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Reply to "Comments on the use of gamma-ray spectrometry for tin and tungsten prospecting"

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Introduction

In previous studies comparing the radiometric signatures of exposed "barren" and Sn/W (as wolframite) mineralized granitoids in southeast Australia (Collins *et al* 1981; Yeates 1982; Yeates *et al* 1982) it was demonstrated that the uranium value of a granitoid is significant in terms of its suitability as a source of, or host to, associated mineralization. Prospective granitoids have more than 4 or 5 p.p.m. U (in various areas) and the abundance of U can be measured simply in the field with a portable four-channel gamma-ray spectrometer housing a sufficiently-sized NaI crystal detector (Collins *et al* 1981, pp. 3–4).

In this note, we reply to criticism that Yeates *et al* (1982) did not evaluate their U measurements in terms of the Cu–Mo–W (as scheelite) and Sn–F–W (as wolframite in veins and greisens, and scheelite in skarns) mineral deposit associations commonly found with "I- and S-type" granitoids respectively, where mineralized (Webster 1984). We also correct other errors in Webster's critique that are relevant to this topic.

Futility of granitoid and related mineral deposit groupings in the Lachlan Fold Belt

In the Lachlan Fold Belt, various groupings of the granitoids have been applied for some time. They have been based on many different attributes as is evident in the reviews by Crook and Powell (1976, pp. 5–8) and Griffiths (1977, table 1). The various characteristics show overlap when compared (Crook & Powell 1976, table 0–2).

Without giving reasons for his preference, Webster (1984) used the regional grouping of Suppel and Degeling (1982) [unavailable to Yeates *et al* (1982) when proofs were returned] that utilises the "I- and S-type" concept of Chappell and White (1974). In the latter it is stated (p. 174): "Tin mineralisation appears to be confined to highly silicic S-type granites whereas tungsten and porphyry-type copper and molybdenum deposits are associated with I-types". It appears that Webster (1984) has accepted this unsubstantiated sentence as unchallengeable. He has also erroneously shown that the "ilmenite-series" granitoids of Ishihara (1977) equate with "S-types" only (Webster 1984, table 1) when Takahashi *et al* (1980) have shown that they can also be "I-types". This is one example of the kind of overlap in granitoid characteristics that exists in the Lachlan Fold Belt.

In our study of the NSW segment of the Lachlan Fold Belt (Yeates *et al* 1982) we purposely avoided evaluating our gamma-spectrometric data in terms of any available classification because of known non-uniqueness and overlap in characteristics, especially in the most felsic granitoids.

Suppel and Degeling's (1982) regional grouping of granitoids used by Webster (1984, fig. 1) is unfinished and requires revision in view of subsequent studies. For instance, W. J. Collins *et al* (1982) [not P. L. F. Collins *et al* (1981) as incorrectly cited by Webster (1984, p. 62)] and White and Chappell (1983) show "A-types" in Suppel and Degeling's "Eastern Belt". Also Glen *et al* (1983) have reported an "I-type" near Cobar in their "Western Belt" of "S-types". Suppel and Degeling's "Central Belt" of "S- and I-types" is not especially meaningful in a twofold subdivision, but it does illustrate geographic overlap of the two types.

Also, many masses in the region have still to be studied sufficiently before they can be assigned "I- or S-types".

The distribution of Sn, W, Cu and Mo occurrences associated with granitoids in the Fold Belt is well known from Markham and Basden (1974) and the 1:250 000 scale Metallogenic and Geological maps. These publications show examples of Sn, W (as wolframite), Cu, and Mo occurring in vein deposits of mineralized granitoids in all three of Suppel and Degeling's granitoid domains, and slightly contrary to data in Webster (1984, table 1).

For instance, Sn occurs with Cu, Mo, and W (as wolframite) at several deposits near Holbrook in the far west of the Fold Belt (Degeling 1974, 1976; Weber *et al* 1978). The host of these deposits, the composite Koetong Granite, is currently designated an "S-type" (Chappell & White 1976). On currently available information, therefore, other factors must be invoked to explain these Cu and Mo occurrences. Alternatively, a greater density of sampling may reveal another type of granitoid in their environments.

Wolframite is the principal constituent of a vein deposit whose host is the Burrinjuck Adamellite in Suppel and Degeling's "Central Belt of S- and I-types" (Bowman 1974). This pluton has been designated an "I-type" and contains 6 p.p.m. U (Owen & Wyborn 1979). Much farther north, the Gumble Granite is host to both Sn and Cu/Mo (Packham 1968). This too is an "I-type" (White & Chappell 1983, fig. 2 and table 1).

In Suppel and Degeling's "Eastern Belt of I-types", the I-type Bega Batholith (Chappell & White 1976) is host to two wolframite deposits in which molybdenite is an accompanying mineral (Weber *et al* 1978). One of these, "the Hammond and Standems claim", occurs close to occurrences of alluvial Sn. The adjacent drainage pattern shown on the Bega 1:250 000 scale Metallogenic Map indicates that the source of the Sn must lie within the Batholith. Thus W (as wolframite) and Sn occur in a host that is part of a well-sampled batholith currently designated an "I-type".

U abundances of granitoids that are the sources of W (as scheelite)

In northwest Tasmania, and in New England, it was revealed that granitoids with associated scheelite mineralization cannot *always* be distinguished radiometrically from "barren" plutons (Collins *et al* 1981; Yeates 1982). The Grassy Granodiorite at King Island, with 7–12 p.p.m. U, and the Attunga Creek Adamellite and Inlet Monzonite in New England, with U values ranging from 6 to 8 p.p.m. (Chappell 1978), are examples of several that do have enriched U. Webster (1984) has ignored these data and stated (p. 62) that "granitoids hosting Cu–Mo–W (tungsten, as scheelite) are not anomalous in uranium content". We presume that by the term "anomalous" Webster meant 'significant' or 'enriched' [e.g. 4–30 p.p.m. as qualified by Yeates *et al* (1982), p. 1728].

In the northeast of the Lachlan Fold Belt, there are several stocks, some of which are notable for associated Cu–Mo–W (as scheelite) deposits (Stevens 1974). They are satellitic to the main outcrop of the Bathurst Batholith, and White and Chappell (1983, fig. 2, table 1) have designated them "I-types". At least three of these stocks have enriched U, i.e. greater than 4 p.p.m. (Bunker *et al* 1975; Facer 1977; Bateman 1982, table 1; Yeates *et al* 1982, table 1; Wyatt *et al* 1984) contrary to Webster's claim. Another stock in this area for which no U abundance has been published is the likely source of alluvial Sn at Meadow Flat (Stevens 1974) showing also that Sn is not excluded from this cluster of "I-type" granitoids. This is also consistent with enriched U (7.48 p.p.m.) in the "I-type" Gumble Granite, which is the source of Cu and Mo mineralization as well.

Whereas most scheelite associated with I-type granites in the region is present in skarns, another type of occurrence has recently been found by Dr D. Wyborn and B. Turner. In the Tantangara district (southwest Canberra 1:250 000 Sheet area) the Boggy Plain I-type Suite of granitoids (Owen & Wyborn 1979) includes a leucogranite with accessory scheelite, high U (up to 15 p.p.m.) and a uranium accessory mineral (Wyborn 1983). Accessory scheelite is also present in part of the Eugowra Granite (east Forbes 1:250 000 Sheet area). The scheelite-bearing phase here also contains up to 15 p.p.m. U (Turner 1983). It is expected that accounts of these occurrences will be available shortly (Wyborn *et al.* in press).

Sn–W mineralization in the Lachlan Fold Belt is associated with granitoids enriched in U regardless of their type, as currently designated. Though Chappell (1984) maintains the "igneous" parentage of "I-types" and the "sedimentary" parentage of "S-types" he noted that the geochemical characteristics of each tend to merge and overlap as they become highly fractionated (and potentially mineralizing). They may therefore be difficult to distinguish (Plant *et al* 1983). Kwak and White (1982, fig. 1) have shown that Sn tends to be associated with the more reduced granitoids compared to W. The more reduced types are mainly "S- and A-types" but they can sometimes be "I-types", whereas the more oxidised types are usually "I-and A-types" but can rarely be "S-types". This scope for overlap may explain the mineral deposit associations discussed above.

Treatment of data acquired by Yeates et al (1982)

Yeates *et al* (1982) assessed the U values of the region's granitoids in terms of their location in geophysical domains 1 and 2 of Wyatt *et al* (1980). This scheme was used only because it was a convenient way of treating a large body of data, and because it was another opportunity to draw attention to one of the great geophysical boundaries (Wyatt *et al* 1980, fig. 3) within the Tasmanides of Eastern Australia. [See Powell (1983) for further discussion of the boundary.]

This division is independent of the mineralogy of deposits containing Sn, W, Cu, Mo etc. and to the granitoids being "I-, S-, or A- types", though "S-types" appear to be common in Domain 2.

Conclusion

This review has shown that Sn, W (as wolframite), Cu, and Mo can all be associated with granitoids designated "I-types" or "S-types" in the Lachlan Fold Belt of NSW.

It is therefore maintained that Webster's criticisms cannot be substantiated. In the Lachlan Fold Belt, no one type of granitoid, as currently designated, is completely exclusive to Sn–F–W (as wolframite) or to Cu–Mo–W (as scheelite). Also, there are known difficulties in deciding whether fractionated leucogranites are "I- or S-types" (Plant *et al* 1983; Chappell 1984). We maintain that explorationists should prospect the environments of granitoids enriched in uranium, regardless of their type.

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