GLOBAL DISTRIBUTION OF TIN ABUNDANCES

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It has long been observed that certain ore deposits are concentrated in well defined parts of the world, called metallogenetic provinces, ore belts, geochemical culminations, etc. Tin is one of the most conspicuous examples of an element that seems to be inhomogeneously distributed over the face of the earth, at least if one considers the distribution of ore deposits and minor occurrences of tin. Its distribution pattern shows rather narrow tin belts of continental dimensions. Some of these belts seem to be cut off rather abruptly by the oceans, but a reconstruction of the continents shows that they must have formed in rather continuous belts before continental drift took place.

From the viewpoint of an economic geologist it would be of great interest to be able to recognize potential ore fields in tin belts even before tin mineralization is discovered. As tin deposits are closely related to granitic rocks, this would entail the search for valid criteria to distinguish between tin-bearing and barren granites. Although the course of the mineralizing processes which give rise to tin deposits may vary, some geochemical link between granitic rocks and tin deposits must exist. If this point is accepted, it is obvious that the possibility of finding tin ore deposits related to a particular granite is higher, if the original tin concentration of that granite is higher. Chemical analysis of granites and its minerals has shown that, as far as the major granite minerals are concerned, tin is noticeably concentrated in micas, biotite being the more frequently occurring mineral. There are indications that tin is accepted into the biotite lattice in amounts indicating equilibrium between biotite and the parent granitic liquid. The following equation may serve as a model for this equilibrium:

$$\frac{\mathrm{Sn}}{\gamma\ \mathrm{Bi}} \cdot [\mathrm{Sn}]_{\mathrm{Bi}} = k \cdot \frac{\mathrm{Sn}}{\gamma\,\mathrm{L}} \cdot [\mathrm{Sn}]_{\mathrm{L}}$$

The temperature of crystallization and the bulk composition of the biotite, which varies widely in granites, will affect the equilibrium constant k in the above equation. As the solid solution of tin in biotite is almost certainly non-ideal, the activity coefficient $(\gamma \frac{\mathrm{Sn}}{\mathrm{biotite}})$ will be concentration-dependent. The observed, relatively regular distribution of tin between biotite and co-existing muscovite may also indicate an approach to initial equilibrium crystallization. Superimposed on the variables affecting the distribution of tin between biotite and granite melt in a crystallizing intrusive, we must also, in evaluating Sn-values in biotite, take into account the deuteric reactions in the post-magmatic stages, and the mineralizing processes by which a large amount of the original tin may leave the granite to become concentrated as ore bodies.

Notwithstanding these possible complications, a number of investigators, especially Russian, claim that the Sn-content of biotites is a measure of the tin potential of a granite. Other investigators deny any correlation between Sn-content of the biotites and tin mineralization. To check these conflicting ideas, a Sn-trace investigation has been carried out on granitic

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rocks and composing minerals of Western Europe. Here we can distinguish two tin belts (mainly of Hercynian age), the Iberian and the Armorican, including Cornwall, Britanny and parts of the Massif Central, which are separated by the almost Sn-barren zone of the Pyrenees. In the belts, syn-orogenic two-mica granites predominate with post-orogenic granites consisting mainly of biotite granite while the predominant rock-type in the Pyrenees is granodiorite. Although the investigation is still in progress, the following general results have been obtained:

1) Sn-levels in biotites differ for different genetic types of granites, and in the different intrusive phases within one type.
2) The Sn-barren belt of the Pyrenees shows low Sn-content in biotites throughout.
3) The Iberian and Armorican tin belts show bot high and relatively low content of tin in biotite.

In W.Europe there seems to be a clear distinction between tin belts and barren belts. Within the well-defined belts variations exist. The Sn-content of biotites from granites associated with important tin mineralization may be fairly low, whereas adjacent non-mineralized, or poorly mineralized granites may show high to very high values. It is tempting to interpret the latter results as an indication of the mineralizing process which would leach the high initial amounts of tin from the main granite minerals, and concentrate this tin in discrete ore-bodies. As a prospecting tool, therefore, analysis of biotite seems to have its value mainly on the strategic level of prospecting, to recognize and delineate tin-belts on the scale of the continents. On a more limited scale geographically (the tactical level of prospecting), the method should be used with caution, and only in conjuction with mineralogical and petrological criteria.

Discussion

H.J. de Wijs wondered what the variation of Sn values would be in biotites taken from one sample location, whether the spatial distribution of Sn values over a granite massif would confirm Emmon's theory on granite cupula, and, finally, what the variation of Sn values would be in biotites from different granites.

R.D. Schuiling answered that the variations in Sn values of biotites from the same sample location appear to be small; average Sn values of different granites display considerably more variation. With a given sampling density of 10 samples per individual granite massif, the author thought that he could hardly comment on Emmon's theory on granite cupula; indications are, however, that Sn values drop near zones of Sn mineralisation.

L.J.G. Schermerhorn wanted to know the mode of occurrence of Sn in biotite and if the mode of occurrence might be different in belts having different mineralogical compositions.

R.D. Schuiling answered that no specific minerals had been observed except in two instances where small cassiterite crystals had been detected. In these instances the Sn content was 400 to 500 ppm, which values may correspond to a saturation level.

I. de Magnée asked if a positive correlation existed between the Sn values in biotite and the biotite-muscovite ratio in granite.

R.D. Schuiling answered that he had no evidence with regard to this point.

W. Uytenbogaardt wondered if the slides of the Asian and Australian tinbelts might be presented. They were duly shown by R.D. Schuiling who had left them out initially so as not to exceed his time limit.

G. Friedrich was curious about the distance between the zone of actual mineralisation and the point at which the Sn values begin to drop.

R.D. Schuiling replied that although this distance could not be precisely determined it would appear that one must think in terms of considerably less than a 100 meters.

A.A.I. Lagerwey wondered if tungsten might not be employed for studies of this kind.

R.D. Schuiling answered that this was not possible. The literature reveals a correlation between tin and tungsten minerals but their mode of occurrence is different.

P. Floor asked the author for a summary of the different factors effecting tin concentration in biotites.

R.D. Schuiling replied that this subject was being studie by one of the geologists of the N.V. Billiton Co.