek, and Ketza areas. Basalt and rhyolite are interbedded with coarse sedimentary rocks and preserved in grabens. The basalt forms both subaqueous and subaerial flows, hydrovolcaniclastic, pyroclastic, and autoclastic deposits. Rhyolite forms intrusions, lava flows, and volcaniclastic deposits. The volcanic and sedimentary rocks probably formed in a series of extensional basins whose original size and shape is yet to be determined. At Grew Creek, gold-bearing chalcedony veinlets and associated argillic alteration are near rhyolite dykes. In the Glenlyon Area, quartz, chalcedony, and fluorite veins and associated silicification are in and near rhyolite dykes.

RÉSUMÉ

Des roches volcaniques tertiaires de caractère bimodal affleurent le long de la fosse de Tintina dans la partie centrale du Yukon, dans les régions de Glenlyon, de Grew Creek et de Ketza. Les basaltes et rhyolites sont interstratifiés avec des roches sédimentaires grossières et conservés dans des grabens. Le basalte forme à la fois des coulées subaquatiques et subaériennes, des dépôts volcanoclastiques sous-marins, et des dépôts pyroclastiques et autoclastiques. Les rhyolites forment des intrusions, des coulées de laves et des dépôts volcanoclastiques. Les roches volcaniques sédimentaires se sont probablement formées dans une série de bassins en expansion, dont la dimension et la configuration originelles restent encore à déterminer. A l'emplacement de Grew Creek, on observe à proximité de dykes rhyolitiques des veinules aurifères de calcédoine, et une altération argilique associée à ces veinules. Dans la région de Glenlyon, il existe à l'intérieur et près de dykes rhyolitiques des filons de quartz, de calcédoine et de fluorine, et l'on observe une silicification associée à ceux-ci.

INTRODUCTION

This report examines the volcanofacies of the Tertiary volcanic rocks in Tintina Trench and their relationship to epithermal precious metal mineralization. Interest in these rocks was spurred by the discovery of the Grew Creek epithermal gold silver prospect, 1 km west of the Robert Campbell Highway halfway between the communities of Ross River and Faro, in south-central Yukon. The Grew Creek property is the first reported Tertiary volcanic-hosted epithermal gold-silver showing in Tintina Trench.

The Tintina volcanics comprise basalt and rhyolite that are interbedded with coarse clastic sedimentary rocks, and preserved in grabens along the Tintina Trench. This report describes three areas of volcanic rocks: Glenlyon, Grew Creek and Ketza River (Fig. 1). The trench is characterized by a dense cover of forest, brush and bog and a thick blanket of glacial and fluvial deposits. Rock distribution is complicated by strike-slip and dip-slip faults along the Tintina Fault Zone that moved during and subsequent to volcanic activity. The poor outcrop exposure and complex tectonic setting obscure stratigraphic relations within the volcanic piles.

Field work was undertaken during a two month period in the summer of 1986 with local geological mapping at a scale of 1:30 000. Eighty samples were chosen for petrographic study; 40 of those were selected for geochemical analysis. Geochemical analyses using x-ray fluorescence were done by X-ray Assay Laboratories, Don Mills, Ontario. Fifteen samples of vein material were analysed for 26 trace elements (including gold and silver) by Bondar Clegg, Whitehorse, Yukon.

ACKNOWLEDGEMENTS

This project was funded by Exploration and Geological Services Division of the Northern Affairs Program in Whitehorse, Yukon Territory, under the supervision of Chief Geologist J.A. Morin. The writer extends special thanks to Robert Stroshein of Hudson Bay Exploration and Development Company Ltd for a tour of the Grew Creek property, as well as allowing access to Hudson Bay's geological maps of the Grew Creek area. I would also like to thank Craig Hart of Noranda for information and maps on the Glenlyon area. Lastly I thank very much Teresa Potter and Bill LeBarge for their excellent field support.

PREVIOUS WORK

Volcanic rocks along Tintina Trench were first recognized by J.R. Johnson (1936), who assigned a tentative Tertiary age to them. He described them as comprising rhyolite, dacite, trachyte, andesite and basalt with associated conglomerate. The area covers parts of three 1:250 000 scale map sheets and reconnaissance geological mapping was done at various times: Wheeler et al (1960) mapped Quiet Lake map area (105 F), Roddick and Green (1961) mapped Tay River map area (105 K) and Campbell (1967) mapped Glenlyon

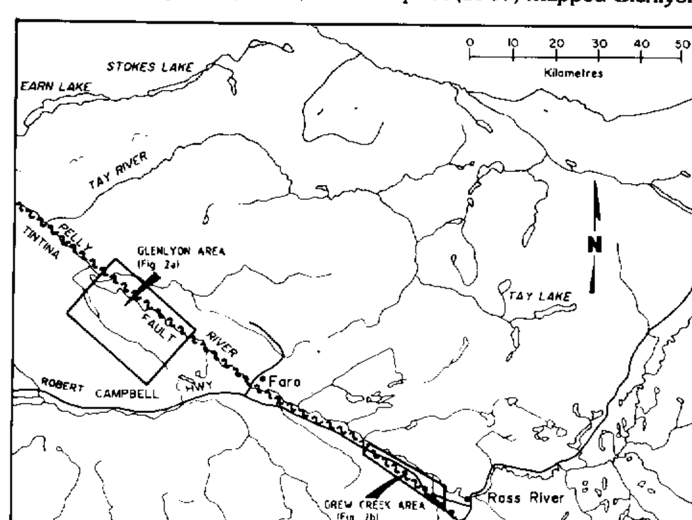

Figure 1. Location map of the volcanic rocks along Tintina Trench.

map area (105 L). Tempelman-Kluit (1972) mapped part of the Tay River map area at a scale of 1:125 000, and in 1977, published an open file report on the Quiet Lake map area. S. Gordey (1988) updated Tay River map area.

In 1983, Mr Al Carlos of Whitehorse discovered the Grew Creek gold deposit. Hudson Bay Exploration and Development Company Ltd optioned the property and in 1984, 1985 and 1986, explored with trenching, diamond drilling, geochemical sampling and geophysics. The discovery led to increased interest in the volcanic rocks along the trench and the staking of claims in the Glenlyon area. Duke and Godwin (1986) undertook a detailed study of the geology and alteration of the Grew Creek deposit and obtained an Eocene radiometric age for the volcanic rocks.

TECTONIC SETTING

The tectonic setting for the Tintina volcanics is complex. Presumably they relate to strike slip movement along the Tintina Fault Zone. Late Cretaceous or Early Tertiary right lateral movement along Tintina Fault amounted to at least 450 km (Roddick, 1967, Tempelman-Kluit, 1979, and Gabrielse, 1985) and juxtaposed Cambrian and Ordovician slates and phyllites of the Pelly Cassiar Platform on the southwest against rocks of the Anvil allochthon on the northeast (Gordey, 1983). The Tintina Trench follows the Tintina Fault Zone and is a physiographic feature that formed by normal faulting in Pliocene time (Tempelman-Kluit, 1980).

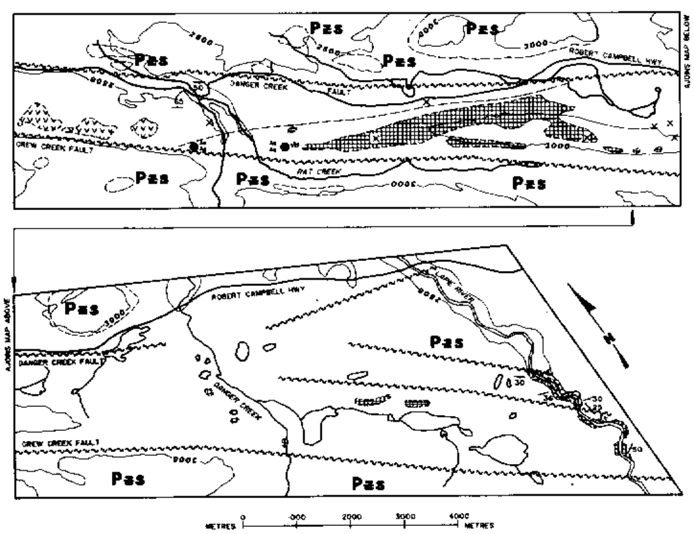

Figure 2a. Geological map of the Grew Creek area.

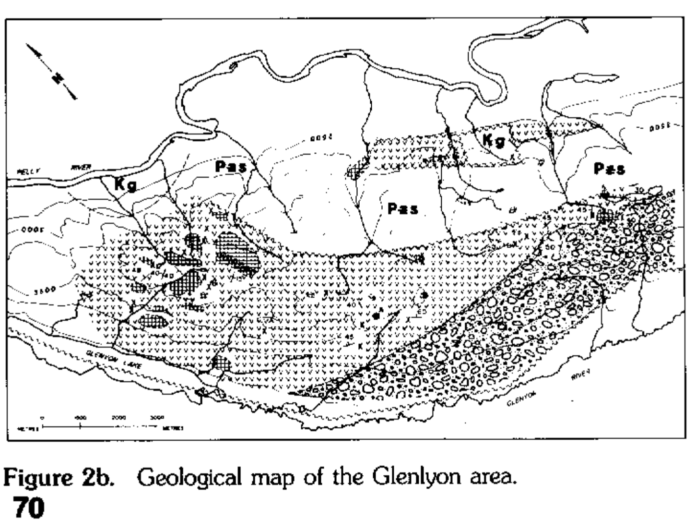

Figure 2b. Geological map of the Glenlyon area.

GEOLOGY

Volcanic rocks in the Tintina Trench include basalt, rhyolite and rare andesite interbedded with coarse clastic sedimentary rocks. The rocks are preserved in elongate, internally faulted grabens (Fig. 2a, b). Extensive faulting and lack of continuous outcrop preclude stratigraphic correlations, but the isolated outcrops still provide information on the type of volcanism. The morphology and petrography of basalt, rhyolite and clastic sediments, are described here. Table 1 summarizes the different characteristics observed in the three areas studied.

BASALT

The basalts comprise subaqueous to subaerial lava flows, intrusions and volcaniclastic rocks. Most exposures are poorly preserved, massive to partly brecciated, altered, fractured and faulted, and contain few or diagnostic morphological features. Basaltic lava flows are the most abundant lithology and locally fill U-shaped valleys (Fig. 3) or are stacked and in places interbedded with clastic sediments and basaltic volcaniclastic rocks (Fig. 4). The flows vary in thickness and are either subaqueous and pillowed (Fig. 5a, b) or subaerial. The latter are massive, columnar jointed, blocky with brecciated and vesicular tops, rarer hyaloclastic basal contacts, and occassional pipe vesicles (Fig. 6).

The textures indicate hydrovolcaniclastic, pyroclastic and autoclastic depositional processes. Two distinct types of hydrovolcaniclastic deposits were observed. The first, found along Grew Creek, is a relatively thick sequence of plane parallel beds and laminae that are commonly subtly cross bedded or lenticular over short distances (Fig. 7a, b). Beds are graded, moderately to poorly sorted, have erosional to gradational contacts and are locally disrupted by soft sediment deformation. They contain approximately

LEGEND

(TO ACCOMPANY FIGURES 2A & 2B)

TERTIARY

-QUARTZ-FELDSPAR AND QUARTZ PORPHYRITIC RHYOLITE FLOW BANDED, MASSIVE AND SPHERULITIC
-FELSIC VOLCANICLASTIC ROCKS

-SUBAERIAL AND SUBAQUAOUS BASALT LAVA FLOWS, INTRUSIONS AND VOLCANICLASTIC ROCKS.

-CONGLOMERATE SANDSTONE, SILTSTONE AND CLAY

CRETACEOUS

Kg -GRANITIC ROCKS

PALEOZOIC

Pzs -GREENSTONE, TUFF, ARGILLITE, CONGLOMERATE, LIMESTONE, HORNFELS, QUARTZITE, GRANULITE AND SCHIST

× -SAMPLE LOCATION

● A -AGE DATING LOCATION

● Au Ag -GOLD AND SILVER OCCURRENCE

-OUTCROP

-AREA ENCOMPASSES MOSTLY OUTCROP

25 -BEDDING

-FOLD AXIS AND DIRECTION OF PLUNGE

-APPROXIMATE FAULT LOCATION

-QUARTZ ± FLORITE CHALCEDONY VEINS

Figure 3. Ketza River area: a columnar jointed basaltic lava flow filling a broad channel.

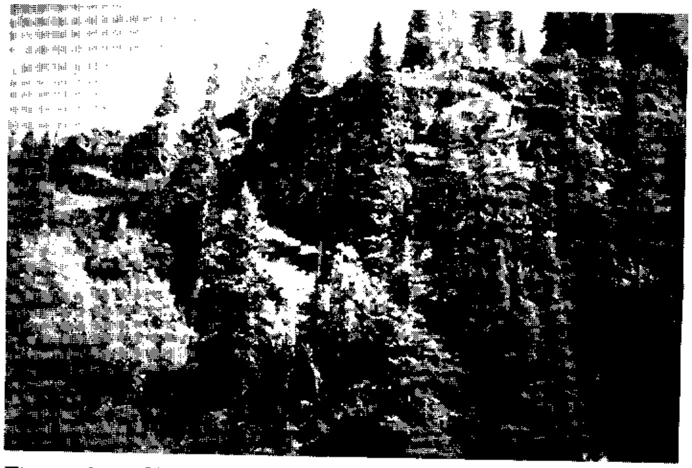

Figure 4. Glenlyon area: a series of stacked subhorizontal basaltic lava flows.

Figure 5a. Ketza River area: photograph of subhorizontal basaltic lava flows interbedded with bedded to laminated basaltic tuff.

Figure 5b. The base of the lava flow above yellow-weathering tuff. The lava presumably flowed into a small lake, forming pillows.(Fig. 5b).

five percent subangular, mostly nonvesicular blocks that are associated with bedding sags in places. Beds comprise mostly basaltic nonvesicular to vesicular, tuff and lapilli size fragments, quartz and feldspar crystals with subordinate accidental fragments, carbonized plant fragments and occasional beds rich in accretionary lapilli. Void spaces are filled with calcite. Although outcrop is limited, this sequence of finely bedded rocks resembles descriptions of base surge deposits in maar volcanoes.

The second type of hydrovolcaniclastic deposit outcrops in the Ketza River area and comprises a relatively thick sequence of one to three meter thick, poorly sorted beds (Fig. 8a). Beds contain variable amounts of subangular, nonvesicular to vesicular blocks and rounded bombs; the bombs are cut by radial cooling joints (Fig. 8b). Blocks and bombs are set in a groundmass of equant, lapilli size, angular, vesicle-free sideromelane shards that are cut by a mosaic of cracks. Void spaces within the breccia are filled with secondary zeolites and minor calcite and quartz. This description resembles the deposits of a littoral cone (Fisher and Schminke, 1984).

Isolated pillow breccias are exposed in one outcrop in the central part of the Glenlyon area. Poorly sorted lapilli size breccia with no observable bedding locally contains about ten percent isolated pillows in a finer equant, angular nonvesicular lapilli-size matrix (Fig. 9). Pillows are slightly vesicular, rounded and have chilled margins. The exact origin of the breccia is unknown. They may have formed by autoclastic processes or secondary processes such as slumping.

Plane parallel beds and laminae of lapilli tuff and tuff are interbedded with pillowed lava flows in the Ketza River area (Fig. 5). Beds and laminae are slightly wavy, lenticular, graded and moderately

Figure 6. Glenlyon area: well developed pipe vesicles in a basaltic lava flow.

to poorly sorted. Some beds comprise well preserved rod-shaped to triangular slightly concave shards, and are interpreted as pyroclastic. These beds probably represent slightly reworked waterlain, airfall and surge deposits.

Poorly sorted heterolithic breccia containing variable amounts of accidental fragments are common in Glenlyon and Grew Creek areas (Fig. 10). These outcrops contain anomalously large boulders

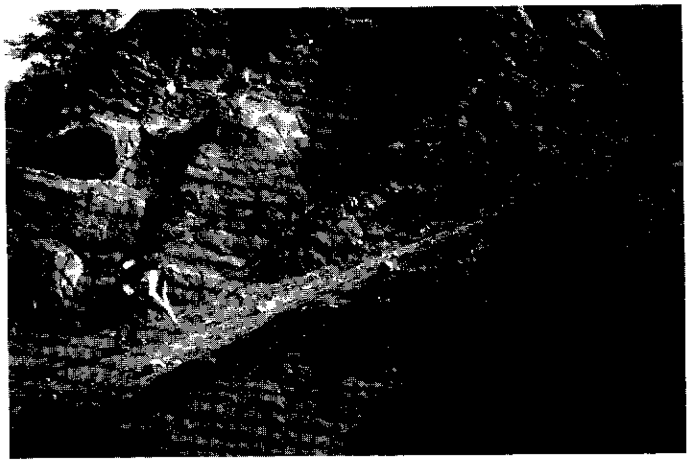

Figure 7a. Grew Creek area: photograph of the bedded and laminated hydro- volcaniclastic deposit. Bedding is near vertical and runs approximately right to left across the photograph. Note the large fragments scattered throughout the outcrop.

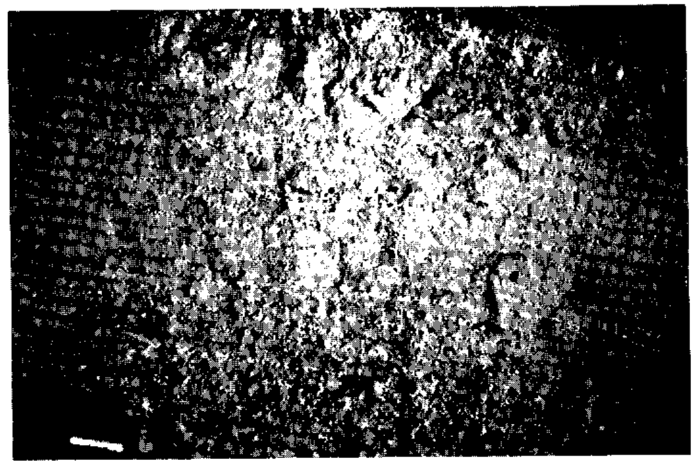

Figure 7b. Grew Creek area: photograph of the bedding in Figure 7a. Note the beds are subtly cross bedded on the upper right hand side of the photograph.

Figure 8a. Ketza River area: photograph of a hyaloclastic bed. The bed is poorly sorted, contains approximately 20% blocks and bombs that are mostly nonvesicular. Matrix comprises lapilli size, equant altered basaltic glass shards that are cut by a mosaic of cracks.

Figure 8b. Ketza River area: photograph of a bomb in a hyaloclastite bed. Note the chilled margin and the radial cooling joints.

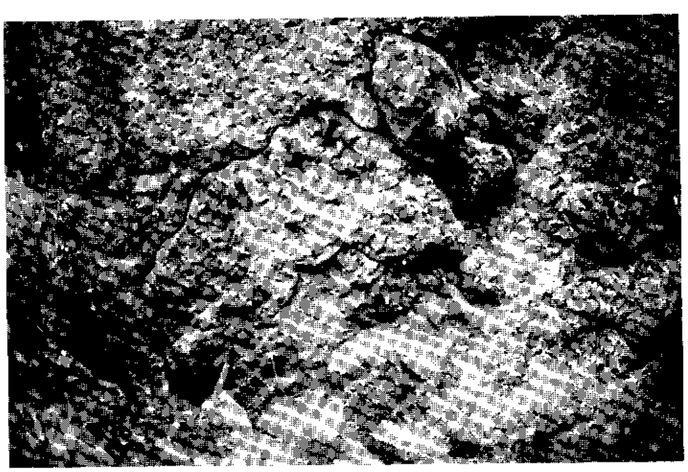

Figure 9. Glenlyon area: a photograph of a hyaloclastite deposit that contains variable amounts of isolated pillows in a groundmass of equant basaltic altered glass shards.

Figure 10. Grew Creek area: photograph of a poorly sorted, matrix supported and heterolithic debris flow.

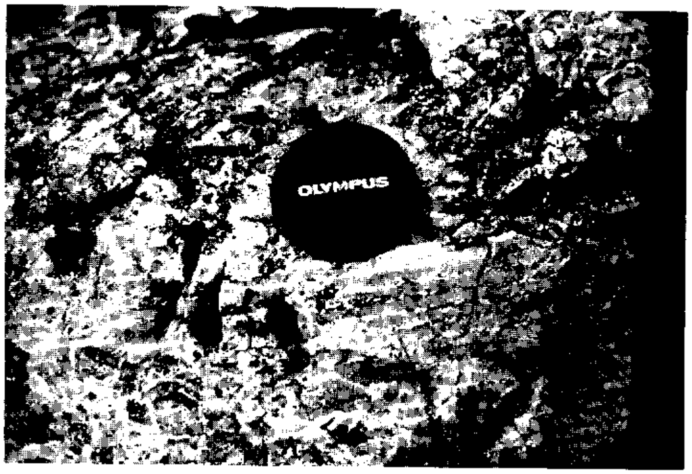

Figure 11. Glenlyon area: photograph of intense quartz veining that forms about 50% of the total rock in a rhyolite intrusion.

Figure 12. Grew Creek area: intensely folded, terrestrial, thinly bedded and laminated fissile, micaceous, carbonaceous and silty shales and sandstone beds.

set in a poorly sorted matrix and represent a series of debris flows. Other epiclastic deposits appear to grade into some of the primary volcanic deposits already described. They may be bedded, contain more rounded clasts, and are commonly more heterolithic.

PETROGRAPHY

The basalts are porphyritic, glomeroporphyritic or aphyric and contain in order of abundance, 0-25% phenocrysts of feldspar, olivine, clinopyroxene and rare quartz. Feldspar phenocrysts are up to 1 cm in length and are mostly labradorite in composition. They are euhedral to subhedral, show textures such as internal melting, resorption, reaction rims, oscillatory zoning and may be fractured and broken. Olivine phenocrysts commonly occur in clusters of small rounded grains that are partly or totally replaced by iddingsite or more commonly completely altered to pseudomorphs of calcite and chlorite. Clinopyroxene phenocrysts are typically poikilitic and enclose feldspar laths. They are commonly more resistant to alteration than olivine and altered to calcite, chlorite, and biotite. One sample contains a few rounded quartz phenocrysts surrounded by reaction rims. Magma mixing or incorporation of foreign fragments are possible explanations for the presence of quartz. Single crystals and sheaf-like aggregates of plagioclase predominate in the groundmass with mafic minerals or glass surrounding them. Opaques, magnetite and ilmenite occur as bladed crystals in the matrix.

RHYOLITE

Rhyolite occurs as intrusions, lava flows and volcaniclastic rocks. Most common are massive or flow-banded plug-like intrusions with near vertical intrusive or fault contacts. Most intrusions are poorly exposed except along creek sections and some cliff outcrops that locally exhibit columnar jointing. Dykes are massive to flow-banded, locally intensely folded and faulted, and rarely continuous for any great distance. Most intrusions are moderately to highly argillized and silicified, making the outcrops easily recognizable from a distance by their pale pastel color.

In the Glenlyon area, subhorizontal lava flows exhibit partly folded flow banding and surface ropey textures, and are associated with breccia. The flows surround a massive quartz-veined rhyolite intrusion of similar composition. The association resembles that of a dissected dome, and suggests that other less well exposed intrusions may also be domes.

Felsic volcaniclastic rocks comprise a small percentage of the rhyolitic rocks along the trench, their original extent being unknown. The volcaniclastic rocks are poorly sorted, nonwelded and contain variable amounts of lithic fragments and broken crystals set in a fine grained tuffaceous and glass shard matrix. Lithic fragments comprise rhyolite, metamorphic rocks and rare basalt. Nonwelded crystal lithic tuff is well exposed in a section along Grew Creek, though alteration has obliterated much of the structure and complicated interpretation of its origin. Presence of relatively unbroken and unworn glass shards suggests a primary volcanic deposition for most of the rocks. Clast size and sorting varies along the Grew Creek section, suggesting more than one type of volcanic deposit or deposition of volcanic ash flows along a relatively hilly topography. Large blocks in some sections suggest a proximal source.

Quartz, minor banded and brecciated chalcedony and late fluorite veins are intimately associated with the altered intrusions. In the central part of the Glenlyon area, rhyolite contains a zone of quartz veins 1.5 km long. Quartz comprises up to 50% of the rock (Fig. 11). Fluorite veins up to 1 m wide cut the quartz veins.

The main Grew Creek gold deposit is in a westward-pointing wedge of altered felsic volcaniclastic rocks bounded to the south by the Grew Creek Fault and to the north by steeply dipping sedimentary rocks that are intercalated with basalts. Gold occurs in banded and brecciated quartz-chalcedony veinlets and stringers that cut crystal lithic tuff (Duke and Godwin, 1986). The mineralization at surface is surrounded by zones of acid sulphate and argillic alteration and includes montmorillonite, kaolinite, jarosite, alunite and iron oxides. About 2 km east of the main deposit, gold-bearing quartz and fluorite veins occur in a large sericite alteration zone (Duke and Godwin, 1986).

PETROGRAPHY

The rhyolites are porphyritic to glomeroporphyritic and contain up to 25% phenocrysts of feldspar (mainly sanidine) and embayed quartz. Feldspar phenocrysts are euhedral to subhedral and altered, commonly cloudy, moth eaten or partly leached. Some rhyolites contain small amounts of primary biotite, but most contain about 5% altered mafic or oxide minerals. The matrix is graphic in texture, and in places spherulitic or partly spherulitic. Typically the rhyolite has undergone a combination of argillic, sericitic and silicic alteration.

CLASTIC SEDIMENTARY ROCKS

Clastic sedimentary rocks along the Tintina Trench are described by Hughes and Long (1979). They are moderately to steeply dipping, are locally tightly folded (Fig. 12) and occur in isolated fault blocks. Only rarely are they interbedded with volcanic rocks. Well to poorly sorted, spheroidal-weathered sandstone beds containing variable amounts of plant debris are interbedded and locally form load structures in finer thinly bedded and laminated, fissile, micaceous, carbonaceous and silty shales. Minor coal seams also form thin lenticular beds through the sequence. Some conglomerate forms normally graded lenticular beds and channels in the dominant fine-grained sequence. One relatively thick exposure of pebble conglomerate forms an erosional contact with the fine beds. The conglomerate is well sorted, normally to reversely graded, plane to planar cross-bedded and fills channels. These coarse conglomerates are interbedded with finer bedded and laminated sandstones that are crossbedded, graded, and in places severely slumped. The conglomerate primarily contains rounded to subrounded clasts of relatively resistant chert, quartzite, vein quartz, metamorphic rock, granite and rare volcanic rock. Hughes and Long (1980) interpreted the sediments to have formed as lake deposits, alluvial fans, fan deltas and minor river deposits.

CHEMISTRY

Table 2 contains whole rock analyses for 38 samples of basaltic and rhyolitic rocks from the Tintina Trench. Samples were collected in geographically isolated areas from rocks with uncertain stratigraphic relations and varying degrees of alteration; therefore the geochemical analyses only provide limited information on petrogenetic evolution.

Binary and ternary plots illustrate the strongly bimodal nature of the Tintina volcanics; SiO_2 contents between 52 to 72% are rare. Solid and blank symbols on the elemental plots distinguish the relatively unaltered samples from the altered samples respectively. Major, minor and trace element contents plotted against silica content show no consistent variation between altered and unaltered samples, although points from unaltered samples tend to cluster more closely than points from altered samples. Generally basalts are high in Al_2O_3, TiO_2 and FeO and low in K_2O and MnO. Basalts have no iron enrichment trends (Fig. 13) and have high FeO/MgO ratios (Fig. 14). The plot of Na_2O+K_2O versus SiO_2 (Fig. 15) shows the apparent subalkaline nature of the basalt, whereas a plot using the less mobile elements (Zr, TiO_2, Nb & Y) shows the basalt to lie in the alkali field (Fig. 16). A Pearce and Cann plot confirms the intraplate affinity of the basalts (Fig. 17). The rhyolites are moderately altered, with high SiO_2 and K_2O (Fig. 18).

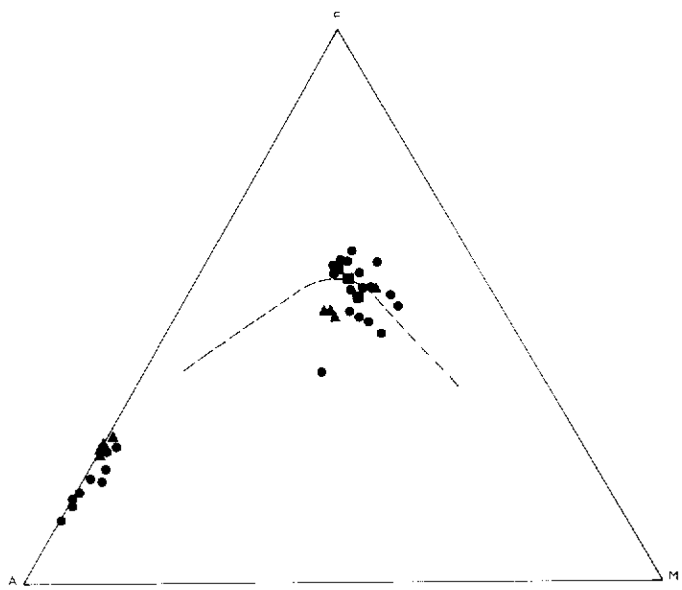

Figure 13. AFM plot (Irving and Barager, 1971) for rhyolite and basalt from Tintina Trench A= K20+Na20, F= Fe203, M= MgO. The dotted line separates the tholeiitic field (above) from the calc-alkaline field (below). The volcanic rocks along the Tintina Trench straddle the dotted line and show no iron enrichment trends. Open symbols = altered samples; closed symbols = relatively unaltered samples.

SYNTHESIS

Bimodal volcanism (basalt and high silica rhyolite) resulting from extension of continental crust is well documented in the western United States (Christiansen and Lipman, 1972 and Snyder et al, 1976). The Tintina Trench bimodal volcanics presumably developed in response to crustal attenuation caused by strike slip movement along Tintina Fault. Basalt and rhyolite intrusions outside the trench

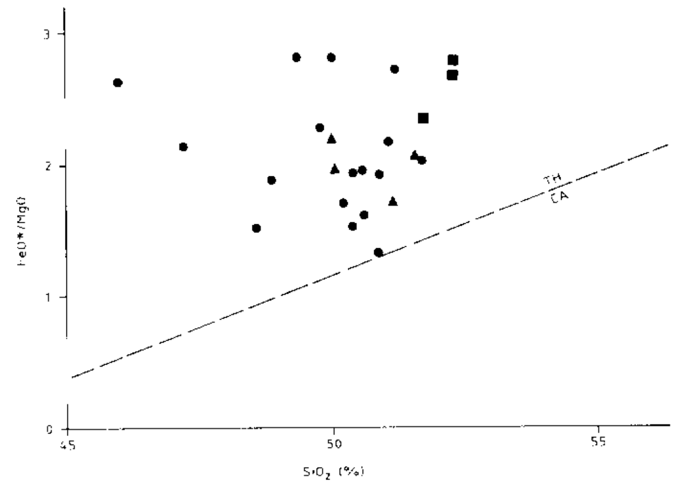

Figure 14 FeO/MgO versus %SiO2 diagram (FeO= total Fe as FeO) (Miyashiro, 1974) for basalt from Tintina Trench. The boundary line separates the tholeiitic (TH) and calc-alkaline (CA) fields.

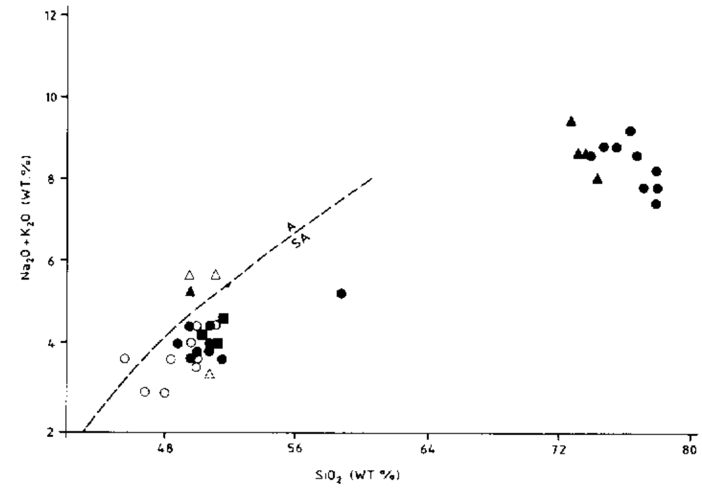

Figure 15. Alkali versus silica diagram (Irvine and Baragar, 1971) for volcanic rocks from the Tintina Trench. Boundary line separates the alkaline (A) and subalkaline (SA) fields, the volcanic rocks plotting dominantly within the subalkaline field.

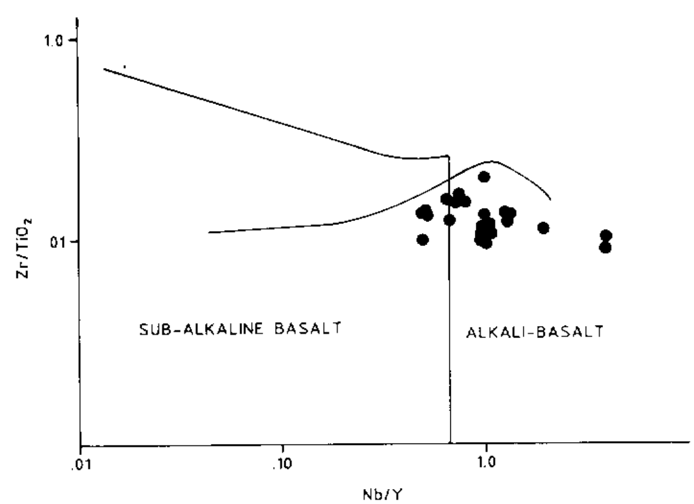

Figure 16. Discrimination diagram (Winchester and Floyes, 1977) for basalts from the Tintina Trench. The discrimination diagram uses immobile elements to separate the alkali verses subalkali fields. The volcanic rocks plot mostly in the alkali field.

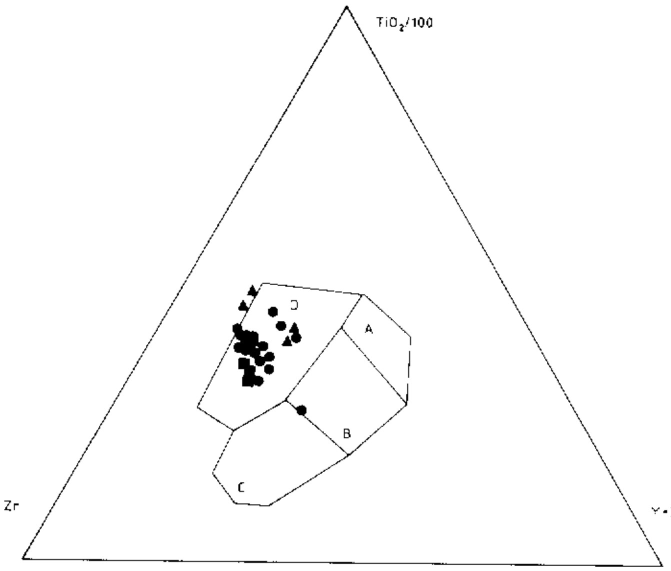

Figure 17. Pearce, Cann plot (1973) for basalts from the Tintina Trench. A+B= K tholeiites; B= Ocean floor basalts; B+C= Calc alkali basalts; D= Within plate basalts.

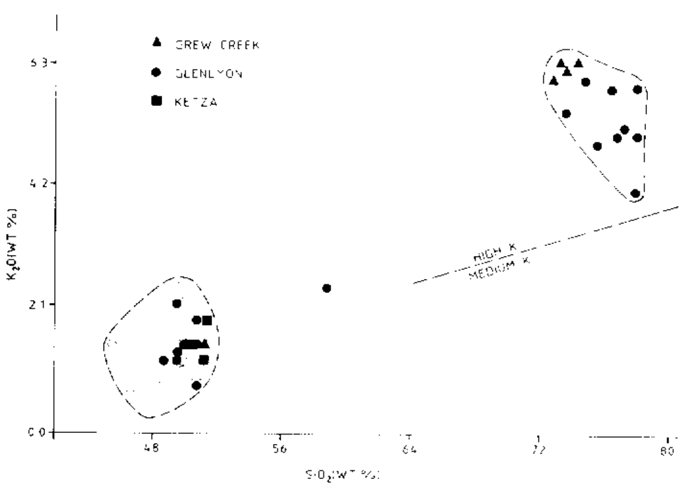

Figure 18. K_2O versus SiO_2 plot for Tintina Trench volcanic rocks. The heavy line separating the high K field from the medium K field suite of rocks is from Gill, (1981). The diagram shows the bimodal nature of the volcanic rocks and places the rhyolite in the high K rhyolite field.

and immediately north of the study area (Jackson et al, 1986) indicates that extension was not restricted to the Tintina Trench. Ultimately, examination of other bimodal volcanic suites in Yukon will help improve our understanding of the tectonic environment that prevailed during Tertiary time.

The terrestrial clastic sedimentary rocks along the Tintina Trench are products of fluvial and lacustrine deposition in isolated basins or a series of interconnected basins which formed in grabens along Tintina Trench (Hughes and Long, 1980). Basalts erupted in the source basins. No basaltic vents are yet known in the trench, but the presence of bombs and large blocks in some of the hydrovolcaniclastic deposits suggests a proximal environment, and indicates that at least some of the volcanics erupted in the trench. Rhyolite intrusions in the trench were probably emplaced along faults and fault intersections.

The volcanic rocks exhibit several differences from one area to another (Table 1). Some differences may be explained by poor exposure and different levels of exposure, but others probably reflect variatious in type, composition and environment of volcanism. The speculation that rhyolitic volcanism may be structurally controlled is suggested by the association with structurally complex areas, (Table 1).

Whether the volcanic rocks were deposited prior to, or subsequent to volcanism is uncertain. Lack of volcanic fragments in most sedimentary rocks suggests that they were deposited after volcanism. Alternatively the sediment source was outside the trench, whereas volcanism was in the trench.

Alteration and mineralization in rhyolite at Grew Creek and the Glenlyon area are different. Argillic alteration is better developed in the Grew Creek area whereas silicification is more pronounced in the Glenlyon area. Quartz and chalcedony, and later fluorite veining are intimately associated with the rhyolite intrusions in the Glenlyon area, whereas at Grew Creek, veins are associated with argillic, acid-leached, and silicified pyroclastic rocks. Mineralization in the Grew Creek area is epithermal (Duke and Godwin, 1986) and was presumably driven by a heat source at depth (rhyolite intrusion). Other deposits similar to Grew Creek probably formed elsewhere along the Tintina Trench. Pyroclastic rocks may not be the only host; clastic sedimentary rocks in particular are exploration targets. The Glenlyon area, although associated with at least three zones of extensive quartz veining and subordinate chalcedony and fluorite veining in rhyolite intrusions, contains no known precious metals. However, the intrusions resemble silicified caps of domes that are associated with precious metal deposits in other areas and their potential should not be ignored.

The chemical data confirms the bimodality of the volcanic suite. However, altered samples are difficult to separate from relatively unaltered samples.

TABLE 1 GEOLOGICAL FEATURES OF VOLCANIC ROCKS ALONG TINTINA TRENCH

STUDY SITE	GLENLYON	GREW CREEK	KETZA RIVER
Lithology sediments† rhyolite	Basalt† basalt† sediments	Rhyolite†	Basalt
Stratigraphy	Rhyolite intrudes basalt; clastic sediments interbedded with basalt	Basalt intrudes rhyolite; basalt clasts in rhyolitic volaniclastic rocks	
Relative abundance of subaerial vs subaqueous deposits	subaerial	subaerial = subaqueous	subaerial = subaqueous
Relative abundance of lava flows (intrusions) vs volcaniclastic rocks	Basalt: lava flows Rhyolite: intrusions	Basalt: volcaniclastic Rhyolite: intrusions, volcaniclastic rocks	Basalt: lava flows = volcaniclastic rocks
Structure	Highly to moderately deformed	Highly deformed (strike 120 with steep dips)	Slightly deformed (minor dip slip faults)
Alteration and mineralization	Basalt: highly altered; calcite and chlorite rhyolite: altered; silicification and argillic	Basalt: highly altered, calcite and chlorite Rhyolite: altered; argillic, silicification and acid leaching	Relatively unaltered
	Barren quartz, chalcedony veins and ization later fluorite veins in rhyolite.	Au and Ag mineral-	No mineralization

TABLE 2

	86-GR-76	86-GL-8	86-GL-9	86-GL-9A	86-GL-37	86-GL-38	86-GL-41	86-GL-42
SiO_2	47.30	46.40	46.70	46.20	48.30	47.70	45.10	47.10
Al_2O_3	16.00	15.20	16.60	14.60	15.80	16.0	17.10	16.40
Fe_2O_3	10.50	11.70	12.30	10.50	10.60	10.9	10.80	11.10
MgO	4.82	3.75	3.94	5.87	4.42	5.13	5.17	5.18
CaO	8.13	8.94	8.96	8.63	9.03	8.5	9.11	7.55
Na_2O	3.26	2.09	2.96	2.41	2.66	2.45	2.88	2.59
K_2O	2.0	2.01	1.03	.90	1.27	1.37	.71	1.11
TiO_2	2.32	2.34	2.10	2.19	2.11	2.25	1.85	2.0
P_2O_5	.58	.91	.68	.56	.73	.87	.45	.71
MnO	.17	.24	.22	.19	.14	.14	.18	.17
LOI	4.23	6.23	4.16	6.93	4.16	3.85	5.16	5.70
SUM (includes trace elements)	**99.6**	**100.0**	**99.9**	**99.2**	**99.4**	**99.4**	**99.8**	**99.8**
NORMS IN WEIGHT PERCENT								
Q	-	4.49	1.11	3.99	4.71	4.41	-	3.82
C	-	-	-	-	-	-	-	-
OR	12.54	12.82	6.44	5.83	7.97	8.57	4.54	7.05
AB	29.23	19.07	26.49	22.33	23.86	21.92	26.33	23.54
AN	24.49	28.20	30.63	28.86	29.07	30.26	34.18	32.06
DI	8.73	6.80	5.56	8.72	7.65	4.96	6.40	1.79
HE	2.69	3.97	4.04	2.50	3.15	1.73	2.90	.79
EN	4.99	6.91	7.8	11.96	8.13	11.21	6.15	13.03
FS	1.76	4.62	6.5	3.94	3.84	4.49	4.23	6.60
FO	2.58	-	-	-	-	-	1.96	-
FA	1.00	-	-	-	-	-	1.72	-
MT	5.87	6.00	5.52	5.86	5.55	5.75	5.25	5.45
IL	4.67	4.79	4.22	4.55	4.25	4.52	3.80	4.08
CR	.03	.03	.03	.04	.03	.03	.02	.03
HM	1.43	2.28	1.67	1.42	1.80	2.14	1.13	1.77
AP	-	-	-	-	-	-	-	-
RU	-	-	-	-	-	-	-	-
WO	-	-	-	-	-	-	-	-
TRACE ELEMENTS IN PPM								
Ba	1090	870	660	580	660	790	1740	750
Cr	150	130	120	170	140	140	80	140
Zr	230	300	250	270	280	290	180	260
Sr	680	500	630	370	530	580	660	550
Rb	30	80	40	30	20	20	30	40
V	20	40	30	30	40	30	30	30
Nb	80	20	20	40	20	40	30	30
Ni	44	49	56	65	31	39	54	49
Co	28	34	35	31	26	28	40	35
Cu	29	15	18	23	14	17	18	16

	86-GL-43	86-GL-51	86-GL-52	86-GL-54	86-GL-55	86-GL-60	86-GL-63	86-GL-65
SiO_2	49.40	46.20	48.20	46.90	48.90	56.20	42.80	41.20
Al_2O_3	15.90	15.20	16.90	15.10	16.00	15.80	16.60	16.30
Fe_2O_3	12.80	10.10	10.30	11.60	11.90	6.45	12.30	11.60
MgO	4.18	5.38	6.11	4.62	3.96	4.25	5.17	3.99
CaO	6.53	8.38	8.48	9.52	8.04	6.49	8.75	10.10
Na_2O	1.77	2.94	3.26	2.44	2.57	2.90	2.40	2.41
K_2O	1.78	1.40	1.11	1.20	1.82	2.30	.46	1.23
TiO_2	2.12	2.04	1.94	2.43	2.29	1.05	2.21	2.41
P_2O_5	.71	.83	.61	.90	.68	.18	.74	.93
MnO	.19	.17	.16	.19	.17	.1	.15	.18
LOI	4.16	6.54	2.85	4.39	3.31	3.77	7.62	9.0
SUM (Includes trace elements)	**99.8**	**99.4**	**100.1**	**99.5**	**99.8**	**99.7**	**99.4**	**99.6**
NORMS IN WEIGHT PERCENT								
Q	10.63	.59	-	4.22	4.84	11.77	.47	-
C	.94	-	-	-	-	-	-	-
OR	11.15	9.01	6.82	7.55	11.28	14.27	3.00	8.13
AB	15.86	27.05	28.63	21.94	22.78	25.74	22.40	22.77
AN	29.40	26.26	29.28	28.39	28.02	24.44	36.58	33.54
DI	-	8.01	6.27	8.83	4.69	5.28	3.2	8.48
HE	-	2.46	1.96	3.76	2.75	1.18	1.65	4.23
EN	11.03	10.86	10.38	8.14	8.16	8.66	12.72	1.82
FS	9.38	3.83	3.73	3.98	5.50	2.22	7.5	1.04
FO	-	-	1.76	-	-	-	-	3.75
FA	-	-	.70	-	-	-	-	2.36
MT	5.56	5.58	5.18	6.06	5.76	3.88	5.93	6.33
IL	4.27	4.21	3.83	4.91	4.56	2.09	4.83	5.11
CR	.03	.04	.02	.03	.03	.04	.03	.03
HM	-	-	-	-	-	-	-	-
AP	1.75	2.09	1.47	2.22	1.65	.44	1.89	2.41
RU	-	-	-	-	-	-	-	-
WO	-	-	-	-	-	-	-	-
TRACE ELEMENTS IN PPM								
Ba	820	920	680	700	670	710	520	750
Cr	140	180	80	110	110	160	130	140
Zr	310	260	220	280	260	170	270	300
Sr	430	650	620	550	470	360	540	680
Rb	80	40	30	20	90	100	30	40
V	40	40	20	40	30	40	30	30
Nb	30	20	40	40	30	30	30	30
Ni	43	44	40	40	30	46	55	57
Co	38	24	32	28	32	21	37	38
Cu	12	15	20	18	11	19	18	20

TABLE 2 Continued

	86-KZ-1	86-KZ-2	86-KZ-6	86-GR-52	86-GR-72	86-GR-75
SiO_2	49.7	50.4	49.7	45.9	46.9	46.6
Al_2O_3	15.3	12.9	14.9	14.1	14.3	15.8
Fe_2O_3	12.0	12.9	11.6	10.4	11.5	10.6
MgO	5.66	4.34	4.45	5.13	5.07	4.37
CaO	8.41	8.06	8.9	8.84	5.57	7.83
Na_2O	2.76	2.79	2.95	2.45	4.37	3.35
K_2O	1.4	1.74	1.06	.75	1.3	2.17
TiO_2	2.31	2.98	2.41	1.98	2.13	2.36
P_2O_5	.78	1.01	.69	.53	.42	.65
MnO	.20	.19	.18	.19	.2	.17
LOI	1.31	1.93	2.39	8.85	8.08	5.93
SUM (includes trace elements)	100.0	99.5	99.4	99.3	100.1	100.1
NORMS IN WEIGHT PERCENT						
Q	8.48	7.83	5.68	5.11	-	-
C	-	-	-	-	-	-
OR	8.48	10.68	6.53	4.95	8.46	13.77
AB	23.91	24.49	25.99	23.12	40.67	30.42
AN	25.83	18.19	25.29	28.18	17.12	23.25
DI	6.65	9.23	8.95	9.46	5.68	8.33
HE	2.79	4.08	4.00	3.56	2.63	2.83
EN	11.35	6.93	7.39	9.86	3.81	2.87
FS	5.45	3.51	3.79	4.26	2.02	1.12
FO	-	-	-	-	5.22	3.47
FA	-	-	-	-	3.06	1.49
MT	5.66	6.74	5.90	5.63	5.79	6.00
IL	4.49	5.87	4.77	4.20	4.45	4.81
CR	.04	.03	.03	.04	.03	.03
HM	-	-	-	-	-	-
AP	1.85	2.43	1.67	1.63	1.07	1.62
RU	-	-	-	-	-	-
WO	-	-	-	-	-	-
TRACE ELEMENTS IN PPM						
Ba	700	870	750	460	880	1220
Cr	200	150	140	150	120	140
Zr	340	460	330	250	210	210
Sr	380	290	430	420	560	680
Rb	40	50	60	60	80	50
V	50	60	40	30	40	20
Nb	40	40	50	30	20	80
Ni	27	5	40	68	57	44
Co	26	13	26	36	35	28
Cu	17	21	19	26	22	33

TABLE 2 Continued

	86-GL-3	86-GL-6C	86-GL-16A	86-GL-24	86-GL-50	86-GL-62	86-GL-76	86-GL-84
SiO_2	76.00	75.60	71.90	73.50	75.70	75.80	76.20	75.40
Al_2O_3	11.10	12.00	13.20	13.60	11.10	11.00	11.10	12.30
Fe_2O_3	.09	.06	.35	.10	.30	.30	.12	.07
MgO	.72	.29	1.10	.43	.07	.09	.34	.27
CaO	3.24	3.62	3.42	2.77	2.89	2.09	3.42	3.49
Na_2O	4.93	4.98	5.28	5.98	5.05	5.72	3.98	5.75
K_2O	.13	.14	.30	.22	.18	.16	.17	.12
TiO_2	.02	.02	.06	.04	.02	.02	.02	.02
P_2O_5	.03	.04	.06	.01	.05	.03	.06	.01
MnO	1.54	.77	2.16	1.54	1.08	1.47	1.39	.77
LOI	-	-	-	-	-	-	-	-
SUM (includes trace elements)	**99.3**	**99.2**	**100.0**	**100.0**	**99.5**	**99.2**	**99.6**	**99.5**

NORMS IN WEIGHT PERCENT

	86-GL-3	86-GL-6C	86-GL-16A	86-GL-24	86-GL-50	86-GL-62	86-GL-76	86-GL-84
Q	38.04	35.51	29.76	34.07	40.04	42.29	41.11	32.97
C	-	.20	-	1.91	.90	1.28	.61	-
OR	29.87	29.86	31.97	35.96	30.49	34.77	24.07	34.49
AB	28.08	31.17	29.62	23.82	24.53	18.17	29.58	29.94
AN	1.2	1.33	5.18	1.90	.22	.32	1.59	.91
DI	.49	-	.01	-	-	-	-	.24
HE	-	-	-	-	-	-	-	-
EN	-	.15	.89	.25	.76	.77	.31	.06
FS	-	-	-	-	.17	-	-	-
FO	-	-	-	-	-	-	-	-
FA	-	-	-	-	-	-	-	-
MT	-	-	.04	-	2.49	1.03	2.07	-
IL	.06	.08	.58	.02	.35	.31	.38	.02
CR	.01	.01	.01	.01	.01	.01	.01	.01
HM	1.38	1.55	1.82	1.75	-	.99	.28	1.20
AP	.05	.05	.14	.09	.05	.05	.05	.05
RU	.10	.10	-	.21	-	-	-	.11
WO	.71	-	-	-	-	-	-	-

TRACE ELEMENTS IN PPM

	86-GL-3	86-GL-6C	86-GL-16A	86-GL-24	86-GL-50	86-GL-62	86-GL-76	86-GL-84
Ba	540	290	660	700	750	1310	460	250
Cr	30	30	30	30	30	30	30	30
Zr	220	230	360	390	1120	840	1090	150
Sr	170	40	70	50	10	10	10	40
Rb	310	310	260	340	440	460	300	430
V	130	120	70	90	190	160	210	110
Nb	60	80	50	40	130	120	140	50
Ni	2	2	5	2	1	1	1	3
Co	1	1	3	1	1	1	1	1
Cu	2	.5	2	.5	2	.5	1.5	15

	86-GL-78	86-GL-80	86-GL-81	86-GL-63	86-GL-64	86-GL-65	86-GL-69	86-GL-2
SiO_2	48.00	48.70	42.80	71.40	70.80	71.00	72.50	74.80
Al_2O_3	15.30	16.70	15.90	13.00	12.90	12.90	13.20	12.50
Fe_2O_3	10.10	9.08	9.89	3.06	2.93	2.88	3.04	2.13
MgO	4.95	6.32	5.90	.08	.09	.07	.12	.15
CaO	8.18	9.49	9.41	.67	.86	1.05	.30	.40
Na_2O	3.09	3.10	2.65	3.54	2.51	2.59	1.90	3.88
K_2O	1.34	.73	.24	5.84	6.12	6.02	6.14	4.87
TiO_2	1.83	1.57	1.44	.32	.31	.30	.31	.22
P_2O_5	.58	.44	.43	.05	.05	.01	.05	.04
MnO	.15	.11	.16	.08	.07	.07	.08	.06
LOI	5.77	5.20	10.5	1.7	2.16	2.47	2.00	.93
SUM (includes trace elements)	**99.5**	**99.5**	**99.5**	**100.0**	**99.0**	**98.8**	**99.9**	**100.0**

NORMS IN WEIGHT PERCENT

	86-GL-78	86-GL-80	86-GL-81	86-GL-63	86-GL-64	86-GL-65	86-GL-69	86-GL-2
Q	2.02	.33	-	27.68	32.03	31.26	38.13	32.80
C	-	-	-	-	.72	.32	3.07	.21
OR	8.54	4.52	1.61	35.28	37.50	36.90	37.25	29.15
AB	28.17	27.43	25.45	30.59	22.00	22.71	16.49	33.22
AN	25.78	30.85	34.94	2.37	4.08	5.13	1.91	1.74
DI	8.09	9.68	8.54	.35	-	-	-	-
HE	3.16	2.62	3.46	.22	-	-	-	-
EN	9.56	11.97	8.34	.04	.23	.18	.31	.38
FS	4.31	3.71	3.88	.03	-	1.06	.15	-
FO	-	-	3.07	-	-	-	-	-
FA	-	-	1.57	-	-	-	-	-
MT	5.20	4.66	4.84	2.70	2.83	2.30	2.69	.74
IL	3.75	3.12	3.10	.62	.81	.06	.60	.42
CR	.03	.05	.07	.01	.01	.01	-	.01
HM	-	-	-	-	.08	-	-	1.23
AP	1.45	1.07	1.13	.12	.12	.10	.12	.09
RU	-	-	-	-	-	-	-	-
WO	-	-	-	-	-	-	-	-

TRACE ELEMENTS IN PPM

	86-GL-78	86-GL-80	86-GL-81	86-GL-63	86-GL-64	86-GL-65	86-GL-69	86-GL-2
Ba	670	520	450	690	740	730	750	420
Cr	140	240	270	30	30	30	20	30
Zr	250	150	140	640	650	610	840	450
Sr	610	460	550	30	40	20	20	110
Rb	50	30	10	300	300	290	310	250
V	40	30	20	80	80	100	90	100
Nb	20	30	30	50	70	50	60	60
Ni	38	73	100	3	2	2	2	2
Co	27	27	39	2	2	2	2	2
Cu	17	29	27	3	2	5	3	1

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