1 Introduction

Porphyry copper deposits represent the principal source of global copper supply. To address the questions of where future copper supplies are likely to come from and how much copper could exist within the upper kilometer of the earth’s crust, the USGS led a cooperative international effort to assess the world’s undiscovered Phanerozoic porphyry copper deposits using a geology-based, probabilistic form of mineral resource assessment (Singer and Menzie, 2010).

Globally, 175 tracts permissive for porphyry copper deposits were defined to include volcanic and intrusive rocks of specified ranges of age and composition. The rocks represent: (1) magmatic arcs that developed on continental crust above subducting oceanic plates, (2) island arcs that formed on oceanic crust, and(or) (3) postconvergent magmatic belts within continents. Quantitative assessments of undiscovered resources were done for 155 of those permissive tracts.

2 Distribution of Permissive Tracts

On the basis of global assessment data, continental margin magmatic arcs represent 44 percent of all the tract settings; island arcs and postconvergent settings comprise 25 and 12 percent, respectively (Fig. 1). About half of the known porphyry copper deposits are associated with continental margin settings. Age ranges assigned to each tract based on geologic map unit age designations suggest that postconvergent porphyry-forming magmatic events may be of shorter duration than those that form island arcs or continental margin arcs.

3 Assessment Results

In South America, 26 continental margin permissive tracts for porphyry copper deposits were delineated in the Andes region; 19 of these tracts host one or more known deposits. A total of 750 million metric tons (Mt) of in-place undiscovered copper resources estimated for the region is slightly less than the 810 Mt of identified resources. The Central America-Caribbean region (combined with South America on Fig. 2) is estimated to contain about four times as much copper as has been identified. The North America region includes 27 permissive tracts that extend through Mexico, the western United States including Alaska, and western Canada. These tracts include mainly Mesozoic continental margin arcs and Tertiary postconvergent belts of interior western United States and eastern Mexico. A mean in-place undiscovered resource of 400 Mt of contained copper for the region is slightly less than the 470 Mt of identified resources.

For all other regions, the mean undiscovered copper resources exceed identified resources. Undiscovered copper resource estimates of 1,200 Mt of copper for mainland Asia far exceed the 200 Mt of identified resources (Fig. 2). The Southeast Asia Archipelago region, mainly island arcs, is predicted to contain about three times as much copper (300 Mt) as has been identified (130 Mt).

The area that extends from western Pakistan and Afghanistan westward through Iran, Iraq, Turkey, and eastern Europe records the complex history of the opening and closing of Tethys Ocean. The 33 tracts identified in the Tethys region represent all four types of tectonic settings. The predicted mean undiscovered copper...
resources represent more than twice the identified resources.

With the exception of the area of the world-class Cadia deposit, Australia has not been particularly prospective for Phanerozoic porphyry copper deposits.

In addition to copper, the undiscovered porphyry deposits are significant sources of co- and byproduct molybdenum, gold, and silver (Table 1). Notably, the postconvergent settings, which include known world class deposits such as Bingham (USA), Dexing (China), and

![Table 1 Mean undiscovered porphyry copper resources grouped by tectonic setting.](image)

<table>
<thead>
<tr>
<th>Tectonic setting</th>
<th>Ca (Mt)</th>
<th>Mo (Mt)</th>
<th>Au (t)</th>
<th>Ag (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continental margin</td>
<td>1,500</td>
<td>43</td>
<td>32,000</td>
<td>510,000</td>
</tr>
<tr>
<td>Island arc</td>
<td>490</td>
<td>8</td>
<td>22,000</td>
<td>160,000</td>
</tr>
<tr>
<td>Postconvergent</td>
<td>590</td>
<td>14</td>
<td>22,000</td>
<td>200,000</td>
</tr>
<tr>
<td>Mixed</td>
<td>500</td>
<td>13</td>
<td>16,000</td>
<td>150,000</td>
</tr>
<tr>
<td>Total</td>
<td>3,100</td>
<td>77</td>
<td>92,000</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>

---

Fig. 1. Permissive tracts for porphyry copper deposits classified by tectonic setting.

Fig. 2. Global distribution of copper in identified porphyry copper deposits and in undiscovered porphyry copper deposits, by world region. Numbers represent millions of metric tons (Mt) of identified resources and mean totals, in millions of metric tons, for in-place undiscovered copper resources.
Almalyk (Uzbekistan), may be important exploration targets for gold- and molybdenum-rich systems.

4 Conclusions

The 3,100 Mt of copper estimated for undiscovered porphyry deposits represents about double the currently identified resources and five times as much copper as has been produced from all types of deposits since the late 1800s (D. Edelstein, written commun., 2014). The assessment shows that many regions of the world that do not have significant identified resources are estimated to contain significant amounts (100 Mt or more) of in-place undiscovered copper resources. Although South America is the largest source of identified porphyry copper resources, other regions, especially Asia, may contribute a larger relative portion of the global porphyry copper resources in the future. Some previously identified resources have not been, and may never be developed for a variety of reasons such as economics, land use and environmental issues, accessibility, and political or social concerns. These same issues may restrict exploration for future resources in some regions.

Acknowledgements

This study summarizes the work of many people who contributed to regional studies. Cooperators and co-authors are listed in the source publications posted at: http://minerals.usgs.gov/global/

References