The deep carbon cycle confronted to mantle electrical conductivities

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The deep carbon cycle is tightly related to (i) subduction processes that injects in the mantle oxidized carbon species, (ii) deep redox processes that traps carbon as graphite or diamond, and (iii) volcanic degassing that transfers carbon form the mantle into the atmosphere. The rate at which such a transfer operates is slow with time-scale comparable to the age of the Earth if it is rate-controlled by solid state mantle convection. Carbonatite melts, however, the oxidized and molten form of mantle carbon, are likely to shortcut these slow processes provided that large scale connected paths exist at depth, and that carbonatite stability is allowed by appropriate redox conditions. Our proposal is that such channels could indeed be revealed by mantle electrical conductivity as deduced from magnetotelluric methods. This approach allows imaging the deep volatile cycling, which has so far relied essentially on petrologically-based models.

Petrologically-based models predict an increasingly reduced mantle with increasing depth, with the possibility that the asthenosphere could be saturated with metallic iron. This should prevent carbonate stability at depth exceeding 200-250 km. Water activity should also be reduced due decomposition into hydrogen. However, there is geochemical evidence for carbonate-rich melts formed at depth exceeding 250 km. This requires redox heterogenities at depth such as oxidized regions within a globally reduced mantle. Similarly, electrical mapping of the mantle images conductive regions surrounded by a globally more insulating mantle. Some conductive mantle regions appear to be spatially connected to subduction regions, which could indicate release of carbonatite at depth, due to melting of subducted carbonates. This process requires that those deep regions are oxygen-enriched and subduction of oxidized material can provide the excess oxygen. In upwelling regions (MOR), underneath volcanic zones that experience CO_2 degassing, electrically conductive zones seems to be deeply rooted suggesting that the deep mantle source regions of those volcanic emissions are more oxidized than the surrounding mantle. We will define the oxygen/carbon ratios required at such depth to reconcile high conductivity and oxidizing conditions.

Tectono-geochemistry exploration and the ore-finding discovery – A case study of the Zhaotong Zn-Pb deposit, Yunnan, China

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The Zhaotong Zn-Pb deposit is one of the typical deposits in northeast Yunnan rich Zn-Pb-Ge deposit district, and is located in the sagged Yunnan basin at the middle end of the Yangtze Platform. It lies in a structurally compounding position of NE-, SN- and NW-trending fault-fold belts. The ore-bodies occur in the Zaige Formation of Upper Devonian and the Baizuo Formation, which are mainly composed thick layer coarse-grained dolomite, is strictly controlled by the interstratified faults. The length of ore-body is 325 m and its depth is more than 500m, its average thickness is about 16m. The ore grade of Pb and Zn is high up to 20%-35% principally with compact lump shape. In the ores there are other elements including Ag, Ge, Cd. Mineral composition in the ores mainly includes sphalerite, galena, pyrite, ferro-calcite, calcite, dolomite and quartz. The dolomitization is widely observed in wall-rock alteration.

Based on studying the structural ore-controlling laws, M-2, M-4 and A-2, A-3, D-2, F-1 tectono-geochemical anomalies in the mining area were delineated by tectono-geochemical mapping for 1:5000, 1:2000 measuring scale. The main anomalies extend in NE-SW-trending, and superimposed anomalies of Zn-Pb-Cd-Mn-Ge-Ba and Mo-U-W element groups are significant. By the IP and TEM geophysical exploration techniques, two positioning targets were proposed. The one parallels the SW-NE-trending mineralized zone of No.1 orebody group, the other is at the depth of No.1 orebody at the southwest end, concealed orebody may extend from 95 exploration lines to 80 lines. By engineering verifying, more concealed orebodies had found. NO.1-6 orebody is one of the largest, its thickness is 15.6-54.2m, its content of Pb and Zn is 25 % - 35 %. The increase of the Pb-Zn metal reserves by near 1.0 million tones so that the deposit changes into a large-type lead-zinc deposit. This discovery is a successful example after an important breakthrough had made by tectono-geochemical exploration technology in the Huize Pb-Zn deposit.

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