Future challenges and research: theory of sampling (TOS)

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Well organised around the WCSB conferences and the bi-annual sister conference in Perth, Australia, the sampling community has never been as dynamic as today. Debates are rich and productive, disagreements are usually handled in a constructive and friendly manner, but research, academic as well as industrial, is still needed on a large number of subjects. Universities are starting to get on board in a more structured way, with the result that a growing number of students around the world are now exposed to TOS during their studies. But the future of TOS is still in the making and we all have a duty to foresee what is needed, and to help and contribute as much as possible.

Theory

On the theoretical front, the last two decades have been particularly productive. Models for the liberation factor were finally proposed that have brought the theory to an advanced stage; such models are now being validated by numerous experimental applications. Methods for realistic and relevant calibration of the thus *completed* variance formulas are being vigorously investigated and improved.

Teaching is increasingly more and more efficient, and typically nowadays stripped of unnecessary mathematical difficulties while, simultaneously, the importance of the qualitative concepts (correctness, distributional heterogeneity) are properly emphasised. Theoreticians are still active and keep following the practical developments to safeguard them from evolving in the wrong direction. Finally, in-depth mathematical modeling research is still going strong with the potential promise of even better applications of TOS in the future.

But challenges also still exist in the background. Augmented models, as well as practical application methods, do not always generate immediate consensus, leaving the impression that TOS and its uses still require some amount of cleaning. Similarly, older developments are not always questioned enough, even though sometimes under attack or suspicion from some of the TOS community. For instance, disagreements still occur as to practical approaches between "purists" (advocating segregation-free methods) and those advocating inclusion of residual segregation effects in the predictive results. Antiquated methods are still proposed to the public even though the underlying techniques have evolved drastically and better tools are in some cases available.

As a good example already described in a paper, Gy's rudimentary, graphical variographic analysis of processes, as it is applied today, uses a flawed splitting of components and would benefit from being overhauled using modern geostatistical knowledge of the true meaning of variogram modeling and its limitations. Another example (along the same line) is the confusion, deep-rooted in the early works, between sampling sensu-stricto (TOS) and in situ measurements, e.g. for 1-D streams (geostatistics). These theoretical flaws and imperfections run the risk of exposing TOS to easy criticism it does not need, and the non-academic practitioner is often left to his/her own devices to sort out the why and the what of such state of affairs.

Overall, however, the knowledge and understanding of the incredible power of TOS have progressed quite satisfactorily, and it can be said it is experiencing its "golden age" in these years. But from the outside, it is sometimes a quite different story that is perceived. As any good "new" science, TOS at times hits a wall of incomprehension, or adverse protectionism from domains where it has not traditionally been applied (yet), even if this is often where it logically is needed the most. Sampling of grain (outside Canada) comes to mind as a striking example, but it is probably far

from being the only domain where this is the case. Also the coal mining industry has not been spared from this point of view, even though it has, to a large degree, been the crib of many excellent sampling methods and inventions for over more than a century. It is nevertheless important to acknowledge that it is only in comparatively well-defined sectors that such reservations are found. Industries traditionally dependent upon good sampling, such as the gold, precious metals, REE and base metal mining industries, have kept growing in their confidence in what TOS has to offer, and commendable efforts and progresses have been witnessed there in renewed dedication to much more reliable sampling. This contemporary evolution forms a close parallel to the one geostatistics has followed earlier.

Practice

Also on the practical front, things are definitely evolving towards a brighter side. New, better sampling devices are regularly derived and invented, progressively closing the gap where no correct samplers were available before. Incorrect sampling devices are now more effectively and more easily identified, and retrofitted solutions or completely new TOS-compliant devices are offered to the users. Many innovations have recently offered better solutions, e.g. for sampling of pulverised dry material and for the sampling of running conveyor belts, while the sampling of conveyed powders and slurries in pressured pipes is already being engineered.

The concept that automatic samplers are ordinary devices that need no further attention save being maintained, is rapidly losing ground to the correct understanding that all sampling systems are precision devices that must be respected in their complete integrity, need to be regularly monitored, verified, cleaned and periodically inspected in an accountable manner. Still, however, our professional conferences are always

blessed with the occasional, hilarious slide of some appalling system... Alas, miracles do not happen often in the TOS community, but, thanks to God, such "humorous sampling" that keeps showing up does so only in small enough proportions for everybody's comfort.

Now readily available everywhere, new teaching material is increasingly emphasising the practical concepts and understanding that are essential for reliable sampling. Excuses for poor sampling, even in unfavourable industrial situations, are losing ground every day.

At the same time, new, experimental calibration methods for the numerical models are being investigated with very promising results, e.g. the use of series of samples taken from hierarchical size fraction setups with no influence from the grouping and segregation error (GSE).

Research

Regarding research, efforts are still very much needed, as ever. Whether it is a problem of lack of sponsorship from the relevant industries, or a consequence of poor appreciation of TOS as a desirable element on regular academic curricula in universities, academies and schools teaching geology, mining engineering, metallurgy or chemistry, is not clear. Even though there are specific exceptions (see below), many such seats of learning and teaching are generally failing in promoting this relevant research. Yet, potential fundamental and applied research subjects do exist in large numbers, at all academic levels, as does the availability of competent academic and industry research directors in our sampling community. There are still only a few handful of university degrees and research projects linked directly to TOS around the world, and a continued, serious effort is needed which would be very favourable to the above mentioned industry sectors. A clear objective for the future, which in this context could be said to start with WCSB7, is to forge a much improved alliance between industry and academia in these matters. It should be emphasised, however, that several oases exist already on this path, doing well (locally doing much better) than this lament, and which are nicely distributed all over the world, notably in South Africa and Australia, in Scandinavia, Brazil, Chile...

A list of possible research subjects would include (list certainly not restrictive):

■ Comprehensive study of the "natural degree of segregation" of a lot of particulate matter, and reliable estimation thereof.
■ A survey of the types of sampling methods, samplers or situations that are still not available in a TOS-correct form, e.g. sampling in slurry tanks, sampling of large stockpiles or of large bodies of liquids.
■ The domain of validity of TOS, and whether, and where, it can be transgressed—or not.
■ Effects of tuning the speed of a rotary splitter.
■ Revisiting and ranking of sample splitting methods.
■ Comprehensive surveys of industrial needs and practices.
■ The economic impact of poor sampling in a variety of real-life scenarios.
■ Spear sampling—a much used, incorrect sampling technique: empirical investigations.
And more…

Conclusions

It is comforting to write in *TOS forum*, because its very existence is a definite proof of well-being for our community. As can be inferred from the quality of our conferences, we are indeed blessed with having brought our discipline to a formidable scientific high, and with a current all-time record in degree of recognition and appreciation from all walks of science, technology and industry.

To address the needs for a sustained evolution, we must nevertheless face the following issues:

■ TOS must be taught much more systematically in many more technical schools, universities and similar—primarily to students and not only to already working professionals.
■ The idea that progress in TOS, or more simply good sampling, however desirable, should cost nothing, must be revisited by everyone involved. Obviously this is an erroneous perception that **must** be changed.
■ Research in TOS and applications needs to be promoted and sponsored more proactively.
■ The economics of sampling must be made clearer to all parties involved. There is huge benefit in furthering this objec-

tive—the "money argument" is always getting a hearing in management circles.
■ Theoreticians must reach a general consensus on issues of fundamental disagreement.

Facing these critical issues cannot be limited to simply acknowledging their rightness. Words are fine—but actions are needed, and influences must be used. This should be felt as the responsibility of everyone in our community, and with the advent of the TOS forum and the next conference in Bordeaux, the time is particularly right for meeting and agreeing on an increased, concerted effort along the avenues described above.

Note from the editor

Continued efforts must be made strengthening the sense of one, united sampling community. At WCSB6 some "murmurings" were accidentally overheard, that "these conferences are incorporating much too much applications that are **not** related to mining..." This is a fatal misunderstanding! On the contrary, it is vital—also for the mining industry—that the ever broadening canvas of the conferences and our work between them, continues to be stimulated and inspired by the widest possible scope of theory, research and applications from all sectors in science, technology and industry.

A French mining engineer, Dr Dominique François-Bongarçon has devoted his research time to Gy's theory of sampling after a career in Geostatistics. The main areas of expertise of his two consulting companies, AGORATEK International and GEOMATEK (Brazil), include sampling equipment design, sample custody, QA/QC, and reference materials.