Heinrich Holland's big event: The Great Oxidation

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Although his research delved into many problems in the geochemistry of Earth, for much of his career H.D. Holland was most passionate about what he termed "the Great Oxidation Event," i.e., the establishment of an oxygen-rich atmosphere in the early Paleoproterozoic. From the early 1960's until his passing in 2012, Holland developed and refined a deep understanding of the geological and theoretical constraints on the chemical composition and evolution of the atmosphere and ocean. This understanding, and the way that only Holland could provide simple yet deep quantification to the problem, is perhaps most elegantly displayed in his 1984 book *The Chemical Evolution of the Atmosphere and Oceans*, the manuscript of which served as my introduction to Holland's work when I was a graduate student studying under lifelong friend and scientific foil to Holland, Robert Garrels. Holland sought to answer the questions of "when did the GOE occur?", "why did it occur?", and "how high oxygen levels rose during the event and subsequently?". For Holland, the answer to "when" has been fairly well constrained by the mass-independent sulfur isotope record of the Paleoproterozoic. The answer to "how high" is rather poorly constrained by geological proxies but approximately 10% of today's level just following the GOE. But the answer of "why" continued to perplex him to the end. A diverse group of researchers has been entrained by Holland's passion for the GOE and will carry the torch forward as the timing, pathway, and mechanisms of the GOE become fully illuminated.

Organic genesis of the sulphur occurences and their relationship with black shales in the Isparta Region, SW, Turkey

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The study area is located in the triple conjunction area of the "Isparta Angle" in the Western Taurus region of SW Turkey. Due to Neotectonic evolution of Eastern Mediterranean Region, the study area is a geologically very complicated region. The rock units are divided into two groups as either allocthonous or autochtonous. Tectono-stratigraphically, the allocthonous units are Paleozoic quartzite, black shale, limestone, arkozic sandstone, interlaminated radiolarite and autochtonuous units are Triassic and Jurassic limestones, and Upper Cretaceous ophiolite. Trachyte, trachyandesite, feldspathoidal trachyandesite porphyry, tuff and pumice were formed by volcanism during the Plio-Quaternary. Recent alluvium and slope detritus cover all the rock units.

Sulphur outcrops are exposed in the Keciborlu native sulphur, Uyuzpınar volcanic gases, Darıdere altered volcanic rocks , Darıdere pyrite in volcanic rocks, Yakaören altered volcanic rocks, Kasımlar blackshales , Kesme road native sulphur in blackshales , İbişler village in native sulphur, Afyon volcanics, Kınık Kızıltepe altered volcanic rocks, Gölbaşı realgar, Gölbaşı gypsum and Şarkikaraagac barite occurrences. The most important sulphur deposits are found in volcanic tuff and siltstone - marl - shale interbedded unit which contains an organic matter.

Sulphur may accumulate around recent fumeroles existing and also as massive mineralization. Field studies and sulphur isotope data show that the sulphur originated from the uppercrust and probably comes from organic matter- rich Paleozoic and Triassic sedimentary rocks. The sulphur did not migrate between the Triassic and Pliocene periods. However, Plio-Quaternary volcanism was the cause of mobility of the sulphur and was followed by formation of the secondary sulphur mineralization due to post tectonic geothermal activities. $\delta^{34}S$ values of the samples coincide with other samples from different shallow marine environments. Since the isotope values of the sulphur samples are quite similar to those of organic materials, it can be concluded that the sulphur might have occurred in the same anoxic environment together with petroleum source rocks.

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