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VIEWS

Geological Mapping in Exploration: A View from the Trenches

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INTRODUCTION

Kevin Heather's (SEG 1998 F) presentation at the September 2015 Chile-Explore Congress, entitled "The Lost Art of Geological Mapping: Should We Care?," regrettably came as no surprise to me, although I have to admit to being more than a little disappointed. Most senior explorationists, I suspect, would probably share these sentiments. Geological mapping is, after all, the very embodiment of all the basic field skills we learn as geologists, and the simple fact is that the alarm bells have been sounding loudly for some time now in our industry: basic field geological skills have been lost in the emerging generation of exploration geologists.

As a geologist with some 30 years of experience in the exploration and mining industry, almost entirely in a field-based technical capacity, I have always maintained that careful geological mapping, based on sound observation, is one of the cornerstones of successful exploration. Indeed, given that our industry is founded on combinations of fortuitous geological phenomena in a complex framework, why would geological mapping and field geology not be positioned at the very forefront the discovery process?

A large part of the debate as to the underlying causes for the general demise of geological field skills has focused on issues at the university level (e.g., fieldwork reduction due to funding cuts and increased liability, changes in undergraduate curricula to more closely reflect the broadening range of geological disciplines to serve wider needs of society, an emphasis on rapidly publishable experimental and modeling research at the expense of more costly field-based studies, etc.). The mining industry has responded by promoting its specific technical and skill set requirements at university level via collaborative research, student training initiatives, and funding programs.

The focus of this Views contribution is to examine several internal industry issues which I believe have contributed to falling standards of geological fieldwork, and which have become apparent to me during extensive time spent in the field in a consulting capacity for numerous major, mid-tier, and junior companies.

THE IMPORTANCE OF GOOD GEOLOGY

A thorough read of articles such as those by Proffett (2004), Brimhall et al. (2006), and Marjoribanks (2010) should dispel any doubts that explorationists might have as to the importance of geological mapping in the exploration and mining business. All these authors are seasoned geological mappers and widely respected explorationists. As discussed by Brimhall et al. (2006), the value of geological mapping is actually very hard to overestimate: geological maps guide strategy and decision-making at virtually every stage of the discovery process, from regional terrain selection through property-scale target definition to detailed deposit-scale studies, ore resource definition, and geotechnical work. Indeed, they concluded that geological mapping would remain an essential part of the exploration and discovery process in the foreseeable future.

Most of us, at some stage of our careers, have probably mapped at the district, property, or deposit scale, where the concept of visualization in order to target mineralization can be most useful. Wood (2006) defines visualization (in the context of exploration) as the ability to assemble often rather disparate observations and exploration data in order to create a 3-D mental image of the perceived target, and thus vector toward ore. Geological mapping remains a fundamental first step in this visualization process, bringing together diverse geological observations in their true spatial (and temporal) context and thus providing initial—and often very significant—constraints on the architecture of mineralized systems and the likely location of ore within these systems. Geological maps, as well as interpretive cross sections derived from them, represent the initial stages of the all-important modeling and targeting process. Integration of ancillary data (e.g., geochemical, geophysical, and spectral data, etc.) adds an essential, holistic, multidisciplinary approach that further enhances the process. However, without the geology much of this important ancillary data may lose value, perhaps be rendered meaningless, or possibly be strikingly misleading. The geological map thus should be the logical starting point for most exploration programs, though, absurdly, this is often not the case.

There has been a significant shift of

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exploration focus recently to partially or, in some cases, completely covered terrains where indirect methods (principally geophysical) provide the only realistic means of targeting. Regardless, I suspect that the majority of exploration projects worldwide encompass variable amounts of outcrop where mapping can still provide significant geological insight.

ALLEVIATING THE SITUATION

A clear message from industry

I expect that most senior exploration managers would concur to a large degree with the arguments above and, thus, a very clear message that affirms the importance of good-quality geological fieldwork and mapping is needed. Some companies promote this message very well, others less so. My personal experience indicates that, quite often, project geologists with several years' experience working for major companies are surprisingly deficient in basic mapping and field geological skills. Similarly, many company maps I review during consulting assignments and property evaluations (mainly, though by no means exclusively, in Latin America) seem to lack many of the fundamental attributes of well-crafted, coherent and, most importantly, exploration-oriented geological maps. This cannot bode well for any subsequent exploration efforts. So are senior managers "carrying the geological flag" and is the message really getting across?

A return to field-based mentoring and training

This message of reinforcing the value of high-quality geological fieldwork requires complementary action on the part of senior management if it is to be effective. Valuable in-field mentoring of junior geologists by more senior staff—which characterized many of the larger mining companies of yore—has all but died out, particularly with consolidation of the mining business and the commensurate reduction in the number of large mining houses having the wherewithal to develop and maintain a high standard of in-house, field-based training. This needs to be reinstigated either as in-house mentoring using company know-how or, particularly in the case of the smaller companies with more limited resources, by regularly bringing in experienced field-oriented consultant geologists for staff training. Taking advantage of the multitude of economic geology-oriented field trips now available can further support these efforts.

Geological mapping is a very particular blend of science and art, but is a skill that actually can be taught; however, mapping ability, like any acquired skill, will depend on experience and continual practice. In recent years, I have been increasingly called on to undertake applied geological mapping courses for both major and junior companies in various jurisdictions. Clients who request this training (a) recognize that discovery is only going to be made in the field and that geologists, therefore, should be active in the field, (b) show an unwavering commitment to technical geological excellence, (c) are aware of the added value that ongoing field training of their geological teams provides, and (d) generally offer long-term job stability and incentives, minimizing the chances that their highly trained staff will defect to higher bidders in the boom times. Most serious mining companies surely would aspire to these corporate philosophies.

The role of senior geologists

Senior company geologists need to occupy a position at the technical and creative epicenter of their exploration groups and adopt a more active role in transferring their knowledge and experience to junior geological staff, including a prominent supervisory role in the field, as was the case when I started out on my career in the late 1980s. More recently, I have quite often seen junior project geologists ploughing a lonely furrow and struggling to get to grips with technical aspects of the geology. A healthy balance between office responsibilities and the field needs to be agreed on between senior geologists and higher management, with the latter recognizing the value and importance of time spent in the field by their more experienced geological staff.

The right stuff for the job

Human nature dictates that not all geologists are going to make great field geologists and mappers, and colleagues have recently reminded me that reluctant mappers have, in fact, always existed! The ever expanding range of increasingly sophisticated tools available to the exploration geologist, many of which are developing into quite specialized subjects of their own, has provided unparalleled scope for career specialization that caters to all tastes: spectral studies, image analysis, lithogeochemistry, database management/GIS, and 3-D data modeling are prime examples. This specialization is likely to increase in the future with further emerging technology, and the need for well-coordinated teamwork, if exploration is to be really effective, has never been greater.

Even though, as geologists, we might aspire to be jacks-of-all-trades, it is now virtually impossible for individuals to master all the multidisciplinary techniques employed in exploration. Not surprisingly, the highly computer literate digital-age generation tends to gravitate toward activities incorporating this technology; geological mapping, while, to some extent, also moving with the digital age, might seem rather "low tech" by comparison. The corollary to this tendency is that those geologists passionate about field geology and determined to remain active in the field are, in effect, also becoming specialists in their own right. The industry needs to recognize these individuals early on and keep them motivated in their field-based activities via ongoing training, promotion, and rewards on a par with other specialists in the exploration team, as well as those in senior managerial roles. A technical career path should never be regarded as inferior in any way.

Computers and new technology... just more tools, really

My personal perception is that the decline in field geological and mapping

skills correlates very strongly with the ascendancy of the computer in the arsenal of tools available to the geologist and, understandably, the latter holds strong appeal to the younger, digital-savvy generation of explorationists. There is clearly a strong temptation to avoid or postpone the rigors of the field, deferring instead to computer-based work, with all its "high-tech" appeal, in the comfort of the office. This will be further fuelled, to some extent, by emerging technologies under development in response to the ever-increasing challenge of finding the remaining orebodies, many under cover and in "deep-Earth" settings.

Computing is an increasingly powerful tool in what we do and invaluable for integrating disparate information, but this should never be at the expense of the up-front fieldwork and collection of hard data that are relevant and reliable. Much of the data we process still have to be collected by humans in the field, where the geological context can be clearly documented. Of course, ever more sophisticated in-field technology for digital data capture is now available for the digitally minded field geologist if s/he wishes to go that route. Brimhall et al. (2006) have even suggested that digital field-mapping technology may in fact help attract the younger generation of geologists to fieldwork; this might be true, although I suspect most committed geological mappers are actually driven by other personal motivating factors.

However, technology should never become a distraction from the basic objectives. Both "low-tech" geological mapping and, for example, "high-tech" analyses of minerals in distal alteration halos are simply tools and methods which should be selected or combined on the basis of which in the end provides the most effective approach—i.e., gets to the ore deposit quickly and efficiently, given the particular scenario. It is important that field-based geological mapping, where relevant and feasible, is not unnecessarily "eclipsed" by other tools simply because the latter are technologically more sophisticated. Considerable advances can still be gained in most exploration situations from low-tech mapping, coupled with insightful modeling.

Computers simply organize and display data and—while of tremendous assistance, particularly with multiple data sets—they do not do the hard thinking or drive the imagination. This must come from the geologist. As discussed by Wood (2010), geological interpretation and the thought that goes into the accompanying visualization/targeting process foster a very particular form of creativity that is perhaps unique to resource discovery. This capability to visualize the orebody existed well before computers came on the scene and will become increasingly important in the next generation of deeper discoveries.

Being effective in the field

A recurrent issue reported by young staff and project geologists is the ever more limited time available to devote to technical work in the field. On numerous projects I have been involved with, project geologists keen to get out and map are frequently swamped with other often nontechnical responsibilities, including logistical and organizational tasks, as well as data management, monthly reports, and lengthy preparation of presentation material. Time-intensive geological mapping is thus relegated to the bottom of the pile and then frequently conducted in very piecemeal fashion, with all the inherent problems of continuity and consistency. The solution here is delegation of nonessential tasks and sensible prioritization of essential tasks. It is appreciated that the ever-present pressure of finite resources weighs heavily, particularly on the juniors, but the use of technical staff for nontechnical responsibilities clearly constitutes very inefficient exploration practice.

Constraints on time—or limited staff resources—are one of the major reasons geological mapping is increasingly contracted out to specialists. This is usually a cost- and time-efficient option but comes with the disadvantage that the unfortunate, office-bound, company geologists are not privy to the geological insight provided by mapping, do not advance their field skills, and become less capable of undertaking their own mapping in the future.

I often witness low productivity in the field, particularly where short shifts of fieldwork are involved, which, in some cases, are reduced to a week or less, with half of that time spent in mobilization. In some jurisdictions (e.g., Chile) these shift restrictions are legally imposed and generally apply to projects at high altitudes. Shift length must be set to strike a balance between achieving significant advances in quality fieldwork and what is considered to be a reasonable time away from home and family.

CONCLUDING REMARKS

The future of geological mapping and fieldwork applied to mineral exploration will depend on the capacity of our industry to find, train, and motivate the next generation of field geologists, who will, like their predecessors, undoubtedly play an important role in delivering the mines of the future, despite the increasing challenges this will entail. Keeping experienced eyes active in the field is key. As noted by Wood (2010), discovery cannot be taught as such, as it requires not only strong technical skills, but other special personal attributes which are not always easily defined. A comprehensive understanding of the nature and field characteristics of mineralized systems, based to a large degree on informed geological mapping and careful fieldwork, has served the industry well in the past and will remain a crucial step on the pathway to discovery.

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