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Conodonts as indicators of mineral prospectivity

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Abstract

A combined technique using conodont Colour Alteration Index (CAI) values and geophysical interpretation provides an initial screening method for determining mineral prospectivity over wide areas.

Further geophysical investigations are warranted in the Mole Creek and Beaconsfield areas of northern Tasmania, and should be undertaken before major changes to land management practices in those areas.

INTRODUCTION

This report was written to document the use of conodonts as a possible initial screening tool when assessing the mineral prospectivity of largely unknown areas, or in areas where blind mineralisation may be suspected. The conodont colour alteration index (CAI) is a valuable tool for assessing regional organic metamorphism because it is a rapid and inexpensive method requiring standard laboratory techniques, and also because standards can be readily assembled and reproduced.

When used together with regional geophysical interpretations and known geology, prospectivity can be assessed and this important information made available to explorationists and land-use planners.

CONODONT PALAEOGEOTHERMOMETRY

Conodonts, the microscopic phosphatic (essentially carbonate apatite) tooth-like remains of worm-like animals, occur widely in Cambrian to Upper Triassic rock successions and are one of the most useful fossil groups for biostratigraphy and worldwide correlation (Lindstrom, 1964; Brasier, 1980). Although they occur in any marine sedimentary rock they are most easily extracted from limestones using dilute acetic acid.

Epstein *et al.* (1977) and Harris (1979), by use of field and laboratory experiments, demonstrated the application of the progressive and irreversible colour changes in conodonts to palaeogeothermometry, grade of metamorphism, structural geology, and to the regional assessment of oil and gas potential. In discussing the use of conodont Colour Alteration Index (CAI), Epstein *et al.* (1977) introduced a standard colour chart with CAI values ranging from 1 to 8 (CAI 1 pale yellow-amber <80°C; CAI 3 dark brown 110–200°C; CAI 5 black 300°C: normally only values of CAI 1–5 are found), and were able to equate CAI with vitrinite reflectance, other thermal maturation indicators and temperature range. CAI is now routinely used by the oil industry in maturation and source potential studies (e.g. Amadeus Basin; Gorter, 1984), and is beginning to be used in mineral exploration studies (e.g. in Canada; Nowlan and Barnes, 1987).

CONODONTS IN THE TASMANIAN PALAEOZOIC

Gordon Group limestones range in age from Early Ordovician (Arenig) to Late Ordovician (Caradoc), and contain conodonts at several horizons (Banks and Burrett, 1980; Burrett *in* Webby *et al.*, 1981). Conodonts are common in the Karmberg Limestone and correlates (late Arenig to Llanvirn), but yields from higher parts of the group are usually low (Burrett *in* Webby *et al.*, 1981).

Burrett (1984) found mixtures of low CAI (~1) Lower Devonian conodonts and Ordovician conodonts with high CAI (~5) in channel samples collected by J. Conkin from the Point Hibbs Limestone. He interpreted the Ordovician conodonts as reworked. Further work by Carey and Berry (1988) showed that the channel sampling had crossed a series of low-angle thrusts that juxtaposed slices of Devonian Point Hibbs Limestone and Gordon Group limestone. Interestingly, conodonts obtained from dolomites within the fault zones exhibit the surface pitting (Rejiban *et al.*, 1987) characteristic of hydothermal alteration.

Lowest values occur in southern Tasmania east of New River, but an anomalously high recording (CAI~6) is immediately adjacent to Jurassic dolerite in contact metamorphosed rocks at Lake Sydney, near Mt Bobs (Correy, 1983; Burrett, 1984).

Intermediate CAI values from the Florentine Valley (CAI~2; Burrett, 1984) in an area close to and probably once covered by Jurassic dolerite, together with regionally low vitrinite reflectance (VR = 0.5–0.65; Banks *et al.*, 1989) values in Tasmania Basin rocks (Upper Carboniferous–Upper Triassic) suggests that heating effects of the dolerite are only local, and that high CAI values in Palaeozoic rocks are due to heating by granite. Depth of burial has been discounted as the major cause of high CAI values, as impossibly thick overburdens have to be postulated (Burrett, 1977).

From the point of view of palaeogeothermometry, conodont yield is not important, as only a small number of conodonts allows for accurate CAI determination. Figure 1 is a map of Tasmania showing recorded conodont localities and contoured CAI values. There is a clear relationship between high CAI values and:

(a) the line of granites running from the Pieman River through to Devonport, and:

(b) around the margins of the "Tyennan nucleus" of Precambrian basement rocks.

GRANITE STRUCTURE AND MINERALISATION OF NW TASMANIA

Figure 2 is a map showing outcropping Late Devonian / Early Carboniferous granitoids of western and north-western Tasmania together with calculated depths to the upper surfaces of deeper, unexposed granitoids using 1 km spaced gravity data (after Leaman and Richardson, 1989; Mt Read Volcanics Project, unpublished data).

Of note is the marked belt of granites extending from the Pieman River to the Devonport region. The eastern margin of the belt is poorly defined, largely because of lack of detailed gravity data in that region. The high CAI values in the Mole Creek area indicate a significant temperature elevation probably associated with igneous intrusion.

The Devonian granites are primary contributors to the mineralisation in western and north-western Tasmania (Leaman and Richardson, 1989), with a particular bias toward Sn, W, Pb–Zn, and Pb–Ag deposits. It is also probable that deep-seated granites contributed to Au mineralisation at places such as Henty and Beaconsfield.

DISCUSSION

Gravity data indicate that the belt of granites extending from the Pieman River to the Devonport region either terminates or is deeply buried to the west of Mole Creek. Unfortunately, the current gravity data in this area are wide-spaced and sparse, and therefore the extent of the belt is poorly defined.

However, CAI values suggest that substantial temperature elevation has occured which is not associated with Jurassic dolerite. Therefore an extension of the granite belt to the east appears to be the likely cause.

Two potential mechanisms are possible:

(a) a continuation of the granite to the east at shallow to medium depth affecting the conodonts but not producing skarns in the limestone, suggesting that the prospectivity for buried Sn, W, or Au mineralisation is enhanced;

(b) the presence of a deep-seated granite continuation with some form of structural control acting as a conduit to affect the conodonts, suggesting that very deep skarn deposits of Sn and / or W may exist, but more importantly that there is the potential for Au mineralisation of the Carlin type.

In summary, the application of the two methods has greatly enhanced the prospectivity of the region to the east of the currently known granite boundary. Further geophysics is required to define the boundary.

A specific search of Tasmanian conodont collections (and / or resampling) for evidence of hydrothermal alteration might give some interesting results.

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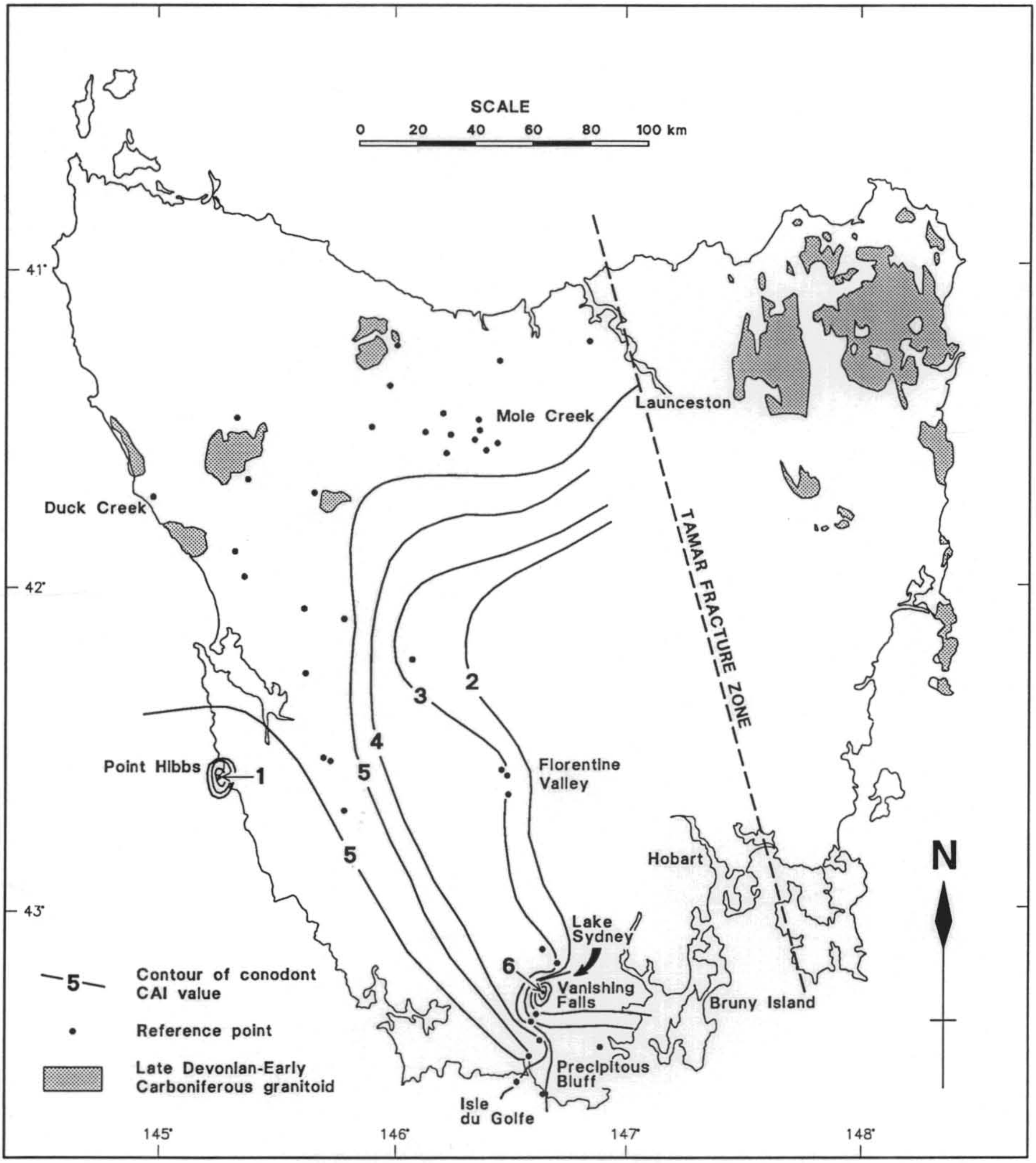

Figure 1. *Conodont locations and contoured CAI values.*

5 cm

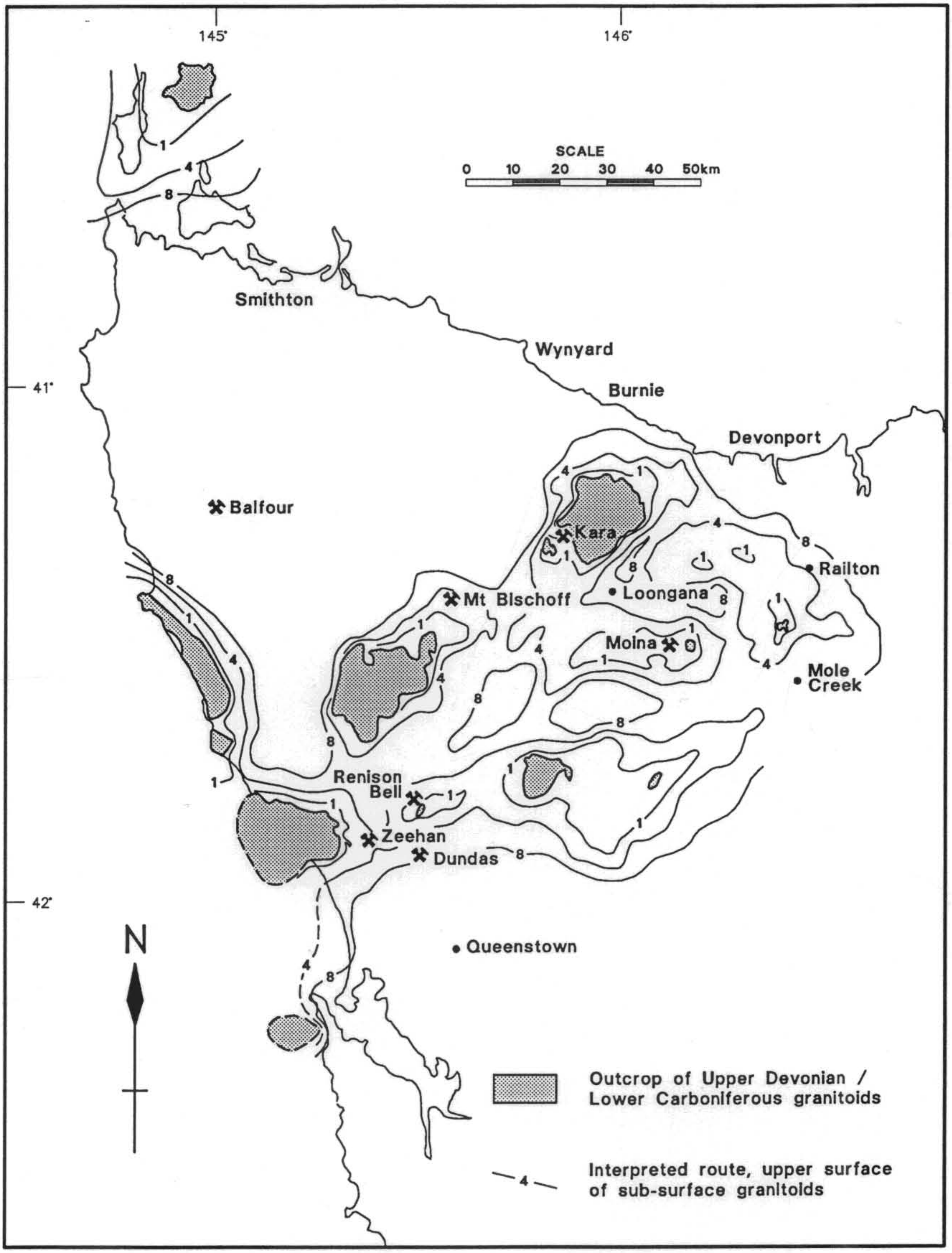

Figure 2. *Granite bodies of west and north-west Tasmania and calculated depths to buried bodies..*

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