Geochemistry of Adakites from the Saindak Porphyry Cu-Au Deposits, Chagai, West Baluchistan, Pakistan*

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The Chagai arc is located in southwest of Pakistan and extends into Iran and Afghanistan (Fig.1A). The border between eastern Iran and western Pakistan roughly coincides with the transition from the collisional Zagros orogenic belt in the west to the Makran accretionary complex and Chagai magmatic arc in the east Siddiqui (2004). The Baluchistan (or Makran) magmatic arc, is an east-west trending, ~500 km long and up to 140 km wide belt of calc-alkaline plutonic, volcanic, and sedimentary rocks, which is part of the continental-scale Tethyan belt that spans eastern Europe and Asia. Activity along the arc began in the Late Cretaceous and continued through into the Quaternary.

1 Geological Setting

Geologically the trending Neogene Baluchistan magmatic arc is located 400 km north of the east-west trending Makran trench and subduction zone (beneath the Arabian Sea), and together with the Hamun-i-Mashkel forearc depression and Makran ranges, comprise the 1000 km long Makran arc-trench system (Razique, Lo Grasso, & Livesey, 2007). This arc-trench system formed during northward subduction of the oceanic slab on the leading edge of the Arabian plate beneath the Eurasian plate in southeastern-most Iran and western Pakistan. It is bounded to the east by a major regional sinistral north-south Chaman and Ormach-Nal transform fault complex (Fig.1B), accommodating the relative motion of the juxtaposed Indian plate which has undergone continent-continent collision with the Eurasian plate to the east (Sillitoe and Khan, 1977).

Sinjrani and Kuchakki Formations are the oldest volcanic rocks in the Chagai arc. The youngest units belongs to the Quaternary Koh-e-Sultan and Koh-e-Dalil of Miocene age. The east-west trending Chagai porphyry copper belt is associated with the Baluchistan volcanic arc in the Makran ranges and Baluchistan Plateau (Fig. 1B). Saindak copper deposits are found near the Saindak Fort, in the western part of Chagai arc near the Pak-Iran border (Fig.1A). Volcanic rocks are spread around Saindak sulphide valley area, south east and north east of Saindak town. The sulphide mineralization is associated with Quartz diorite and Monzodiorite in Saindak formation of Eocene age with intrusive in the volcano-sedimentary suite of Oligocene age Amlaf formation.

2 Discussions and Conclusions

Chemical analyses were conducted and samples were chosen for dating. LA-ICPMS U-Pb dating of magmatic zircons from the Qtz-diOrites yielded weighted mean $^{206}\text{Pb}^{238}\text{U}$ ages ranging from 24 to 22 Ma, which suggest forming periods of Miocene.
Three zircons recovered from these rocks have Paleoproterozoic of 1827 to 1867 Ma which probably inherited zircons from continental plate in this area. Geochemical signatures can distinguish these intrusive rocks into two types as Monzodiorites and quartz dikes in Saindak area. These quartz dikes mainly plotted in metaluminous to peraluminous fields on A/NK vs A/CNK diagram. The Qtz-diorites and Monzodiorites are all calc-alkaline, ant they are LILEs enriched, high field strength element (HFSE) depleted, and negative Nb and Ti anomalies. Trace element data indicates these lavas have a very minor continental affiliation. Zr, Hf discrimination diagram Rb vs Y+Nb and Nb vs Y showing that these rocks are formed in volcanic arc, and Sr/Y vs. Y and La/YbN vs. YbN further showing affinity of adakites. The SiO₂ vs Mg (wt%) and Al₂O₃ vs K₂O/Na₂O diagram show these adakites are derived from oceanic slab melting during subduction zone area.

The intrusions are considered by to have been emplaced during the time of active compression in Pleistocene epoch (Khan, 1974). These intrusions have occurred in a narrow structural zone which is traversed by parallel closely spaced fractures, which increase the potential for mineralization. The Saindak area is a chain of the Tethys metallogenic belt, the Tethyan orogenic and metallogenic belt stretches from the Alps, through the Balkans, Turkey, Iran, Pakistan, Tibet, Indochina, and finally into the southwest Pacific. It was formed during two major orogenic events, one in the early-mid Mesozoic reflecting a cluster of the Paleo-Tethys Ocean, and the second in the early Cenozoic to Recent reflecting of the Neo-Tethys Ocean (Sengör and Yılmaz, 1981).

Fig.1 Geologic map of Saindak area, Chagai arc, Baluchistan
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