

# Brief communication: Electron pair donors and Earth's energy generation

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**Abstract.** This Brief Communication presents a series of model calculations for the electron pair donor densities required for *tresino* thermal energy generation in the Earth. The crucial density of electron donors is determined from the ratio of  $^3\text{He}$  and  $^4\text{He}$  after many years starting from initial densities of the donor pairs. In addition, a new proposal is introduced that connects Cooper pair formations to the deuteron *tresino* nuclear reaction chain (the chain that determines the  $^3\text{He}/^4\text{He}$  ratio).

5 Furthermore, it is proposed that magnetotelluric (MT) observations may be connected to Cooper pair formation either with or without substantial heating.

## 1 Introduction

The paper with my late colleague John Reitz (Mayer and Reitz, 2014) from a few years back outlined the geophysics problems involving thermal energy generation and helium release from the Earth. It showed how proton and deuteron *tresino* generation 10 (see Sections 1 & 2 of Reference 1) provided a quantitative resolution to most of the problems. Where proton to proton-*tresino* accounts for about three quarters of the energy generation (due to the much larger number of protons in sea water compared to deuterons  $\approx 6600$ ) and another quarter of the energy release is due to the deuteron to deuteron-*tresino* and the ensuing deuteron-*tresino* nuclear reaction chain that gives rise to both  $^3\text{He}$  and  $^4\text{He}$  in later time (see Section 3 of Reference 1). It is this 15 later ratio and its connection to the starting water content that is the focus of the present work. This paper attempts to complete the theoretical understanding of this new geophysics picture. In order to facilitate clearer understanding, the reader is urged to consider our first paper before addressing the present paper. It is expected that most geophysicists are firm believers in the Standard Earth Energy Paradigm (SEEP) which we show to be inconsistent with most of the geophysics measurements of heat and helium generation from the Earth. Because of this some effort is required to fully understand this work.

## 2 Electron-Pair Donors and *Tresino* Formation

20 This paper describes a new proposal relating to *tresino* formation and thermal energy generation (Mayer and Reitz, 2014) in the Earth; it represents an extension of our prior work on the thermal energy generation in the Earth. In our NPG paper, we had to make an assumption regarding the collisions that gave rise to the transfer of a pair of electrons required to form a *tresino*, hence energy generation from the *tresino* bound state. The assumption was that the electron pairs were delivered in

a collision between a proton (probably  $\text{H}_3\text{O}^+$  i.e., a hydronium ion) and a doubly negatively-charged ion, for example  $\text{O}^{2-}$  (see Panel A of Figure 1), in which the weakly-bound electrons were captured in the collision (see Section 3 of Reference 1). In this paper, another process is put forward, namely: that in the Earth's very mixed and varied materials of both insulators and metals, a "superfluid" of Cooper electron pairs forms (for an introduction see-<https://en.wikipedia.org/wiki/Cooper-pair>)

5 in some regions such that the pairs can migrate and eventually collide with a proton (here again, most probably  $\text{H}_3\text{O}^+$  or its deuteron cousin) (see Panel B of Figure 1) to form either a proton *tresino* or a deuteron *tresino*. The ensuing reaction dynamics and energy generation then follows the same reaction chains as discussed in our earlier NPG paper (Mayer and Reitz, 2014). Unfortunately, the microphysics of the formation of the Cooper pairs is quite complex because the physical processes, the materials, and the spatial length scales may all be diverse even in laboratory experiments, which are in fact generally performed

10 at low temperatures, as described in the overview paper of (Hirsh, Maple and Marsiglio , 2015).

Cooper pairs have recently been proposed in (Feigel'man and Ioffe, 2015) and (S. Dolgopolov, 2015) in somewhat mixed materials, including at interfaces, see e.g.[(Gariglio, et.al. , 2015)]. So considering "superfluids" of Cooper pairs created in Earth materials, perhaps under pressure, seems a reasonable assumption in the Earth. Of course, determining the materials operative in the Earth will have to be experimentally assessed (this situation might be expected to be operative in a limited

15 number of materials relatively close to the surface, see (Mayer and Reitz, 2014). Interestingly, the "superfluid" has only to be a (local) transient process but repeated frequently for the Cooper pairs to exist long enough to collide with a proton or deuteron. So, this is the *new* proposal: Cooper pairs form in the Earth materials in some situations and if a sufficient amount of acidified water is present, they can form *tresinos* in collisions, thereby driving the sequence of reactions we described earlier in (Mayer and Reitz, 2014).

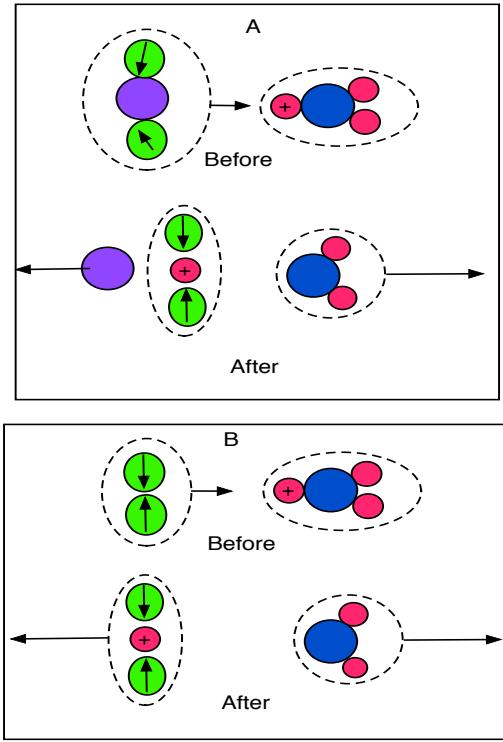
20 Note that in many Cooper pair theories the spins of the two electrons are opposed which is just the situation required for the pair to "fall into" the proton potential well forming a *tresino*, therefore releasing its binding energy as recoil kinetic energy. This collision is illustrated in Panel B in Figure 1; the broken circles in Figure 1 surrounding composite particles are meant to indicate that they are bound. Further, note that the binding energy released at *tresino* formation is delivered as recoil kinetic energy ( $\approx 3.7$  keV) to the participating *tresino* and its heavier partner, in both cases, a water molecule. It is important to point

25 out that a "superfluid" of Cooper pairs may have already been observed for many decades in magnetotelluric (MT) scans but just not recognized as such.

### 3 The Ratio of $^3\text{He}$ and $^4\text{He}$

It has proved useful to examine a series of model calculations of the helium isotope ratio because this ratio can be traced back to the electron-pair donor density ( $n_{ee}(0)$ ) at the start of the *tresino* energy release. It has been instructive to use the

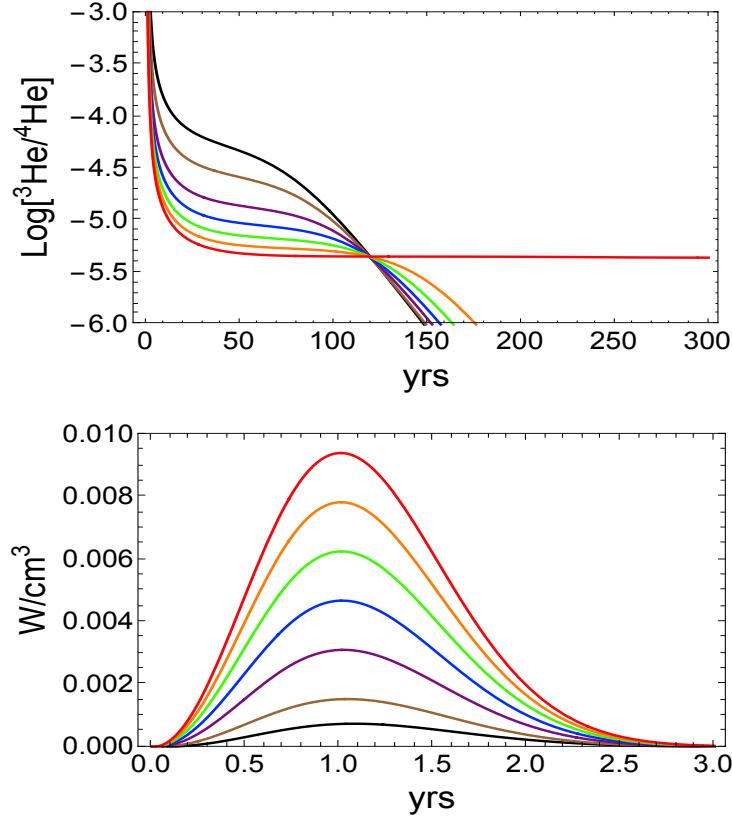
30 *tresino* reaction dynamics of our paper (Mayer and Reitz, 2014) to examine the effect of differing levels of water for proton and deuteron *tresino* formation that generate the  $^3\text{He}$  and  $^4\text{He}$  isotopes. In particular, the deuteron *tresino* nuclear reaction chain determines the level of the helium isotopes produced and is sensitive to the starting value of the electron-pair donor density. And the ratio of  $^3\text{He}$  and  $^4\text{He}$  isotopes has been well-documented as we discussed in (Mayer and Reitz, 2014). The



**Figure 1.** Panel A: schematic of electron capture by an  $O^{2-}$  ion. Panel B: schematic of electron capture by a Cooper pair. Electrons in green with spin orientations as shown, protons in red and oxygen atoms in blue.

long-time (beyond about 200 years) ratio and far away from any volcanic activity, has been found to be  $\approx 10^{-5}$  around the Earth. Therefore, by adjusting the amount of water (i.e., proton and deuteron densities) it is possible to estimate the amount of water content as well as the pair donor density of electrons either from  $(O^{2-})$  ions in Panel A or from Cooper pairs in Panel B. A sequence of model calculations is shown in the upper panel of Figure 2. The values taken for these calculations  $n_{ee}(0)$  were 5 [0.5, 1, 2, 3, 4, 5 and 6]  $\times 10^{20}$  protons/cm<sup>3</sup> at the start of an approximately one year introduction of water ( $\nu = 1$ ). The curve yielding the isotope ratio curve at  $6 \times 10^{20}$  protons/cm<sup>3</sup> appears to agree best with the geophysically-observed ratio data beyond about 200 years. Note that beyond this value, the  $^3He$  content is too small to provide another data point. This happens because the deuteron density has been depleted about six years after the water injection. Therefore, the  $6 \times 10^{20}$  protons/cm<sup>3</sup> data point also provides an estimate of the Cooper pair density at the same value ( $6 \times 10^{20}$  pairs/cc) for this particular parameter set. On 10 the other hand, a similar density of doubly-charged negative ions such as  $O^{2-}$  as we had suggested in our earlier NPG paper gives the same result. Finally, note the linear dependence of the power output versus the proton content as shown in the lower panel of Figure 2. Clearly, with very little water there is very little energy generation. Of course, the model calculations do not

select one or the other of these electron pair donor possibilities but they do indicate the densities required in the *tresino* energy generation picture.



**Figure 2.** The upper panel plots the helium isotope ratios for different amounts of water or starting proton content: [0.5 (Black), 1 (Brown), 2 (Purple), 3 (Blue), 4 (Green), 5 (Orange), and 6 (Red)]  $\times 10^{20}$  protons/cm<sup>3</sup> at  $t = 0$ . Other relevant parameters (defined as in our earlier NPG paper) for the model calculations were:  $\nu = 1$ ,  $T = 1555^\circ\text{K}$ ,  $P = 2.33 \times 10^{-5}$ ,  $n_d(0) = n_p(0)/6600$ ,  $\eta = 10^{-16}$ ,  $\epsilon = 0$ , and  $n_{ee}(0) = 2n_p(0)$ . The lower panel plots the power output (W/cm<sup>3</sup>) in early times for the same range of starting proton densities.

#### 4 Superfluids and Magnetotelluric Data

Magnetotelluric data scans often find zones of very-high electrical conductivity; see, for example, a typical paper by (Ritter, et al. , 1999). Furthermore, as these authors comment “A large number of electrical conductivity anomalies have been detected in the Earth crust around the world. There is no clear consensus as to the causes and origins of these anomalies, particularly in crystalline regimes”. On the other hand, it is clear from basic electromagnetic considerations that these zones have enhanced electrical conductivity, a situation certainly consistent with generation of Cooper pairs. It is important to note that such zones

may be found even without substantial heating (i.e., *tresino* generation) in those situations where there is insufficient acidified water (hydronium ions) present, as well as lower levels of heating from small amounts of acidified water. It should be obvious that there must be equal numbers of hydronium ions for each Cooper pair to undergo a *tresino* formation in order to release its binding energy.

## 5 5 Discussion

There does not seem to be a straightforward way to distinguish between the two different processes by which a *tresino* can be formed either: (a) a collision between a hydronium ion and a doubly-negatively charged ion such as  $O^{2-}$  and (b) a collision between a hydronium ion and a Cooper pair. Of course, much of the research into superconducting materials (Herrman and Maple, 1991) has focussed upon low-temperature systems even though much research has pushed on to some higher-  
10 temperature superconductivity materials because of their practical importance. However, the existence of HTSC suggests that perhaps even higher-temperature superconductivity might be found in geophysical systems but not yet examined.

## 6 Conclusions

Of course, this new proposal will have to be looked at closely to determine if there may be geophysical data that supports it (or not) and also what geochemical components there may be that might allow it to be examined in the laboratory. Finally, if those  
15 geochemical components can be identified, then a new research direction for understanding "superconductivity" may present itself.

*Competing interests.* there are no competing interests

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