British Columbia Geological Survey
Geological Fieldwork 1989

EVIDENCE FOR A CRYPTIC INTRUSION BENEATH THE ERICKSON-TAURUS GOLD-QUARTZ VEIN SYSTEM, NEAR CASSIAR, B.C.*
(104P/4, 5)

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KEYWORDS: Economic geology, Erickson-Taurus, gold-quartz veins, alteration assemblages, metamorphic facies, Sylvester allochthon, fluid inclusions.

INTRODUCTION

The Erickson and Taurus mines are located near Cassiar (Figure 1-23-1) on the Stewart-Cassiar Highway 120 kilometres south of the Alaska Highway junction. At the time of writing, these mines are closed pending evaluation of potential new reserves. Ore production at Erickson and Taurus has come from gold-quartz veins that are part of the larger Erickson-Taurus system (Nelson *et al.*, 1989). This system has been previously well described by Diakow and Panteleyev, 1981; Panteleyev and Diakow, 1982; Sketchley, 1986; Sketchley *et al.*, 1986, Dussell, 1986 and Boronowski, 1988. Veins occur in basalts of Division II of the Sylvester allochthon and along the base of the Triassic Table Mountain sediments which overlie them (Nelson *et al.*, 1989; Harms *et al.*, 1989). Productive veins are limited to a few hundred metres below the base of the Triassic sediments. The Erickson-Taurus system consists of a set of east-northeast-trending vein zones, in which individual steeply dipping veins strike 045° to 070°; and of flat veins such as the Vollaug vein at the base of the Table Mountain sediments (Panteleyev and Diakow, 1982). The vein system is slightly elongated in a northerly direction (Figure 1-23-1).

THE PROBLEM

The Erickson-Taurus veins show typical mesothermal characteristics. They are white bull quartz with orange-weathering carbonate alteration envelopes in basalt; some, notably the Vollaug vein, are finely ribboned with carbon. Sketchley (1986) studied alteration patterns at Erickson and identified alteration assemblages in basalts including ankerite, siderite, kaolinite, dolomite, pyrite, carbon, titanium oxide, arsenopyrite and sericite. Higher gold grades are associated with slivers of serpentinite along the base of the Table Mountain sediments. Most of these serpentinites are altered to talc-ankerite schists and quartz-ankerite-mariposite listwanites. Ore mineralogy in the veins includes free gold, pyrite, tetrahedrite, chalcopyrite, arsenopyrite, and sphalerite. Gold/silver ratios average slightly greater that 1. Fluid inclusions in the bull quartz are H_2O-CO_2-NaCl solutions, generally three phase at room temperature; total homogenization temperatures cluster in the range 250 to 300°C (Nelson and Bradford, unpublished data).

In terms of these characteristics, the Erickson-Taurus veins strongly resemble classic mesothermal deposits such as the California Mother Lode (Bohlke and Kistler, 1986; Weir and Kerrick, 1987), Bralorne (Leitch and Godwin, 1988), the Juneau belt veins (Goldfarb *et al.*, 1988), and Archean volcanic-hosted deposits such as the Sigma (Sibson *et al.*, 1988) and Giant Yellowknife mines (Allison and Kerrich, 1980). Their structural setting is a point of very significant

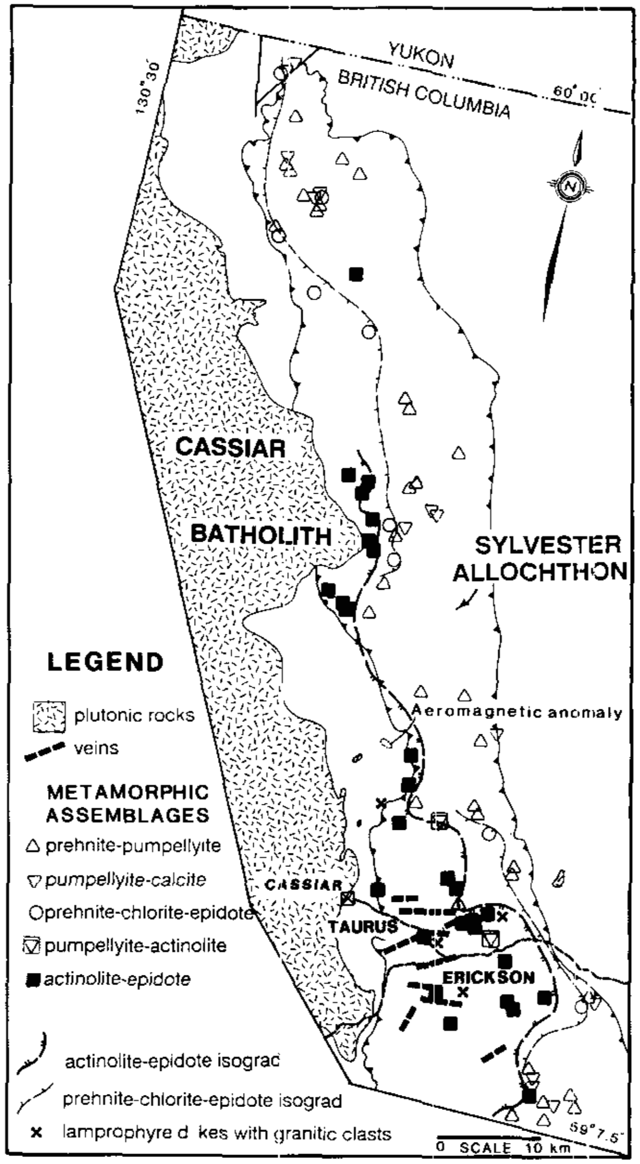

Figure 1-23-1. Regional map of the Erickson-Taurus system and its surroundings : veins, metamorphic assemblages, isograds, and granite-bearing lamprophyre dikes.

* This project is a contribution to the Canada/British Columbia Mineral Development Agreement.

difference, however. Most mesothermal deposits are formed in or adjacent to steeply dipping major faults or even crustal-scale sutures such as the Melones fault zone in California, the Cadwallader fault zone at Bralorne, the Coast Range megalineament near Juneau, the Porcupine-Destor and Kirkland Lake–Cadillac breaks in the Superior Province, and the Con and Campbell shears near Yellowknife. Deposit models call on deep fluid circulation along these faults (Sibson *et al.*, 1988, McHaig, 1988). By contrast, major structures within and bounding the Sylvester allochthon are flat; the allochthon is a thin klippe perched on miogeoclinal strata. The east-northeast trending structures that host the Erickson veins are minor faults and fractures with minimal offsets. Neither they nor the thrust faults provide conduits for deep, large-scale fluid circulation. The suggestion of Nesbitt *et al.* (1985), that the veins "formed from deep circulation of meteoric water in major fault zones", is rendered unlikely by the lack of any major steeply dipping fault zones in the area.

Abbott (1984) has suggested that the dominantly north-northeasterly to northeasterly fractures that host epithermal silver-lead veins in the Cassiar Mountains are extensional features related to dextral motion on northwest-trending major faults. The orientation and distribution of the Erickson-Taurus structures have resisted such regional kinematic interpretation. Although the veins formed at about 130 Ma (Sketchley *et al.*, 1986) when the regional strain pattern was probably dextral-transcurrent on major faults such as the Tintina, Kechika and Cassiar faults (Gabrielse, 1985), they are oriented at high angles to the main faults and occur in the compressive rather than extensional regime of the strain ellipsoid. They are not en echelon in plan view but form a box-shaped array (Figure 1-23-1). They may be en echelon in cross-section and could have formed in response to near-horizontal motion on the fault at the base of the Table Mountain sediments (R. Britton, personal communication, 1988). Top-to-the-south movement on this fault during mineralization is shown by extensional duplex structures and slickensides within the Vollaug vein.

Thus important questions remain unresolved concerning the structural regime that gave rise to the Erickson-Taurus vein structures and the nature and driving mechanism of the fluid system that introduced the ore.

NEW EVIDENCE

A study of metamorphic assemblages in mafic rocks of the Sylvester allochthon was conducted as part of regional mapping of the Midway-Cassiar area. Based on this work, three syn to postemplacement metamorphic facies have been identified within the allochthon: prehnite-pumpellyite, transitional prehnite-chlorite-epidote and actinolite-epidote. The interpretation of assemblages and the identification of isograds is based on the experimental and theoretical work of Liou *et al.* (1985) and Cho and Liou (1987) (Figure 1-23-2). Figure 1-23-1 shows the regional distribution of the three facies. In general, the actinolite-epidote facies is restricted to a narrow band along the margin of the Cassiar batholith. It is assumed to have developed through contact metamorphic upgrading of regional prehnite-pumpellyite assemblages. North of Cassiar the actinolite-epidote facies widens somewhat around small intrusive bodies east of the Cassiar batholith – the Lamb Mountain and Contact stocks. Another buried intrusion may be indicated in this area by a negative magnetic anomaly centred 2 kilometres northeast of the Lamb Mountain stock; by abundant contact-metamorphic andalusite up to 3 kilometres from the margin of the Cassiar batholith; and by granitic clasts in a nearby lamprophyre dike (Figure 1-23-1).

East of Cassiar the actinolite-epidote isograd swings abruptly east to enclose the entire Erickson-Taurus system. The thermal peak in this area is postkinematic, as shown in thin sections by actinolite sprays growing across small shear zones and zones of chlorite fabric. Although of apparent contact metamorphic origin, this anomalously wide zone of relatively high-grade metamorphic assemblages is unlikely to be related to the Cassiar batholith. A study of the assemblages bordering Erickson veins shows a strong retrograde overprint, with actinolite replaced by pumpellyite. The Erickson veins were emplaced roughly 20 Ma before the mid-Cretaceous cooling age of the Cassiar batholith; given the

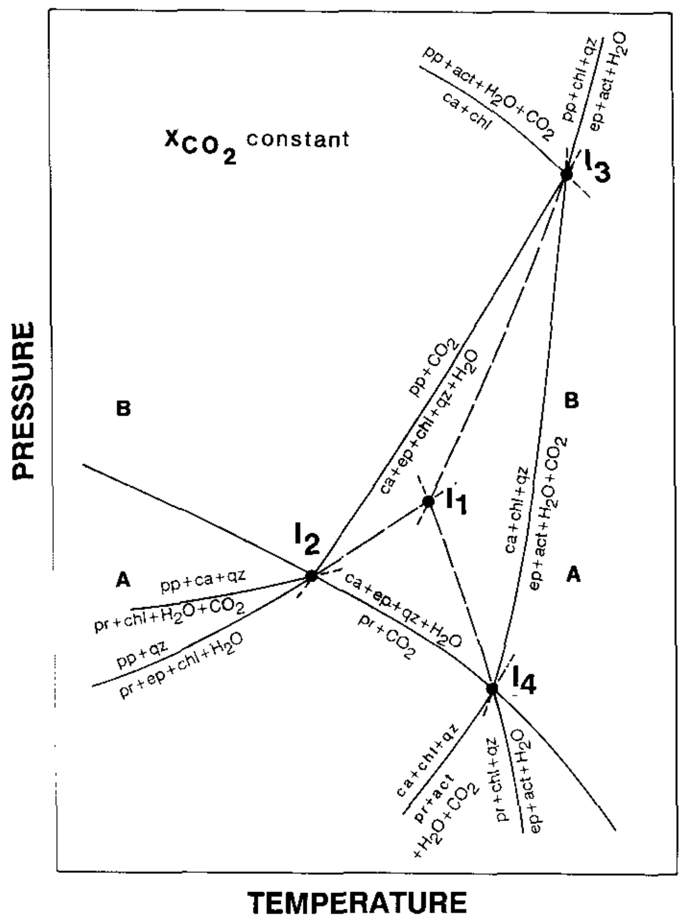

Figure 1-23-2. Schematic P-T phase relationships for the model basaltic system CaO-MgO-Al_2O_3-Fe_2O_3-H_2O-CO_2, from Cho and Liou (1987). X_{CO_2}<0.1. With increasing CO_2, the triangle I_2-I_3-I_4 expands, making the assemblage ca + ep + chl + qz stable over a wider range of pressures and temperatures. Increasing amounts of iron shift the grid to lower pressures and temperatures.

textural and age relationships, the actinolite near Erickson cannot have been generated by the batholith.

Lamprophyre dikes are common in the Erickson-Taurus camp. Where relationships are demonstrated, they are post-mineral, but tend to follow fractures surrounded by carbonate alteration and are themselves somewhat carbonate-altered. "Fresh" dikes contain prehnite-pumpellyite assemblages. Panteleyev (unpublished data, cited in Sketchley, 1986) obtained one K-Ar age of 110 ± 4 Ma on a lamprophyre dike, slightly younger than the sericites in the veins. Three lamprophyre dikes in the camp are known to contain granite xenoliths: one near the Taurus mine (Peter Read, unpublished report for Taurus Resources Limited), one on the east side of Table Mountain near the Erickson veins (Sketchley, 1986), and one north of Snowy Creek discovered in the course of this study (Figure 1-23-1). The dike north of Snowy Creek occupies a fracture surrounded by orange-weathering carbonate alteration (Plate 1-23-1a), although the lamprophyre itself is fresh. The inclusions are strongly clay-carbonate-altered medium-grained granite (Plate 1-23-1b), that originally consisted of plagioclase, orthoclase and quartz intergrown in a cumulate-like mosaic with minor biotite and other unidentified mafic minerals. In contrast, a lamprophyre dike in basalts of the allochthon north of the Erickson-Taurus system contains abundant clasts of subjacent miogeoclinal units, but no granite.

INTERPRETATIONS AND CONCLUSIONS

It is proposed that a large granitic body exists at depth below the Erickson-Taurus system. Contact metamorphism related to it generated the broad actinolite-epidote zone that coincides with the vein system. Constant-pressure cross-section A-A on Figure 1-23-2 shows the most likely prograde path based on the observed transitional assemblages, which passes below the invariant point I_1. Figure 1-23-3 is a T-X_{CO_2} diagram along this cross-section. On it are shown paths of prograde and also of retrograde metamorphism which accompanied veining. It is seen as a constant-temperature event, with X_{CO_2} decreasing progressively away from the veins. A typical sequence of assemblages passes outward from Sketchley's (1986) outer carbonate zone, which contains iron-magnesium carbonate, through chlorite-calcite-(epidote), into prehnite-pumpellyite-calcite-chlorite.

This sequence can be explained in terms of fluid/rock reactions. During the later stages of cooling, a hydrothermal convection cell centred on the granitic body. Fluids, consisting of mixed H_2O-CO_2 solutions in which gold was carried in sulphite compounds, ascended along a series of fracture zones in the cupola. They reacted with the mafic country rocks, producing carbonate halos that pass outward into carbonate-poor assemblages. The fluids were ponded at the base of the Table Mountain sediments, which formed a combination physical-chemical trap due to their carbon-rich

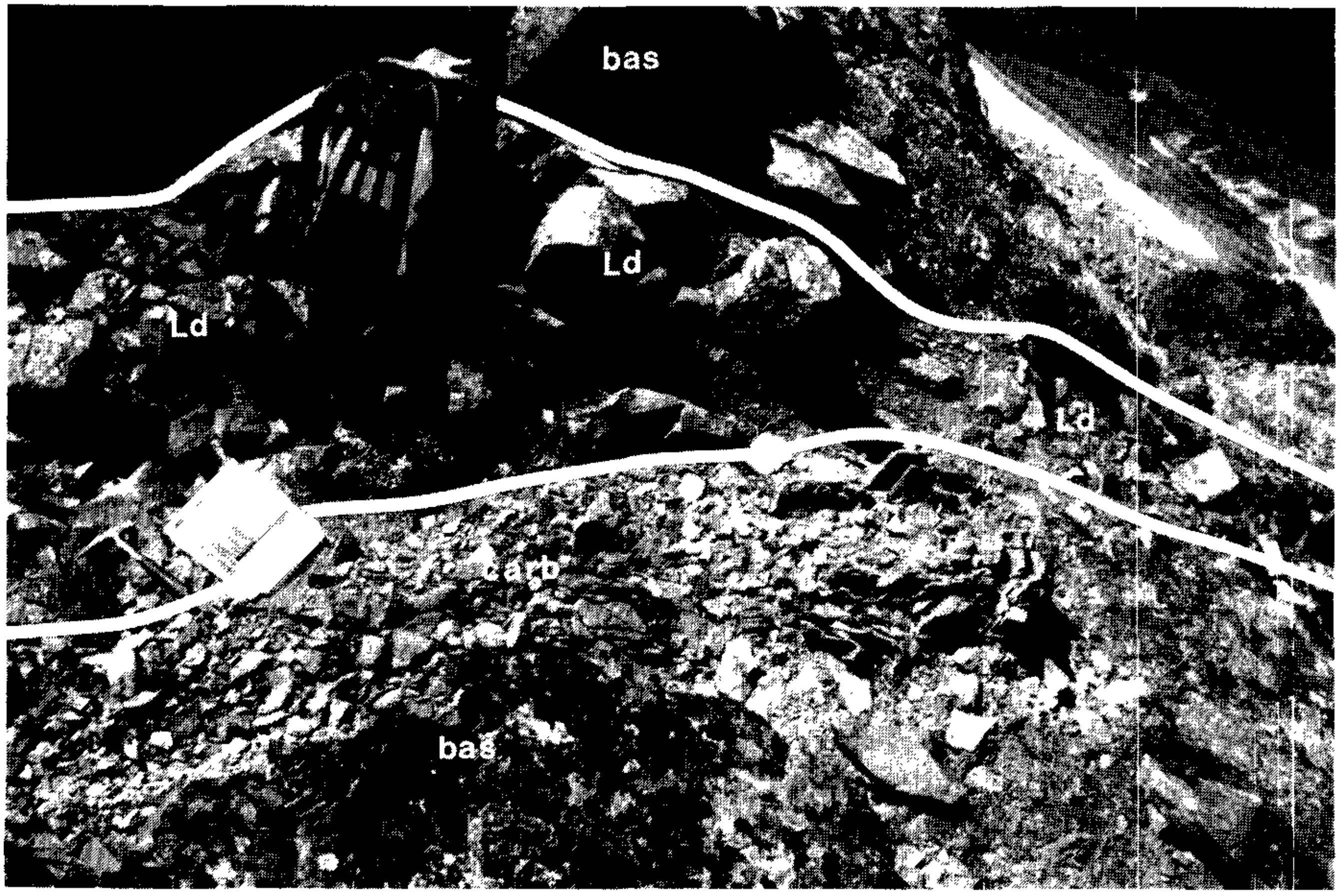

Plate 1-23-1a. Carbonate alteration zone (carb) north of Snowy Creek which hosts lamprophyre dike (Ld) containing granite clasts within basalt (bas).

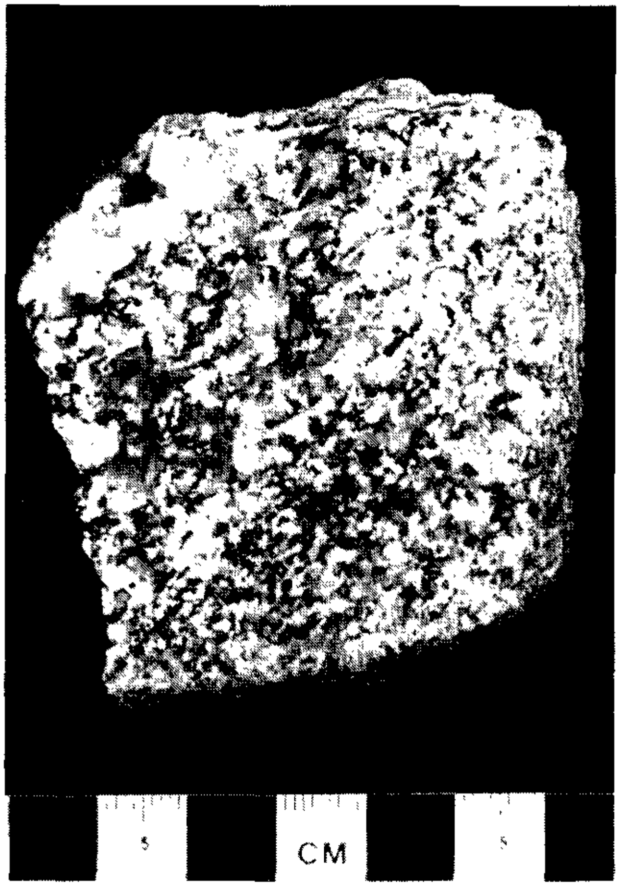

Plate 1-23-1b. Granite clast. Unlike rocks of the Cassiar batholith, this mafic-poor granite is medium grained and equigranular with a graphic texture.

composition and inability to sustain fractures. Gold precipitation probably occurred as a result of cooling, carbon-controlled reduction and absorption of sulphur in pyrite and arsenopyrite in basalt and particularly ultramafic wallrocks. Fluid inclusion data (Nelson and Bradford, unpublished) do not reveal the presence of coexisting immiscible H_2O-CO_2 fluids, so boiling was not a contributing mechanism.

Although cryptic intrusions have not ben previously linked to volcanic-hosted mesothermal gold-quartz veins in the northern Cordillera, they are an important element in models of another key type of deposit in the Cassiar and Pelly Mountains: mantos. Bradford (1988) summarizes evidence for a buried intrusion near the Midway silver-lead-zinc manto deposit, including quartz-sericite alteration, skarn development at depth, rhyolite dikes and a negative magnetic anomaly. The Butler Mountain deposit 20 kilometres north of Midway contains synmineralization rhyolite dikes that may represent the upper levels of a similar but younger pluton (Nelson and Bradford, 1987). Abbott (1977, 1986) attributes anomalous block uplifts in the Seagull and Ketza River districts and at the Mount Hundere manto zinc deposit to subjacent granites.

Remarkably, every significant precious metal deposit in the region, no matter what its immediate setting, seems to be linked to unexposed granite. By combining existing manto deposit models with observations of the Erickson-Taurus system, an extensive list of the surface expressions of these intrusions can be made. This list includes:

- Unexplained postkinematic metamorphic culminations.
- Anomalous horsts.
- Felsic dikes.
- Granitic inclusions in dikes.
- Negative magnetic anomalies.
- Alteration: carbonate/listwanite in basic and ultrabasic hosts, quartz-sericite in pelites.

These surface expressions are exploration parameters of general application. The local host determines what type of deposit will occur, whether gold-quartz veins in eugeosynclinal settings, or mantos in platformal carbonates. The strong influence of the local host on deposit character is particularly well demonstrated by the Erickson-Taurus system, where veins and alteration assemblages, indistinguishable from those in purely eugeosynclinal settings like the

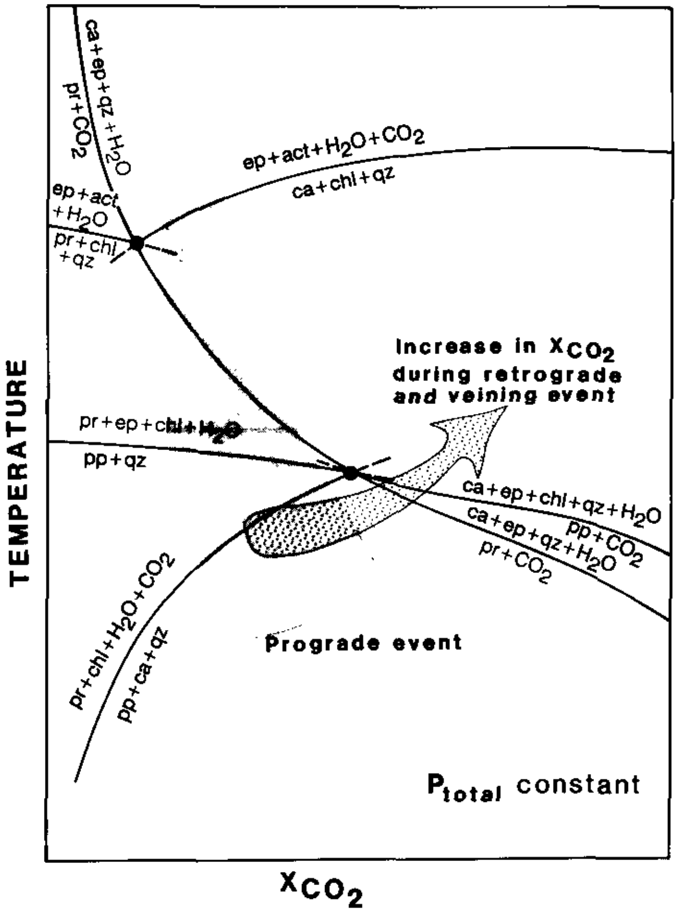

Figure 1-23-3. X_{CO_2} diagram representing cross-section A-A on Figure 1-23-2, below invariant point I_1. X_{CO_2} in this schematic diagram is less than 0.1. With higher X_{CO_2}, as in the alteration zones around the gold-quartz veins, additional carbonate phases such as dolomite and ankerite will develop. The retrograde arrow represents increase of X_{CO_2} towards, but not into, such zones.

California Mother Lode, have formed in a thin eugeosynclinal sheet, less than 600 metres above the underlying miogeocline.

This model for the Erickson-Taurus system accounts for both its similarities to and differences from other mesothermal gold-quartz deposits. The similarities – vein mineralogy and texture, and alteration assemblages – are due to local hostrock character, fluids consisting of H_2O, CO_2, NaCl, sulphur species and metals, and ambient pressure of 200-250 megapascals (Nelson and Bradford, unpublished data). Mixed H_2O-CO_2 fluids also occur in the manto deposits, as shown at Midway (Bradford, 1988). The major difference is the lack of a deep controlling structure for Erickson-Taurus. But, as shown above, an intrusion-driven, rather than a regional-scale hydrothermal cell adequately accounts for the presence and the distribution of the veins. The east-northeasterly fractures can be linked to extension in the cupola of a northerly-elongate granite. The top-to-the-south motion on the Vollaug vein, near the southern end of the system, is consistent with this interpretation.

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