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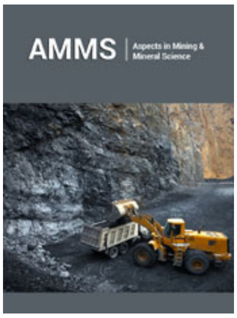
Opinion

Global Metallogeny of the Precambrian Stage Geological Evolution of the Earth

Turchenko SI*

Institute Geology and Geochronology of Precambrian Russian Academy of Sciences, Russia

ISSN: 2578-0255



***Corresponding author:** Turchenko SI, Institute Geology and Geochronology of Precambrian Russian Academy of Sciences, Saint Petersburg, Russia

Submission: May 17, 2022

Published: May 30, 2022

Volume 9 - Issue 2

How to cite this article: Turchenko SI. Global Metallogeny of the Precambrian Stage Geological Evolution of the Earth. Aspects Min Miner Sci. 9(2). AMMS. 000709. 2022.
DOI: 10.31031/AMMS.2022.09.000709

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Opinion

Eoarchean era represent time epoch of pre-geological lives of the Earth from period planetary accretion T_0=4,567 up to 3.85Ga, where enter stages: last accretion stage, proto-core forming, primary mantle and mafic proto-crust also as heavy meteoritic bombardment when most part of primary proto-crust was destroyed. Mantle was formed in result differentiation meteoritic substance in time after accretion from Solar nebula. Accessible chemical, isotope and astronomical evidence support those materials such as meteorites initially were fragments at the orbit between Jupiter and Mars. Meteorites have maximal old age 4567.1±0.16Ma (Amelin et al. [1]) and Fe-Mg siliceous (chondrite) and Fe-Ni metallic contents. Distribution of meteoritic substances on the Earth were very irregular so that in following fell on the forming mantle, crustal and metallogenic substances were non-homogenous. Paleoarchean era, which started geological stage evolution of the Earth, characterize set of mineral deposits more typical for Proterozoic eon. But some types of mineral deposits differ by structural-tectonic position from younger Archaean analogs. So, Paleoarchean lode gold deposits were formed in tectonic conditions differ from orogenic positions of forming typical for Proterozoic deposits. In the set scientific works have been show that exist a little geologic evidence of about plate-tectonic style development of continental crust in Early Precambrian cratons for period 3515-3240Ma [2,3]. These authors come to the conclusion that early growth of earth crust occurred in result action of series mantle plums evoked smelting of mafic basalts which formed oceanic plateaus. Such earliest plumes initiated crustal growth geologic areas, but no form belts, which were typical for plate-tectonics. Besides, in result plume actions occurred expand of lithosphere that leaded to possibility forming of series plume domes and volcanic covers as volcanic paleo-basins.

Periodical development volcanic paleo-basins at mafic-ultramafic (further maf-umaf) plume plateaus created ideal conditions for origin massive volcanic sulfide deposits. Such objects were motherhood sources for maf-umaf rocks – bearers of Ni and PGE mineralization apart from age (from Paleoarchean up to Proterozoic). For such rocks Paleo- and Mesoarchean ages (3.6-3.2Ga) determine by Sm-Nd isotope data positive or close to CHUR means εNd, relating initial delating of chondrite reservoirs. However, because of deficit sulfur in such oldest volcanic rocks Ni and PGE mineral deposits are unknown but was determine only one small deposit (Shangani) in komatiites with age 3526±48Ma and εNd +0.7 in lower part Onwervaht group greenstone belt Barberton in Kaapvaal craton of S. Africa. For maf-umaf rocks mantle origin Meso- and Neoarchean ages (3.4-2.6Ga) by Sm-Nd isotope data determined positive means εNd evidence about initial mantle magmatic reservoir of the greenstone belts rocks. Archean large sulfide Ni-PGE deposits in komatiites it is known only in Yilgarn craton W. Australia (ore districts Kambalda and Fortescue), in other World cratons known only ore occurrences. It is possible, the same considerable metallogenic difference Paleoarchean era from Meso-Neoarchean and Paleoproterozoic eras were tectonic conditions in which gold deposits developed. Lode gold deposits during most parts Precambrian geologic time related to linear, scale of earth crust, displacement zones. In contrast this lode gold deposits formed before 3200 Ma related to large ring faults, around which granite intrusions were concentrated that occurred, for example, in ore districts Bambu Creek, craton Pilbara [4] or Witwatersrand, Kaapvaal craton.

Periodical re-melting of lithospheric mantle during successive plum events occurred all more evolutionary rock-melts (A-type granite), which were perspective for accumulation lithophyle elements typical for rare-metal deposits, for example, Ta and Sn pegmatite in Pilbara craton. First A-type granite appeared in Neoarchean (~2.8Ga) however, property this type magmatism in Precambrian comes at interval ~2.0-1.0Ga. From this time new stage mantle dynamic starts that determines beginning new super-plum-continental cycle. Typical and wide-spread representative this type of magmatism was granite-rapakivi with which associate big circle ore deposits. Main types are rare-metal, Sn-rare-metal, Cu-U-Au-REE, Fe-Ti-apatite and U deposits type «nonconformity». It was determined that majority large deposits were formed during two episodes 1.85-1.70 and 1.30-1.00Ga, and all practically were connected with activity of mantle plumes. The Proterozoic eon host considerable mineral resources, some from which were largest in the World. These present:

1) BIF with iron deposits,

2) fluid-faulting strati-form and strati-bound sedimentary-exhalative Pb-Zn deposits (especially into Australian ore-bearing structures).

These mineral systems were formed into inner-plate, plate-marginal, accretion behind volcanic arc basins and collision conditions. So, for example, Hamersley basin possess own large iron resources that equivalent age near 2400Ma and Transvaal group – BIF in South Africa. The origin of BIF leave discussed between models' hydrothermal springs in oceanic basins or type Red Sea pickles. Orogenic magmatic ore-bearing systems wide-spread in Late Proterozoic rock complexes of Australia, e.g., granites Pine Creek, Tanami, Arunta, Capricorn orogens where these rocks reflect accretion and collision events 1800-1790Ma. Orogenic lode gold deposits also timed to these events. Magmatic Ni-Cu-PGE and Fe-Ti-V deposits in maf-umaf systems lie in Halls Creek orogen and in complex Musgrave with age near 1080Ma. Mineral systems connected with anorogenic magmatism embrace wide circle of hydrothermal ore deposits from these economic important are Olympic Dam Fe-Cu-Au deposit in S. Australia. To this group belongs also Pb-Zn-Ag-Ba deposits (with Cu-Au-W mineralization) in orogen Capricorn and large Au-Cu deposit Tefler. Within alkaline rocks with age 1100 and 800Ma and in diamond-bearing carbonatites and lamproites were determined diamond deposits - Argil (1180Ma) – largest diamonds producer in last years. Within sedimentary rock series in Australia lied World class Zn-Pb-Ag sulfide deposits with age near 1700 and 1500Ma (MacArtur, Mount Isa and Broken Hill).

Genetic types of ore deposits possess diverse in time distribution with picks at specific periods development of the Earth. Mineral deposits show poly-stages character of the forming during long history of origin super-continents of the Earth. The forming of Precambrian mineral deposits occurred mostly near 2.7 and 2.0-1.8Ga and rarely in period 1.7-0.6Ga from cycle-to-cycle continental growth of earth crust in the time of changings in aspect plate-tectonic style processes. Volcanogenic Massive Sulfide (VMS) deposits were formed at convergent margins of continent on which also formed orogenic gold deposits. First arising Fe-oxide-Cu-Au deposits near 1.55Ga also related to Precambrian metasomatized Sub-Continental Lithospheric Mantle (SCLM) under earlier cratons – centers of super-continents. Classic example can be giant deposit Olympic Dam, S. Australia. Giant Paleoproterozoic goldfields with U, such as Witwatersrand in S. Africa, were formed under action of fluvial sorting heavy minerals in extremal climatic conditions. Gold deposits timed to felsic intrusions, having mantle-crustal isotope means, were formed at margins of craton – nucleus Early Precambrian super-continents. U-Pb isotope zircon age data together with Nd isotope data show considerable growth of continental crust starting 3.0Ga with peak near 2.7 and 1.9Ga. In the first case this connect with global forming of main greenstone belts 2.75-2.60Ga (e.g.: in Yilgarn craton, W. Australia; Superior and Slave provinces in Canada; cratons of W. Africa, India, Sao Francisco in Brasil; Karelian in Fennoscandian Shield; Middle Dneprian province, Ukraine Shield). In the second case (under growth crust at 1.9Ga) this connects with new stage forming of juvenile Paleoproterozoic crust. One from the last stage increase of continental crust 2.1-1.6Ga replaced growth Rodinia super-continent and further (in period 1.4-0.6Ga) it disintegrates and new growth of Gondwana and Laurasia proto continents. Structural-tectonic development of Precambrian stage geological evolution of the Earth planet into proto-continent Laurasia (basements East-European, East Siberian and North American platforms) during Meso- and Neoproterozoic (1.6-0.54Ga) occurred by platform scenario. Active action of Precambrian tectonic-magmatic processes in such scenario did not occur, because did not occur active metallogenic consequences and various ore-forming processes. Into southern hemisphere of the Earth affair occurred more complexly, so far as Late Proterozoic period at main-lands of Gondwana group did not finish by the forming of platform structures, but in it continued develop orogenic belts (1600-600Ma) and collision belts (age near 1100Ma) tectonic-thermal reworking of old structures. Tectonic-physics reason of this natural phenomenon is rarely who explain, but in my opinion its explanation considers in global-planetary phenomenon - stabile displacing 23.4-degree inclination axle rotation of the Earth and periodical precession on 1-1.5 degree, arising just exactly to this period life of the Earth. Because of this heavier core-mantle masses of the Earth were displaced in direction of southern hemisphere and displayed in this act continuous of tectonic-physical activity plume and asthenosphere nature orogenic structures of Late Proterozoic in this part of the Earth. There were: Andean, West Antarctic, New Zealand, Inner Gondwana regions (Sierra in Argentine, Cape Town

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in South Africa, Ellsworth in Antarctica and Tasman orogens in East Australia) framed Late Proterozoic belts. The same these orogenic belts (Brasilides in S. America, Pan-African, Ross in Antarctic, Delamerian – N. and Central Australian) and regions of tectonic-thermal reworking (Rondonia in S. America, Kibara in Africa, Albany-Fraser and Musgrave in Australia) of more old structures settled down in central parts of Gondwana proto-mainland.

The appearance some genetic types of ore deposits Fe-oxide-Cu-Au and essentially Pb-Zn deposits in Late Paleoproterozoic orogenic structures of North-Central Australian belt related to changing chemistry of ore-forming processes. During sedimentary-volcanic accumulation in orogenic basins were created conditions for origin Pb-Zn ores which were expressed in arise deep warm and mantle ore substances in result of new activating appvealing because of Late Paleoproterozoic core-mantle dislocations in southern hemisphere of the Earth. In the belts of tectonic-thermal reworking, such as Limpopo or Namaqua-Natal (with age near 1400Ma) at S. Africa, which anything contented only small ore occurrences in the time of laying metamorphism and fold-fault deformations gave bodies of high-quality ores. Tectonic-physical event on the Earth, which mentioned upper, in the time coincide with stage of mantle evolution determined by isotope data showed what these rocks, at all the World, have age 1600±200Ma. It is possible, just exactly in this time large mantle moving occurred, following tectonic-physical event on the Earth. From this event in sediment accumulation occurred change mainly deposition of Ca-Mg (dolomite) faces on (mostly cases) Ca (limestone)-carbonate faces that immediately reflect at forming of ore-bearing faces (visible appearance Pb-mineralization in ore deposits). Examples can be large Pb-strati-form deposits (with Zn, Ag) of North-Central Australian orogenic belt (Mount Isa, MacArthur, Broken Hill). From such examples could be propose that in Late Proterozoic (1600-600Ma) of Southern hemisphere riftogenic processes have essential means in ore forming. These could be supporting the fact that Cooper belt deposits of Pan-African tectonic-thermal structures were controlled by rift zones, especially at southern hemisphere of the Earth. The period from 900 to 600Ma at southern hemisphere of the Earth turn out as in northern hemisphere also non very productive for ore deposits so final stage of Precambrian geological development of the Earth here also change from active processes to absorbed of continents. This, it is possible, were connect with uplift of oceanic ranges – the start new stage of life of the Earth - the Phanerozoic eon that expresses in active dislocation tectonic plates, creation of orogenic cycles and variety ore forming processes reached non-percentage high-level.

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