On the use of preprint in geochemistry: the good, the bad and the ugly

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In recent years, the pace of the dissemination of scientific information has increased (Piwovar et al., 2018). In this context, the possibility and value of sharing open access (OA) online manuscripts in their preprint form seem to be growing in many scientific fields (Tennant et al., 2019). More and more platforms are especially dedicated to free preprint publishing. Preprints? What? Also called e-prints, they are published, non-peer-reviewed scholarly papers that typically precede publication in a peer-reviewed journal (Ginsparg, 2016). They have been a part of science since at least the 1960s (Cobb, 2017). In 1990, Tim Berners-Lee created the World Wide Web to help researchers easily share knowledge. A few months later, in August 1991, as a centralized web-based network, arXiv (https://arxiv.org/, pronounced ˈär kīv like the word archive) was created. arXiv is arguably the most influential preprint platform and has supported the fields of physics, mathematics and computer science for over 30 years. Since, preprint platforms have become popular in many disciplines (*e.g.* bioRXiv for biological sciences) due to the increasing drive towards OA publishing, and can be publisher- or community-driven, profit or not for profit, and based on proprietary or free and open source software. A range of discipline-specific or cross-domain platforms now exist (*e.g.* Penfold et al., 2020). There is an exponential growth these last five years as highlighted on Figure 1. While preprints as a whole still represent only a small proportion of scholarly publishing (*e.g.* 2% of the biomedical literature published every month ; Penfold and Polka, 2019), a strong community of early adopters is already beginning to experiment with such value-enhancing tools in many more disciplines than before.

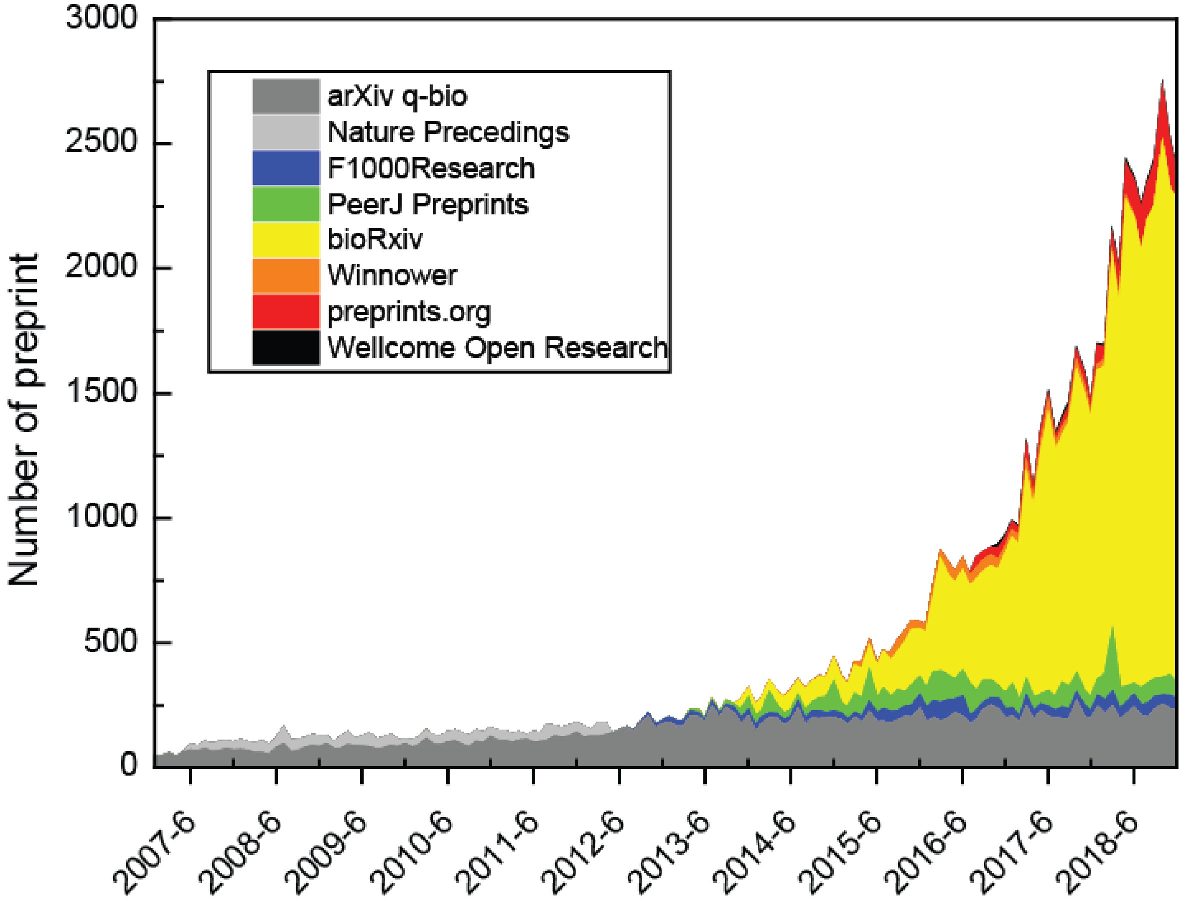

Figure 1 Preprints evolution per month in biological sciences (source http://www.prepubmed.org/monthly_stats/; accessed on 03/14/2020).

The reasons for this growing importance, the popularity and acceptance of the trend of preprints are numerous. One of the reasons is the delay in the peer review process and the eventual subsequent publication (Figure 2), which can also impact the career progress of researchers. Further research has shown that preprints also tend to be of similar quality to their final published versions in journals (Carneiro et al., 2020). This raises major issues around the "added-value" of both the publishing and peer review processes, which continue to cost billions of dollars in public money each year to support (Johnson et al., 2018).

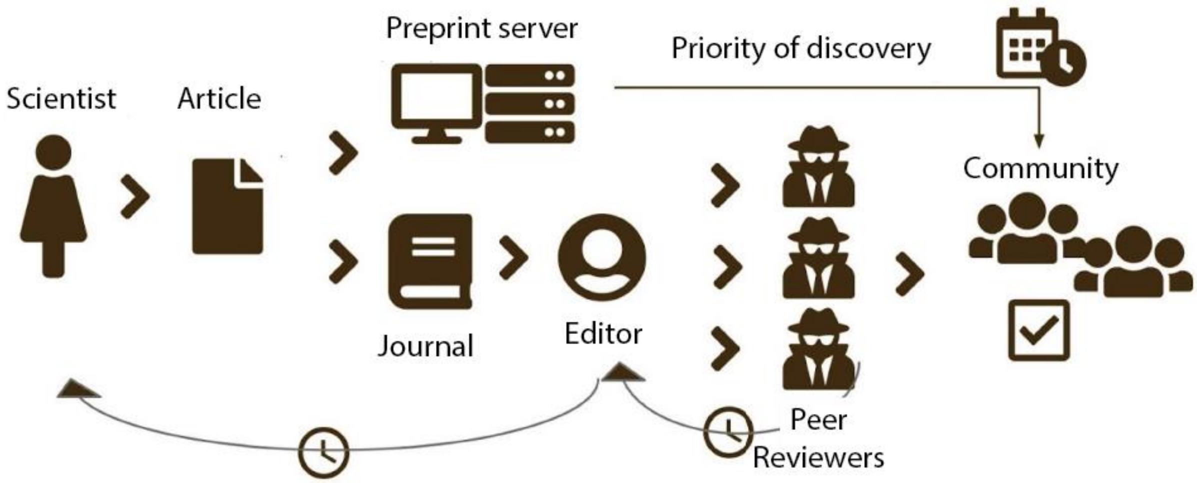

Figure 2 Preprint submission workflow establishing priority of discovery (modified after Tennant et al., 2019).

There are a number of benefits but also potential drawbacks of preprint publications. Many of the possible benefits of preprint publication include:

- rapid sharing of research results, particularly during outbreaks (*e.g.* COVID-19);
- visibility and accessibility (*i.e.*, not placed behind a paywall);
- sharing new types of outputs such as data, research code, or methods;
- extra feedback and peer-review possibility;
- small or even non-existent costs for authors;
- assignment of a digital object identifier (DOI) so that the paper is known and stored in the digital world;
- possibility of setting research precedents (preventing scooping);
- work can be reported on internationally, and then be improved (*i.e.*, overall quality, integrity, and reproducibility of research outputs) and released later;
- incentivizes further collaboration;

- authors retain full copyright on their article;
- far simpler to use than publishing submission portals (*e.g.* it takes about five minutes to upload a preprint to the Open Science Framework).

The preprint model still has some possible drawbacks. This has the ability to increase the dissemination effect, for example, of low-merit studies on social media or even of fake news, and adds an extra potential burden on journalists reporting on new research (Tennant et al., 2018). According to Altmetric, the most-shared research article ever at the time of writing is a bioRxiv preprint about the COVID-19 virus (Pradhan et al., 2020). This article has since been withdrawn due to flaws in the research. However, retractions are common even in peer-reviewed scholarly journals, so this is not necessarily a trait exclusively for preprints; in fact, preprints actually tend to make the process of correcting the scholarly record far simpler. The preprint model also increases the scientific community's responsibility by not legitimizing preprint publications that lack scientific rigour. Thus, the burden is on researchers, and indeed everyone, to think critically about the research they read, whether it has been peer reviewed or not.

Despite this development, there is still some resistance to preprints. One major barrier is the question of their citation. Some researchers have argued that preprints are no different from other grey literature due to their preliminary existence. It is a direct consequence of our academic culture where typically only work that has been explicitly peer reviewed and published in a scholarly journal is usually cited. Another argument is that a preprint might bring confusion in citation when it has been published formally in a journal. On top of that, we also receive reports from authors to have their manuscript rejected because similarity-check software shows high similarity between submitted and preprint version. The extent of these issues remains poorly understood, but should be clarified in journal policies and at preprint platforms.

"It should be noted that reference 15 is a non-peer reviewed version. I suggest referring to a peer-reviewed publication from another source."

Reviewer #2

Eventually, sustainability of such system is questionable, as popular, not-for profit, community driven preprint servers (*e.g.* INA-Rxiv) face closure because of financial troubles (Mallapaty, 2020) or are moving towards other economic options (*e.g.* EarthArXiv). This highlights the issue with sustainability of these services, which should perhaps not be an issue considering how much money is currently being spent on less-efficient and less-sustainable for-profit systems (*i.e.*, commercial publishing activities). Governments and funders desperately need to reconsider their focus on where they allocate funds during decisions related to scholarly communication (Tennant, 2020).

In the Earth Sciences only a few articles are submitted as preprints every month (Nature Geoscience Editorial Board, 2018; Narock et al., 2019). But what about preprints in Geochemistry? As stated by Pourret et al. (2020a) and Pourret (2020), the preprint model is unfortunately still little-known and is not being routinely used by geochemists. A small overview of preprints available in Earth Science category and Geochemistry, Geochemistry and Petrology, Biogeochemistry and Cosmochemistry sub-categories, and Geochemistry category (depending on servers) show that less than 250 articles have used this model in total in the last three years (Table 1). This number is very low compared to the 9,326 and 9,196 articles published in the field of geochemistry in 2018 and 2019, respectively (Pourret et al., 2020b).

Table 1 Number of preprints by servers

Servers	**Homepage**	**Number**
EarthArXiv	https://eartharxiv.org/	146
Preprints	http://www.preprints.org	25
OSF Preprints	https://osf.io/preprints/	17
ESSOAr	https://www.essoar.org/	15
PeerJ preprints[#]	https://peerj.com/preprints-search/	8
INA-Rxiv	https://osf.io/preprints/inarxiv	7
arXiv*	https://arxiv.org	4
AgriXiv	https://agrixiv.org/	3
Zenodo	https://zenodo.org/	>2

[#] discontinued

* via Hyper Articles en Ligne (HAL : https://hal.archives-ouvertes.fr/)

However, as stated by Pourret (2020), a majority of the journals in geochemistry have a green colour according to the SHERPA/RoMEO grading system, indicating that preprint (and postprint) articles submitted to journals can be firmly deposited on a preprint server, without compromising authors' abilities to publish in parallel in a journal. Moreover, in their study Pourret et al. (2020a) highlighted that the majority of journals in geochemistry allow authors to share preprints of their articles (47/56; 84%). Therefore, the relatively low uptake of using preprints in geochemistry is not because the opportunity is not there. More likely, similar to other small research communities, it is likely that a complex network of sociocultural factors is responsible for their low use (*e.g.* a similar pattern is observed in palaeontology), even if data sharing was acknowledged by the community for more than 15 years (Helly et al., 2003). The two main alternatives for geochemists are EarthArXiv that is a free preprint service for the Earth sciences initially powered by OSF Preprints and ESSOAr that was developed in a joint initiative by the American Geophysical Union with financial support from Wiley. Moreover, geochemists who published in journals of the European Geosciences Union have already become accustomed to such openness and are posting their work prior to peer review as a discussion on the Copernicus platform (Voosen, 2017).

Attempts to close this gap between the inherent benefits of preprints and their relatively low uptake by research communities have concentrated primarily on making preprints more citable for instance by having improved metadata, permanent identifiers (DOIs), and even the look and feel of a conventional and historical journal article (*e.g.* Preprints.org). There are good preprints and bad preprints, just like there are with journal articles. We believe that we should not be using journals as an excuse to absolve ourselves of the responsibility to think critically and cite responsibly. Overall, don’t be afraid to be scooped or plagiarized! Stealing research ideas from preprints is not a concern when preprints are common practice in a scientific community, as they are in high energy physics, for example. Editors and peer reviewers should also be aware of the actual owners of the research work (Bourne et al., 2017). Preprints actually protect against scooping (Ginsparg, 2016; Sarabipour et al., 2019). Preprints establish the priority of discovery as a formally published item. A preprint acts as proof of provenance for research ideas, data, code, models, and results - all outputs and discoveries. The fact that most preprints come with a permanent identifier (*e.g.* DOI) also makes them easier to cite, index and track; and articles that are published as preprints appear to gain more citations at a faster rate (Fu and Yughey, 2019). Even almost thirty years after arXiv was established, we're only just at the start and there's a long way to go still for preprints. The Earth Sciences are extremely complex, with many subdisciplines like geochemistry – each with its own norms. It is reasonable that a “one size fits all” model for preprints would never work across the entire scientific community and that geochemists need to develop and sustain their own model. The community should really be developing this, along with new standards for linking their datasets in the spirit of FAIR model (Wilkinson et al., 2016), and the usage of open standards, licensing, and Free and Open Source Software. In the near future, given the increase in the use and profile of preprint servers, and alternative publishing platforms such as F1000 Research, it will be necessary to identify how many servers exist, to describe their scientific scope (*i.e.*, covered disciplines), and to compare their characteristics and policies. In the vast usage of public software sharing platforms (e.g. Github, http://github.com and Gitlab, http://gitlab.com), there is also strong encouragement to make code re-usable, shareable, and citable, via DOI or other persistent link systems. For example, GitHub projects can be connected with Zenodo for indexing, archiving, and making them easier to cite alongside the principles for software citation (Smith et al., 2016).

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