



Information Sheet

Geology & Mineralisation

Regional geological & Tectonic Setting.

Fiji presently lies at the midpoint between the opposing Tonga - Kermadec and Vanuatu convergence zones, separated from these actual convergence zones by two extensional back-arc basins: (the North Fiji Basin to the west and the Lau Basin to the east; Figure 1), and a series of transform faults e.g.; the Fiji Fracture Zone, and the Matthew-Hunter Ridge. Most paleotectonic reconstructions of this part of the Pacific agree, however, that Fiji was not so long ago an integral part of the Pacific “rim of fire” the complex plate boundary between the Pacific and the Indo-Australia Plates. This boundary, outlined by a complex array of island arcs, associated oceanic trenches, volcanic belts and transform faults is well recognised as the locus of several major world class porphyry copper-gold and epithermal gold systems.

The early history of this plate boundary system (before Late Miocene, about 10 Ma) shows subduction of Pacific crust from the east with Fiji forming part of an extended Outer Melanesian island arc system, the Vitiaz arc, that incorporated the Solomon Island, New Hebrides, Fiji and the Tonga island arcs. Remnants of this subduction zone are preserved as part of the Vitiaz Trench, whilst Eocene-Miocene cores of the ancient arc system form part of the geological basement in Tonga (Eua), Fiji (Viti Levu) and Vanuatu.

During the Late Miocene, (10-7 Ma) subduction along the Vitiaz arc-trench system was partially blocked through the arrival of a thick sequence of oceanic crust (Ontong Java Plateau) in the Solomons and northern Vanuatu portions of the trench. Subduction was effectively immobilized and later reversed in the areas to the north and west of the Fiji arc. Shortly following this reversal initiation of back arc spreading to the west of Fiji led to the formation of the North Fiji Basin and the effective rotation of the Vanuatu arc to the southwest, away from Fiji.

Further breakup of the arc occurred in more recent times (about 5.5 Ma) with the initiation of intra-arc extension behind the Tonga Trench. This caused the opening of the Lau Basin separating the remnant Lau Ridge from the active Tofua Arc in Tonga.

Much of the younger (Late Miocene to Pliocene) structural features of the Fiji Platform can be related to transformation of the older arc to its present day configuration through creation of the North Fiji and Lau back-arc basins. This period also saw major changes in volcanism throughout the group with initial eruption of voluminous shoshonitic volcanics in northern Viti Levu (5.5 to 3.0 Ma) followed by later alkalic volcanism more akin to oceanic basalts.

In terms of crustal development, the geological evolution of Fiji can be viewed as having had four main stages:

- (a) Early arc stage (35-12 Ma)
- (b) Mature arc stage (12-7 Ma)
- (c) Early arc rifting stage (7 to 3 Ma)
- (d) late arc rifting stage (3Ma to recent)

These stages reflect the growth of Fiji as an island arc, its maturity and final arc breakup with the early periods (up to 7 Ma) dominated by subduction related geology and geochemical signature changing to a later more extensional-related regime with relatively diminished amounts of subduction component.

Geology

Current knowledge indicates that the geological history of Fiji is restricted to the Cainozoic era. The oldest known rocks are pillow lavas, gabbros and platform limestones of Late Eocene age (40-36.5 Ma and Tertiary Stage b) and the youngest are subaerial volcanic ashes erupted on Rotuma and Taveuni in historic times (less than 20 000 years B.P.). A sketch map of the main geological and structural features is given in Figure 2, whilst Tables 1 and 2 provide summarised descriptions of the major formations.

Eocene & Oligocene

In the Fiji archipelago, early Tertiary rocks are found only on Viti Levu and in the Mamanuca and Yasawa islands where there is a succession of volcanic rocks and their sedimentary derivatives with minor intercalations

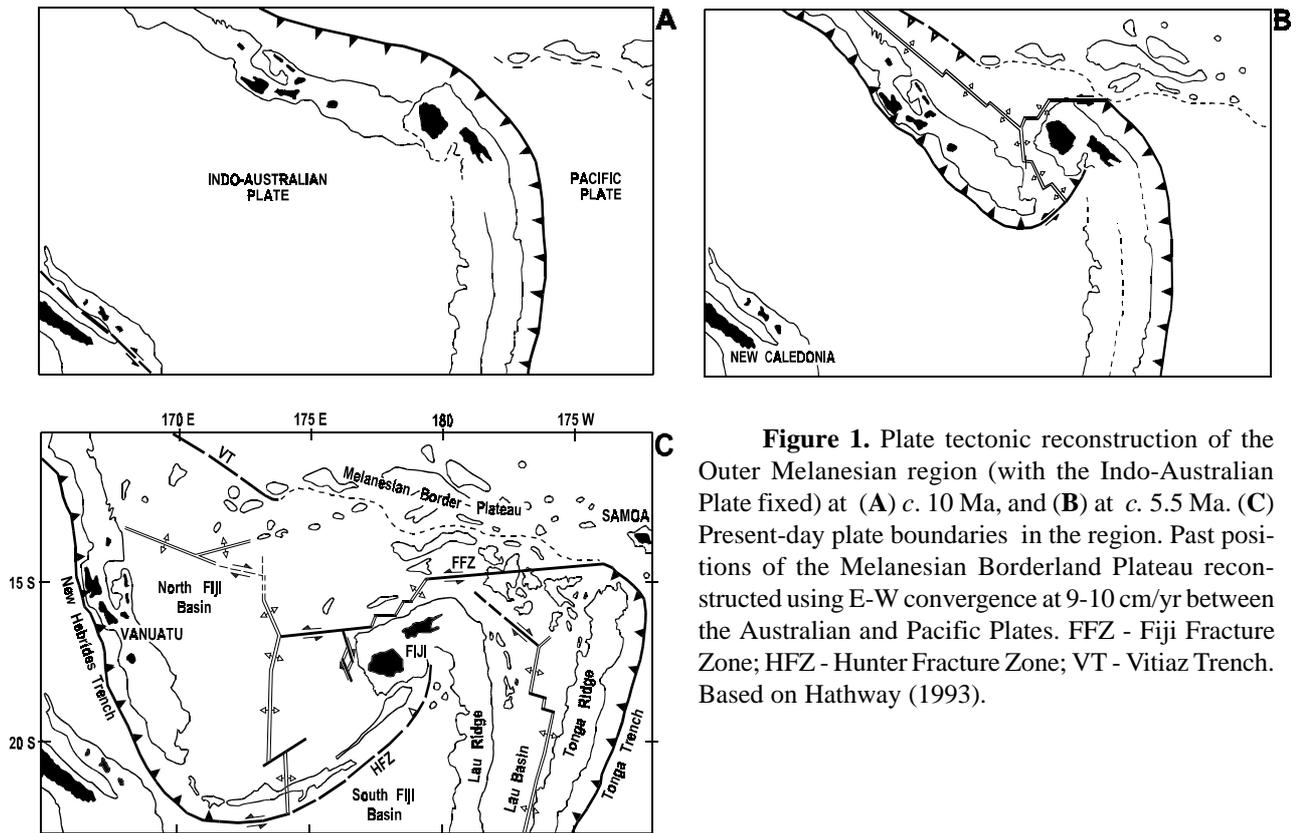


TABLE 2. Description of the major rock groups of Vanua Levu.

GROUP	LOCATION	THICKNESS (metres)	PETROLOGY	REMARKS
Bua Volcanic Group	SW Vanua Levu	900+	Oceanic basalt-trachyte	Subaerial and minor submarine olivine-basalt flows and pyroclastics and their differentiates.
Nararo Volcanic Group	Vanua Levu		Tholeiitic Calc-alkaline	Mainly acid-andesite plugs with associated breccia sheets. Possibly ignimbritic in places.
Natewa and Monkey Face Volcanic Groups	Vanua Levu	1500+	Tholeiitic	Predominantly submarine flows, breccias and volcanoclastic sediments of basic-andesite composition.
Udu Volcanic Group	NE Vanua Levu	approx 300	Tholeiitic	Mainly submarine flows, pyroclastics, and volcanoclastic sediments of andesitic to rhyodacitic composition.

TABLE 1. Description of the major rock groups of Viti Levu.

GROUP	LOCATION	THICKNESS (metres)	PETROLOGY	REMARKS
Ba Volcanic Group	Viti Levu	1500-3000	Alkalic Shoshonitic Tholeiitic	Mainly basic flows, breccias and volcanoclastic sediments of both submarine and subaerial derivation. Intruded by gabbroic, essexitic, and monzonitic sills and plugs.
Koroimavua Volcanic Group	NW Viti Levu	1000+	Shoshonitic	Mainly basic submarine flows, breccias, and volcanoclastic sediments. Intruded by small monzonitic stocks.
Nadi, Navosa, Ra, Cuvu Sedimentary Groups	N and W Viti Levu	500-2000	Tholeiitic Calc-alkaline	Rudaceous and arenaceous epiclastic sediments with rare carbonate and euxinic beds. Subordinate andesitic flows, breccias, and plugs.
Medrausucu Group, Verata Sedimentary Group	SE Viti Levu	900+	Calc-alkaline	Andesitic flows and pyroclastics grading laterally into arenaceous and fine-grained sediments.
Savura Volcanic Group	SE Viti Levu	600+	Tholeiitic	Andesitic to rhyodacitic flows, breccias and volcanoclastic sediments. Minor basalt flows and intrusions.
Colo Plutonic Suite	S and C Viti Levu		Tholeiitic	Gabbroic to tonalitic stocks with a marginal facies of trondhjemite, diorite, and hornblende andesite and microdiorite.
Upper Wainimala Group	SW and NE Viti Levu	6000+	Tholeiitic	Argillites, sandstones, reef limestones, and important basic to andesitic volcanic intercalations. Zeolite facies metamorphism.
Lower Wainimala Group	W and C Viti Levu	7000+	Tholeiitic Spilitic	Pillow lavas, flows, breccias, volcanoclastic sediments, and minor reef limestones. Volcanic breccia - conglomerate is especially abundant. Zeolite to greenschist facies metamorphism.
Yavuna Group	SW Viti Levu	unknown	Tholeiitic Spilitic Boninitic	Pillow lavas, flows, breccias, platform limestones, gabbro, tonalite. Zeolite to greenschist facies metamorphism.

of carbonate rock. The succession ranges in age from Late Eocene to Oligocene and a recent revision of the stratigraphy assigns the rocks to the Yavuna Group and the Wainimala Group.

The Yavuna Group is exposed in SW Viti Levu and consists of a sequence of basaltic pillow lavas interlayered with coarse volcanoclastic units, minor dacitic tuffs and breccias, and platform limestones of Late Eocene to Early Oligocene age. Geochemically the Yavuna Group is markedly similar to material of Late Eocene age exposed on Eua in Tonga. A large tonalite body, the Yavuna Stock, small gabbroic pods and dolerite dykes intrude the sequence. To the south of the Yavuna Group in SW Viti Levu there is another sequence of basaltic pillow lavas associated with thinly bedded hemipelagic sediments and intercalated acidic tuffs which are assigned to the Wainimala Group. These have a latest Oligocene age and can be correlated with a sequence of pillow lavas, volcanoclastic sediments and limestones of similar age in the Mamanuca islands and on Waya in the southern Yasawa islands.

Early and Middle Miocene

Rocks of Early and Middle Miocene age are found within the Wainimala Group of central, southwest and northeast Viti Levu. The succession consists principally of shallow submarine coarse breccia and lapillistone with rare tuffs. The composition ranges from basaltic to dacitic, and although volcanic centres are very difficult to recognise, a high proportion of flows is taken to indicate proximity to a centre. Primary volcanic rocks of dacitic to basaltic composition also occur in the Savura Volcanic Group of SE Viti Levu and although undated these are thought to be of Early to Middle Miocene age. Undoubted Early to Middle Miocene rocks occur in the Yasawa and Mamanuca islands. These are similar to Wainimala Group rocks and lithological types include pillow lavas and breccias, dacite flows and limestones. It has long been suggested that the older rocks of the Yasawa-Mamanuca chain are the equivalent of the Wainimala Group. These older rocks in Viti Levu and the Yasawa-Mamanuca chain exhibit zeolite to greenschist facies metamorphism.

The oldest known rocks exposed in the Lau islands are assigned to the Lau Volcanic Group and the Futuna Limestone with the latter dated palaeontologically at roughly 12 Ma. The oldest K/Ar date is 14.55 ± 0.29 Ma for a pyroxene andesite flow.

Miocene - Colo Orogeny

The latest Middle Miocene and much of the Late Miocene was a period of intense orogenic activity during which folding and faulting of the Wainimala Group occurred. In southern and central Viti Levu, Eocene to Middle Miocene strata occur in a curved belt (Fig. 2) which swings from ENE to WNW and within which the strata are deformed into longitudinal folds more or less parallel

to the curvature of the belt. The cores of some folds contain elongate plutonic bodies assigned to the Colo Plutonic Suite. The main rock-types are tonalite and gabbro, and there is a marginal facies dominated by trondhjemite, diorite and hornblende andesite-microdiorite. True granites are very rare and there is little evidence for acidic volcanism associated with the intrusions. The abundance of coarse-grained plutonic rocks in more-deeply eroded portions of Viti Levu suggests that plutonic rocks may form the 'basement' to Viti Levu. Aeromagnetic data lend support to the concept of a major plutonic belt flooring much of southern and central Viti Levu.

The oldest accurate date for a Colo plutonic body is 12.46 ± 0.51 Ma for the Wainivalau Stock in central Viti Levu. The age of the youngest stock is uncertain because of doubts on the reliability of the K-Ar dating, however, the Korolevu Stock in southern Viti Levu is probably no older than 7 Ma.

Following the Colo orogeny the first substantial landmass was established in the Fiji area. Rapid uplift, probably associated with isostatic doming of the plutonic mass, led to intensive erosion and rapid unroofing of the plutons. Conglomerate horizons full of plutonic clasts flank some of the plutons and these have a fauna indicating an age of 6.5 - 7.0 Ma.

Late Miocene to Recent

The period following the close of the Colo orogeny (between 6.5 and 2.5 Ma) was one of widespread and voluminous volcanism in Fiji.

On Viti Levu, Late Miocene volcanic activity was initiated in the southeast with the eruption of the calc-alkaline volcanic rocks of the Medrausucu Group. Primary andesitic rocks are prominent in the Namosi district where there appears to have been a large caldera. Moving away from this district, particularly eastwards, there are distinct facies changes into derived volcanoclastic and epiclastic sediments assigned to the Medrausucu Group. Similar calc-alkaline activity, but on a smaller scale, was also taking place at this time in western Viti Levu. This volcanic activity was accompanied by widespread sedimentation with sediments being derived from the erosion of the older Wainimala-Colo "basement" as well as the contemporaneous volcanic centres. Much of the sediment was deposited in small, pull-apart basins related to a regime of strike-slip tectonic activity in Fiji in the Late Miocene. These sediments and the contemporaneous volcanic rocks are assigned to the Nadi, Tuva, Navosa, Cuvu and Ra Sedimentary Groups. All of these Groups unconformably overlie the Wainimala-Colo rocks and in many places their basal units contain Wainimala and Colo boulders and cobbles.

By the Early Pliocene the focus of volcanic activity had shifted to northern Viti Levu with the eruption of predominantly shoshonitic and high-K calc-alkaline rocks

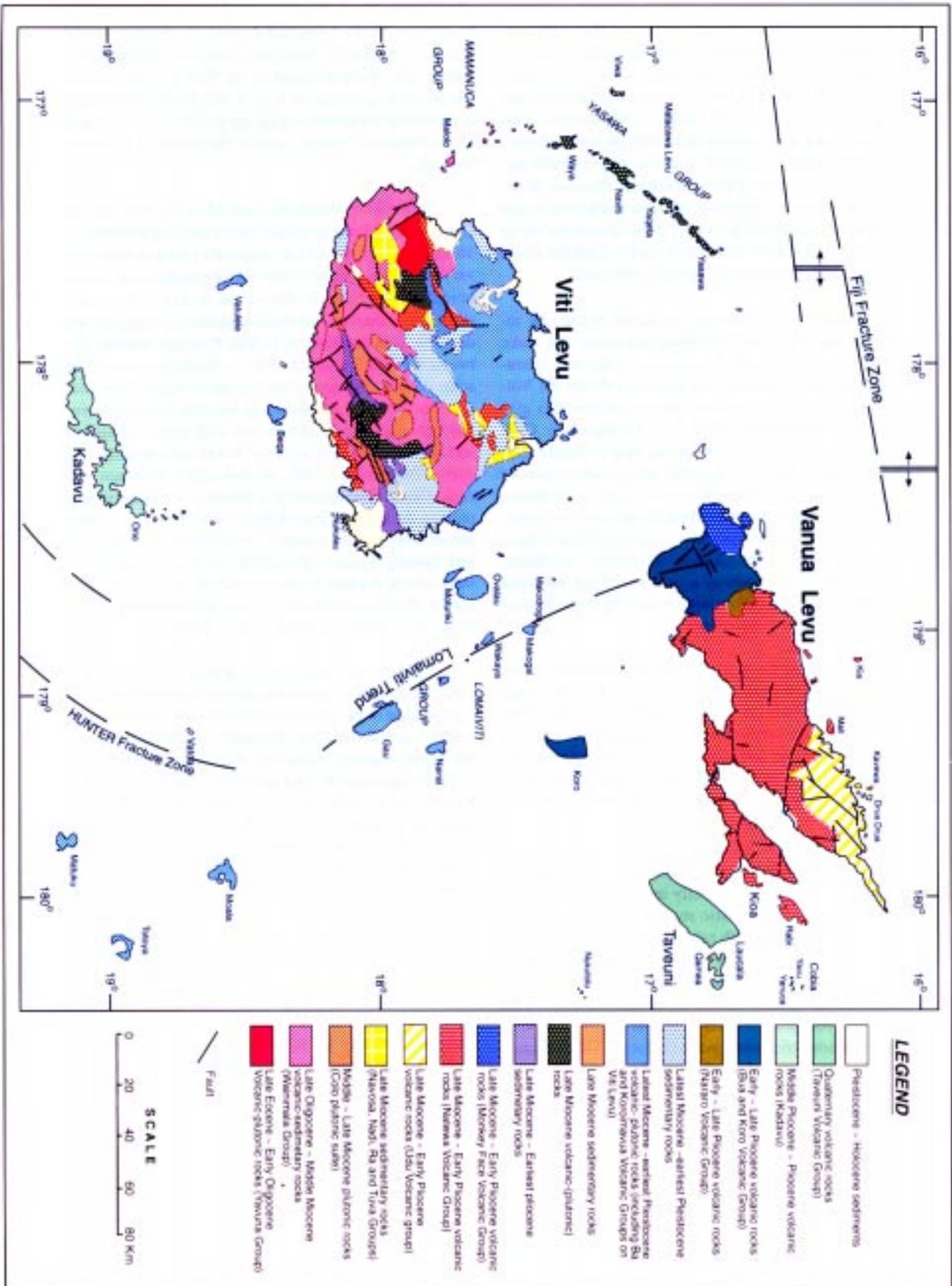


Figure 2. Sketch Geological Map of the Fiji Island Group

from a number of important volcanic centres (e.g. Tavua, Rakiraki, Vuda). The volcanic rocks and their sedimentary derivatives are assigned to the Koroimavua and Ba Volcanic Groups. Flows, breccias and volcanoclastic sediments of both submarine and subaerial depositional environments are generally alkalic or shoshonitic composition in the west, but become more tholeiitic or calc-alkaline in character towards the east. Considerable uplift of Viti Levu took place in the Early Pliocene, probably as a result of continuing isostatic readjustment and transpressional tectonic activity. Pillow lavas in the Tavua Volcano now occur at 880 m above sea-level and the whole volcano has been tilted 10 degrees to the north.

Extension of Ba-type volcanism to the east resulted in the single and composite volcanoes that make up the Lomaiviti islands. Lithological types and chemical compositions indicate correlation with the Ba Volcanic Group, and radiometric dating confirms this giving ages predominantly in the 5.0 - 3.5 Ma range. On a number of volcanic centres on the larger islands (e.g. Ovalau, Gau) caldera development has revealed a number of subvolcanic monzonitic intrusions similar to alkalic minor intrusions found in the Ba-Koroimavua succession. The variety of rock types in Lomaiviti includes basic rocks of tholeiitic, calc-alkaline, shoshonitic and alkalic composition. The sequences consist mainly of subaerial volcanic rocks with pillow lavas occurring at the base of the succession on some islands.

On Vanua Levu, volcanism was initiated in the Late Miocene with the eruption of the Udu Volcanic Group, in NE Vanua Levu and the Natewa Volcanic Group in central Vanua Levu. The Udu succession is made of flows, breccias and tuffs, commonly of a pumiceous nature in the upper part of the sequence and generally of submarine origin. The rocks are of tholeiitic composition ranging from andesite to rhyolite.

The Natewa succession forms a "basement" to most of the island and is chiefly made up of submarine volcanic and volcanoclastic rocks of tholeiitic basic-andesite composition with rare dacite and rhyolite units. Epiclastic sedimentation is restricted, occurring in small intervolcanic basins (e.g. Dreketi Basin). Radiometric and faunal dating is patchy but the Group appears to cover an age range from about 7.5 Ma to around 3.5 Ma. The very limited radiometric dating available for the Udu Volcanic Group gives an age of around 7.0 Ma. In central Vanua Levu the Natewa succession is cut by small plugs of acid andesite of the Nararo Volcanic Group. Stratigraphic relationships suggest an Early to Middle Pliocene age. The bulk of the Udu-Natewa succession is of submarine derivation. There appears to have been rapid island-wide uplift after the cessation of the main phase of volcanism, probably in the Middle Pliocene, because pillow lavas and marine volcanoclastic sediments of Early Pliocene age are now found at elevations of over 900 metres.

After the main phase of emergence, eruption of alkali olivine basalt of ocean-island composition occurred in western Vanua Levu and formed the Seatura shield volcano. The basalts, which are mainly of subaerial derivation, have been assigned to the Bua Volcanic Group and have an age range of 3.3-2.9 Ma. Rocks of a similar composition but younger in age are found in eastern Vanua Levu (Suvasuva Volcano) and on the islands of Koro and Taveuni.

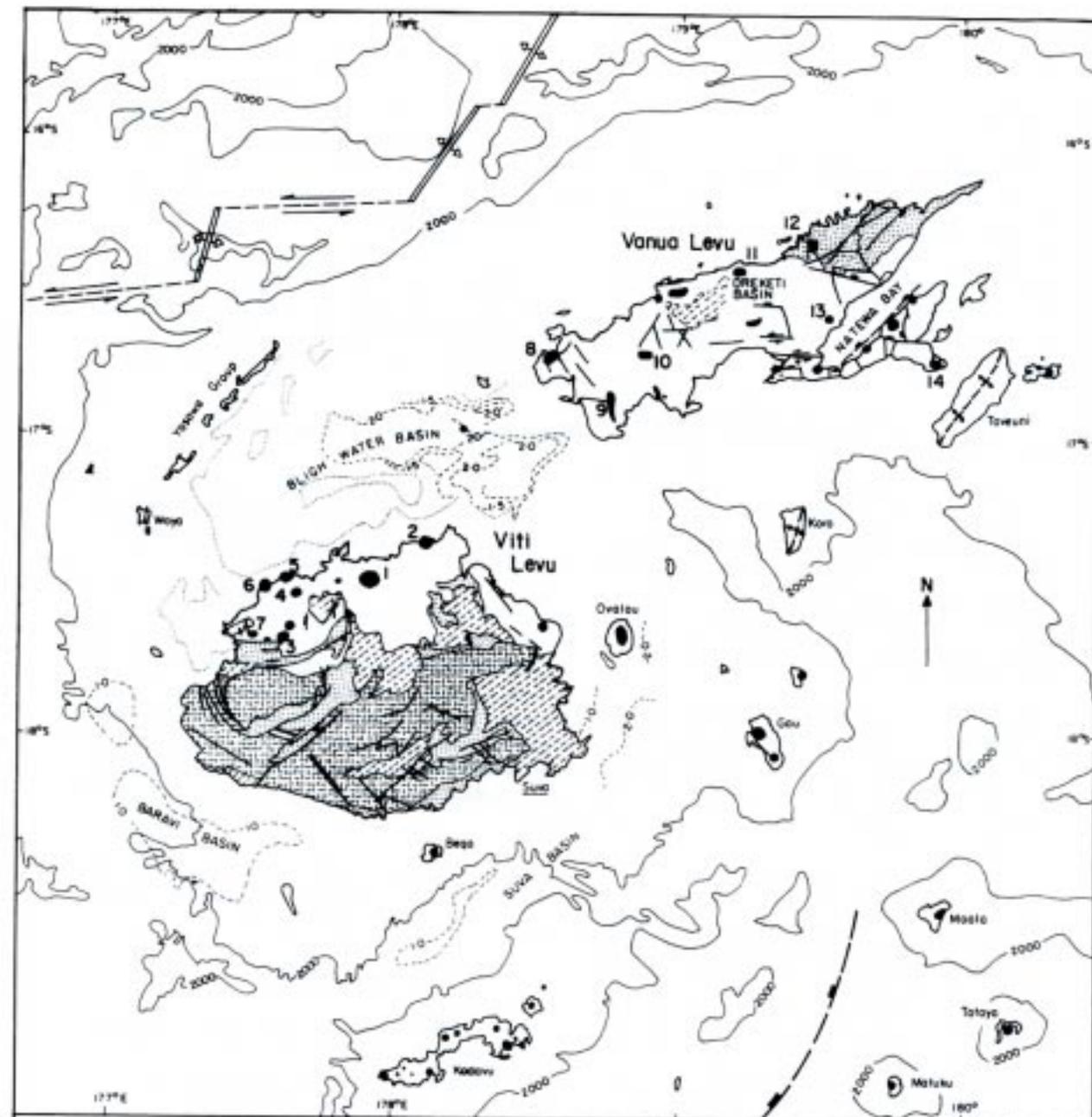
In the Lau islands the Late Miocene rocks of the Lau Volcanic Group (younger part) were erupted between 10 and 5.4 Ma. The rocks are generally varieties of breccia varying in composition from basalt through pyroxene and hornblende andesite to dacite and rhyolite. Sequences show both subaerial and shallow submarine eruption and deposition. In the Early to Middle Pliocene, roughly between 4.5 and 2.5 Ma, basaltic volcanism occurred in some northern islands of the Lau archipelago. These basaltic rocks form the Korobasaga Volcanic Group and usually occur as flows and breccias with minor extrusions and intrusions of basic andesite, hornblende andesite and dacite. From about 2.2 Ma, alkali basalt of the Mago Volcanic Group was erupted in a number of islands principally in the northern part of the group. These rocks show close compositional similarity to the basalts of Bua, Koro and Taveuni. Finally, throughout the Lau islands, limestone of the Tokalau Limestone Group, of various ages, can be observed overlying volcanic rocks ranging in age from latest Middle Miocene to Late Pliocene.

During the waning stages of the Colo orogeny, basaltic volcanism of predominantly submarine derivation formed most of the Yasawa islands. Basaltic pillow lavas, breccias and derived volcanoclastic sediments dominate the island sequences, however, there are important units of dacite and andesite, and limestone. Gabbroic sills and basaltic dyke swarms occur on some islands. The rocks range in age from 8.3 to 5.6 Ma. In the Yasawa islands considerable crustal shortening occurred sometime after 7 Ma. The Late Miocene sequence on Waya has been folded into an asymmetric syncline with an eastern limb that is vertical to partly overturned and possibly thrust over the latest Oligocene strata that form the eastern half of the island. Folding and thrusting is also seen in a number of other islands in the Yasawa chain.

The island of Kadavu is wholly volcanic and is composed mainly of subaerial, coarsely porphyritic andesites containing hornblende and biotite. Basaltic agglomerates of oceanic-island basalt affinity occur at the eastern end of the island chain and basaltic dykes cut the andesitic rocks. Radiometric dating gives an age range of 3.4 - 0.36 Ma with the younger ages coming from basaltic rocks at the western end of the island chain.

Structure

Figure 3 shows the major structural features of the Fiji platform, including the location of some of the better



- / Volcanic centres and fissure zones.
- Volcanic rocks
- ▨ Sedimentary rocks
- Upper Miocene
- ▨ Upper Eocene to Middle Miocene
- Normal fault and High angle reverse fault
- Transcurrent fault

Pliocene and younger

- 20--- Sediment isopachs or structure contours in seconds two-way travel time
- Approximate limit of Pliocene sedimentary basins in Blich Water (from Johnson 1991)
- ~2000~ 2000 metres submarine contour

50 km

1. Tavua
2. Rakiroki
3. Navilawa
4. Namasau
5. Karavi
6. Nacilau
7. Vuda
8. Karainasolo
9. Seaturo
10. Nabuna
11. Naduri
12. Buccaisau
13. Uluiqala
14. Dakuniba

known eruptive centres. Rocks of the Yavuna Group (Late Eocene to Early Oligocene) are considered to be the remnants of a Melanesian arc formed after convergence began between the Indo-Australian and Pacific plates (the Vitiaz Arc). To the south of the Yavuna block the Wainimala Group rocks form a younger, Wainimala arc (latest Oligocene to Middle Miocene) which has an axis running through south-central Viti Levu and into the Mamanuca-Yasawa chain. A small half-graben, the Sigatoka Basin, separates the Yavuna and Wainimala arc blocks in SW Viti Levu.

The intrusion of the gabbros and tonalites of the Middle to Late Miocene Colo Plutonic Suite, principally into rocks of the Wainimala arc, has been attributed to a phase of deformation, the Colo Orogeny. Although many of the older 1:50 000 maps show synorogenic intrusions in the cores of anticlines, more recent work has cast some doubt on the extent of compressive tectonic activity in the Middle to Late Miocene. Mapping suggests that many of the folds in SW Viti Levu post-date intrusion of the Colo stocks and that the folds may in fact be drapes over plutonic domes.

Recent work has established a phase of compression-transpression in the Late Miocene (post 7 Ma). Folding, overturning and probable thrusting in Late Miocene rocks of the Yasawa chain has been provisionally related to opening of the North Fiji Basin and rotation of the Yasawa chain towards Viti Levu. Recent palaeomagnetic work in the Yasawas has shown a maximum of 120° rotation in the chain. In SW Viti Levu, deformation in Late Miocene sedimentary sequences (e.g. Tuva Group, Nadi Sedimentary Group) is now related to transpression caused by strike-slip tectonism, again probably related to the opening of the North Fiji Basin. The transpression appears to have formed small pull-apart basins and “flower” structures. Thus it would seem appropriate to regard the Colo Orogen as the result of diapiric-isostatic adjustments and tectonism during the Late Miocene.

Faulting and fracturing of rocks is widespread and locally intense. Recent analysis of SLAR imagery for Viti Levu record two major directions, ENE to NNE (Taveuni trend) and NNW to NW (Lomaiviti trend) and a minor E-W trend. There is also a higher density of lineaments in the Wainimala-Colo arc, suggesting that much of the fracturing was pre-Pliocene. Although faults are not easily observed on the ground, there are a number of features in Fiji that reflect the major structural directions.

The NE direction is demonstrated by the alignment of the fissure zone on Taveuni and its extension north into the Ringgold Isles, by the strike of Udu Peninsula, by the strike of Sovi-Yalavou and Wainikoroiluva fracture systems on Viti Levu and by the alignment of volcanic centres in northern Viti Levu (Fig. 3). The Lomaiviti trend is demonstrated by the strike of the Lomaiviti islands, by the elongate nature of the Seatura Caldera (Bua Volcanic Group) in western Vanua Levu, and again by the alignment of volcanic centres in NE Viti Levu.

The E-W fracture system is best seen in Vanua Levu where the Nayarabale and Mariko fault zones cut the island into major blocks. Lateral movement on the latter has led to the pull-apart rhombochasm basins of Savusavu Bay and Natewa Bay.

The Late Miocene to Pliocene structures of Fiji can be related, although with some uncertainty, to the opening of the North Fiji Basin and the Lau Basin and to transform/spreading-centre accommodations on the Fiji Fracture Zone.

Mineralisation and Development Potential

Fiji's location along the Pacific and Indo-Australian Plate boundary is indicative of it having major potential for porphyry copper-gold, and epithermal gold mineralization. Currently this group of new and ancient volcanic arcs hosts major epithermal gold deposits at Lihir (Ladolam Deposit), Gold Ridge (Solomon Islands), Emperor and Mt Kasi (Fiji): several similar epithermal gold deposits are also known from the Coromandel Peninsula, in New Zealand's North Island. Bougainville (North Solomons Arc) and Namosi (Fiji) are two major porphyry copper deposits. The extension of the arc into northern and eastern PNG is also host to several (e.g., Porgera, Ok Tedi, Misima) major epithermal gold and copper-gold porphyry systems.

Mineralisation styles in Fiji are broadly correlateable to the various proposed phases of arc evolution recognized for the island group.

Early arc stage

This stage is characterised by a geochemically primitive low-k tholeiitic series of volcanics trending towards slightly more evolved types including low to medium-k calcalkaline types within Wainimala Group exposed in the Yasawa and Mamanuca islands. Mineralisation is restricted in the most part to the Wainimala Group and comprises:

- (a) important massive sulphide occurrences at Coloi-Suva, Wainileka and Wainivesi districts of southern and south eastern Viti Levu; and,
- (b) manganese mineralisation in SW Viti Levu hosted within volcanics and associated sediments, particularly in the Sigatoka and Nadi Basins.

Mature arc stage

The Mature stage of arc development is dominated by plutonic rocks, the Colo Plutonic suite being comprised primarily of low-K tholeiitic gabbros, tonalites and trondjhemites. Mineralisation within this stage is widespread and comprises:

- (a) numerous vein systems carrying base and precious

- metals occurring in close proximity and probably related to the Colo plutonics, particularly in SW Viti Levu (Momi, Kubuna areas);
- b) disseminated mineralisation within the roof zones of the various Colo plutonics and the various Wainimala host rocks. Pyrite and minor base-metal mineralization is widespread throughout the Wainimala-Colo volcano-plutonic belt; and,
 - c) skarn-type mineralisation associated with the various plutons consisting of volumetrically small but relatively high-grade deposits distributed throughout the plutonic belt.

Early rifting stage

The initial part of this stage is marked by eruption of tholeiitic to calc-alkaline rocks, particularly in SE Viti Levu and the later part of the stage by the extensive development of varied volcanism on Vanua Levu. In northern Viti Levu the later parts of this stage ~ 5.5-3.0 Ma saw extensive eruptions of shoshonitic volcanics (Ba and Koroimavua Volcanic Groups). Mineralisation is similar extensive and varied in nature and intimately related to the various volcano-intrusive centres. They include the following types:

- (a) major porphyry type copper deposits associated with the Namosi Andesite at Namosi, Waivaka, Waisoi and Wainibama together with their associated skarns and peripheral epithermal vein systems;
- (b) massive sulphide mineralisation associated with acid volcanics of the Udu Volcanic Group at Nukudamu, Wainikoro, Mouta, and Coqeloa in SE Vanua Levu;
- (c) epithermal gold deposits within the Ba-Koroimavua volcanic centres of northern Viti Levu at Vatukoula, Vuda, Sabeto Valley, Tuvatu, and Rakiraki; and,
- (d) important epithermal gold mineralisation related to tholeiitic volcanism of the Natewa Group on Vanua Levu, particularly in the Yanawai District (Mt Kasi), and at Koroinasolo, Waimotu, Dakuniba, and Savudrodro.

Late rifting stage

Volcanism of this stage had an oceanic character with eruption of ocean island basalts on Taveuni, SW Vanua Levu (Bua), parts of Lomaiviti and Lau. High-K calc-alkaline andesites were erupted on Kadavu. Mineralisation is minor and represented by:

- (a) epithermal vein-type deposits associated with the High-K andesites on Kadavu;

- (b) surficial, residual bauxite deposits developed on erosion surfaces at Drasa (Lautoka) and Wainunu (Bua); and,
- (c) Placer-type at Waimanu (gold), Sigatoka sand dunes and the Ba delta (magnetite).

Mines and advanced prospects

Vatukoula Goldfield.

The Tavua goldfield is situated in northern Viti Levu within and along the margins of the caldera of the Tavua Volcano. Payable quantities of gold were discovered in Lololevu Creek, at the site of the present mine complex, by W. ("Bill") Borthwick in 1932.

Since mining began in 1933, the goldfield has a total gold production to June 1997 of about 163,177 kg of gold from 18.9 Mt of ore. In June 1997 the *proven and probable ore reserves* of underground ore at the mine were estimated at 4.7 Mt at 7.07 g/t Au (1 066 650 ounces). Total *geological resources* (measured, indicated and inferred) of underground ore were estimated at 11.3 Mt at 9.74 g/t Au (3 532 990 ounces). In addition, tailings dams contain an additional 225 000 ounces of gold with a *proven and probable reserve* classification. Hence the contained gold in known reserves and resources totals well over three million ounces.

The rocks of Tavua Volcano were derived from a potassium-rich magma of the shoshonitic association with an apparently relatively simple evolution from an absarokite (olivine basalt) parent magma to shoshonite, banakite (trachyandesite) and monzonite derivatives.

Most authors agree that the Tavua caldera was formed by collapse along normal faults following non-explosive extrusion of absarokite flank lavas leading to depletion of the underlying magma chamber. Caldera infill rocks cover an area of 5 km x 6.5 km. There is, however, no longer a topographic expression along the caldera contact zone as erosion has caused recession, and the infill sequence now lies within a basin of about 78 km².

Mineralisation at Vatukoula is located within a large fractured block created where prominent northwest-striking shears intersect the north-striking caldera fault zone.

The major lodes cover an area of 2 km², and are mostly within 600 m of the surface. Lodes occur in three main structural settings:

- i) steeply dipping northwest-striking shears;
- ii) flat-dipping (10 - 40°) fractures (flatmakes); and
- iii) shatter blocks between shears.

Alteration associated with the lodes consists of quartz ± sericite ± adularia ± roscoelite extending out for a metre or so from the ore-bearing veins and passing into

an assemblage of ankerite \pm dolomite \pm quartz \pm chlorite \pm K-feldspar. Beyond this, for distances up to 9 m in major lodes, a propylitic alteration halo is developed consisting of chlorite \pm tremolite \pm magnetite \pm carbonate. Most of the gold and silver at Vatukoula occurs in tellurides and there are also significant quantities of gold in pyrite.

The mineralisation at Vatukoula has generally been described as epithermal, however, the presence of shoshonitic and monzonitic intrusive rocks as dykes and stocks indicates a relatively deep level in an epithermal system. This has been further emphasised by more-recent work, describing porphyry-style mineralisation in the caldera with high-level epithermal hot-spring activity probably overprinting the porphyry-style mineralisation. An apparent increase of copper mineralisation at depth is noted and the probability exists of a link between porphyry- and epithermal-style mineralisation.

Yanawai District - Mt. Kasi

The first major gold discovery in Fiji was made in the Yanawai district in the vicinity of Mt Kasi. Mining at Mt Kasi from 1932 to 1946 extracted ore principally from a large open-cut with associated adits. Estimates of ore produced during the mining period vary slightly and an acceptable estimate would be 265 000 t of ore grading 7 g/t Au.

Major mineralisation occurs within the Kasi Corridor which extends northwesterly from the mine area for about 2 km and appears structurally related to faulting. Within the zone there are strongly altered, usually silicified rocks, and in addition to the mine area, several other major prospects have been located. Assuming dimensions for the corridor of 2000 x 200 x 20 metres, then 20 Mt of altered rock possibly exists along the corridor and could be host to a near-surface gold resource.

The Mt Kasi Mine area includes a number of old workings in addition to the open-cut. About 64 000 oz of gold was won from these workings. At the mine, basaltic andesite flows, breccias and tuffs are cut by an altered feldspar porphyry of dacitic composition. Brecciation is common and a variety of breccia types have been recognised (e.g. rock flour, jigsaw, sheeted).

Alteration in the mine area is widespread and intense, and includes silicification and argillic-advanced argillic alteration. Regional low-grade propylitic alteration probably related to burial metamorphism, is in the vicinity of major fracture zones overprinted by an argillic assemblage of kaolinite-quartz-illite-illite/smectite-pyrite, with a central core of advanced argillic alteration consisting of quartz-kaolinite-pyrite-barite-anatase.

The primary ore-bearing minerals identified include native gold, pyrite, enargite (luzonite), tennantite, goldfieldite, chalcopyrite, tellurides and cassiterite. Sec-

ondary minerals include covellite, chalcocite and neodigenite. At the mine, the gold-bearing rocks occur within the "Kasi structure", a silicified fault zone 5-25 m wide which strikes northwesterly. Ore minerals occur in veins of quartz-barite with crustification and banding, quartz-stringer networks being common. All the recent writers on Mt Kasi have considered it to be epithermal, and owing to the abundance of sulphide minerals (up to 20% in silicified rock) it has been classed as being a high-sulphidation (enargite-gold) type.

Following the diamond drilling in 1992, the latest revised *hard-rock resource* estimate is 1 240 000 t at 3.0 g/t Au, using a cut-off grade of 1 g/t Au. The *measured, indicated and inferred eluvial resources* total 838 000 t at 1.9 g/t Au, using a cut-off grade of 0.5 g/t Au. The best grades are at shallow level. Weathering has produced a significant eluvial gold resource comprising an undifferentiated combination of slumped ore, colluvium and weathered bedrock *in situ*.

Mine commissioning commenced in early April of 1996 initially to mine and treat the eluvial resources followed by open cut mining of the hard rock resource. The mine closed in mid-1998 largely as a result of declining gold prices. Total production for the period of operation was 54,336 oz of gold and 3,937 oz of silver from 789,817 tonnes of ore mined.

Namosi District - Porphyry Copper

The mineralised area of the Namosi district lies about 30 km NW of Suva and centred upon the upper reaches of the Waidina River and tributaries, particularly within the Waisoi and Waivaka drainages. Mineralisation in the area has been known since the early 1930's but a detailed search for porphyry copper deposits only commenced in 1968. This exploration continued into the 1970's and early 1980's. Over 50 000 m of drilling was completed over this period and feasibility studies indicated a combined estimate of 590 Mt of ore at 0.47% copper at the two main prospects at Waisoi. The project was unfortunately declared uneconomic. Placer Pacific Ltd undertook re-investigation of the prospects in 1991. It was however, unable to secure a joint-venture partner to move the project to a feasibility stage, and in August of 1997 transferred rights over the tenements to Royal Oak Mines Inc, a North American based based gold producer. Royal Oak's tenements were cancelled in at the end of 1999.

The major porphyry copper prospects are located at Waisoi, Waivaka, Wainabama, and Wainiwi and a number of polymetallic vein and skarn systems are also developed peripheral to the main prospects.

In the Namosi area, the Wainimala Group consisting of weakly-metamorphosed amygdaloidal basalt, porphyritic andesite and minor tuffaceous sanstones is

intruded by Colo-type tonalite stocks, and is unconformably overlain by the Namosi Andesite. The sequence is cut by later intrusions which include quartz-porphyry, diorite, quartz-diorite porphyry, hornblende porphyry and andesite dykes. The main areas of mineralisation, at Waisoi, are associated with quartz-poor porphyry, occurring either within it or along brecciated contact zones.

Much of the project area is still at a preliminary stage of exploration and further geological investigation is needed. The Waisoi mineralisation has been extensively explored, however, and is considered mammoth by world standards, although of low grade. The geological resource in the Waisoi East and Waisoi West deposits is 950 million tonnes at 0.43% Cu, 0.14 g/t Au, with a cut-off grade of 0.3% copper equivalent.

Sabeto Valley - Tuvatu

Several gold prospects (Vuda, Sabeto, Nawainiu Creek, Kingston and Tuvatau) are known in the Sabeto area to the west of Nadi, all associated with monzonitic and shoshonitic intrusives of the Koroimavua Volcanic Group. Whilst the Kingston and Vuda prospects have had exploration dating back to the early 1900's, the most recent and most advanced of the prospects is that of Tuvatu discovered by Geopacific in 1987.

The deposits occur as a series of steeply dipping veins as well as a number of flatmikes, hosted within monzonite and micromonzonite of the Navilawa Stock. Geopacific concentrated in evaluating the shallow, open-cut potential of the deposit and had in 1993 outlined an oxide gold resource (proven) of 11 250 t at 9.9 g/t with indicated and inferred resources of 25 600 t at 8.2 g/t.

Emperor acquired an option on the prospect in 1995 converting this to full ownership in June of 1997. Extensive exploration has been completed since and a feasibility study is presently underway. This work has involved geological mapping, structural studies, region geophysics and extensive drilling, both diamond and RC together with the commencement in 1997 of an adit to follow the continuity of ore veins underground and bulk sample ore material.

Current resource estimates stand at 982,000 t at 7.8g/t in vein type mineralisation associated with monzonitic intrusives.

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