

## *Geological-reasoning training as preparation for the “thinking warfighter” in the next-generation military<sup>1</sup>*

Alexander K. Stewart, PhD, U.S. Army (retired)

### **Introduction**

In the modern, asymmetric battlefield environment unimagined missions are occurring faster than the military can train their forces in their traditional schools.<sup>2</sup> Since the 1990s, militaries have made the connection between the rapid evolution of technology and the flood of information it generates. This rapid onslaught of technology-driven information and equipment, in addition to the loss of Cold-War tactics and strategies, has forced, for example, the U.S. military to train and equip a modern, thinking force able to operate “on its feet” in multinational operations.<sup>3,4</sup>

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<sup>1</sup> This manuscript is based on the author’s experiences as a “thinking soldier” in Afghanistan with the Texas ADT (143<sup>rd</sup> Infantry, Long-Range Surveillance, 82<sup>nd</sup> Airborne Division). Thanks to Dr. Peter Doyle, *Geology Today*, for a first look at this idea and Dr. Dean Eppler, NASA, for insight into astronaut training and geological reasoning. I’d also like to thank St. Lawrence University for travel support. Thank you to my brothers-in-arms and fellow Texas geoscientists SFC Robert Becknal and SGT Todd Plybon; sounding board CPT Neal Litton and, *in memoriam*, my fellow “thinking soldiers,” SSG Christopher N. Staats and A. Gabriel Green who were killed in action (16OCT09) while on a mission for the people of Afghanistan.

<sup>2</sup> Sharon Riedel, “Training critical thinking skills for battle command: how to think, not what to think,” *ARI Newsletter 2* (2001): pp. 7-10.

<sup>3</sup> Marvin S. Cohen, Eduardo Salas and Sharon L. Riedel, “Critical thinking: challenges, possibilities and purpose,” U.S. Army Research Institute Technical Report 02-1 (2002): <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.136.8771&rep=rep1&type=pdf>

“Thinking,” as a result, should not be required only of the strategist (i.e., commissioned officers), but also of the ground-operator or tactician (i.e., enlisted), who for thousands of years has been thought of as reactionary—not proactionary. As a result, all soldiers need to have mental adaptability, or an intellectual agility to plan (officers) and execute (enlisted) missions in an ever-changing environment. As a first step toward developing an all-thinking military, the U.S. Army successfully implemented Agricultural Development Teams (ADT) in support of the War in Afghanistan. These ADTs were small, self-sufficient, counterinsurgency teams driven by 12 agriculture-related experts. The best prepared of whom were the requisite geologists, who made up to 25 percent of the teams strength. In an effort to win the hearts and minds of the local populace in Afghanistan, this counterinsurgency tool helped military leadership realize the potential of a thinking warfighter on the battlefield.

### **Critical Thinking**

As commanders struggle to prepare soldiers to deal with unimagined missions that are occurring more rapidly than training opportunities<sup>5</sup>, they have realized that critical-thinking skills are the key to a new, “thinking warfighter.” Critical thinking is a process or method of thinking, which has been traced in Western thought to the Socratic method of ancient Greece.<sup>6</sup> In the modern era, critical thinking is becoming an important component of most professions; typically, developed at the university level. Critical thinking has been defined many ways, but is basically a “rational response to questions that cannot be answered definitively and for which all the relevant information may not be available”<sup>7</sup> using cognitive skills or strategies that increase the probability of a desired outcome; it is purposeful, reasoned and goal oriented.

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<sup>4</sup> Robert Pleban, “Training small unit leaders adaptive thinking skills.” *ARI Newsletter* 17 (2007): pp. 1-4.

<sup>5</sup> Sharon Riedel, “Training critical thinking skills for battle command: how to think, not what to think,” *ARI Newsletter* 2 (2001): pp. 7-10.

<sup>6</sup> Daniel Fasko, “Critical thinking: origins, historical development, and future directions,” In *Critical thinking and reasoning: current research, theory, and practice* 3rd edn., ed. Daniel Fasko (Cresskill, NJ: Hampton Press, 2003), pp. 3-17,

<sup>7</sup> Joanne G. Kurfiss, “Critical thinking: theory, research, practice, and possibilities.” *ASHE-ERIC Higher Education Report No. 2* (Association for the Study of Higher Education, Washington D.C., 1988), p. 20.

Critical thinking is too important to be left to chance; however, there are concerns about its usefulness in the battle context and the time-and-training resources required to develop these skills in the modern soldier. Despite these concerns, the U.S. military is continually developing and employing counterinsurgency (COIN) techniques under an expeditionary mindset<sup>8</sup>, which relies on critical thinkers to help win the hearts and minds of the local people.

### Counterinsurgency

Counterinsurgency is a comprehensive civilian and military effort taken to simultaneously defeat and contain insurgency and address its core grievances.<sup>9,10,11</sup> As a result, COIN is primarily political and incorporates a wide range of activities, of which security (ground troops) is just one. In order for COIN operations to work, in general, a unified action is required where the host nation works with U.S. and multinational agencies. In order for this to be most effective, operational conditions must allow a civilian agency to lead the effort. This cannot be initiated until the operational area is safe and relatively stable.

COIN requires that joint forces fight and build sequentially or simultaneously (depending on security and other factors) with offensive and defensive operations against insurgent combatants or guerillas. These stability operations address the core problems as well as the drivers of the conflict, so they are essential to long-term success. This long-term success, however, is dependent upon successful COIN operators. These COIN operatives (ground forces) require a comprehensive understanding of the insurgents, the scope of the insurgency and external, environmental elements. These

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<sup>8</sup> Patricia M. Shields, "An American perspective on 21st century expeditionary mindset and core values: A review of the literature," In *Core values and the expeditionary mindset: Armed forces in metamorphosis*, eds. Henrik Fürst and Gerhard Kümmel (Berlin: Nomos Publishers, 2011), pp. 17-34,

<sup>9</sup> Department of the Army, *Counterinsurgency: Field Manual 3-24* (Washington, D.C. . 2006 (updated in June, 2014 as *Insurgencies and Countering Insurgencies*)).

<sup>10</sup> Joint Chiefs of Staff, *Counterinsurgency operations: Joint publication 3-24* (Washington, D.C.), updated in June, 2014 as *Insurgencies and Countering Insurgencies*.

<sup>11</sup> U.S. Government Department of State, *Counterinsurgency guide* (Bureau of Political-Military Affairs, 2009).

operatives must also be adaptable and flexible of mind with compassion and understanding of the host-nation culture.<sup>12</sup> As a result, only the on-the-ground operators (tacticians) are privy to collecting and managing geospatial and human intelligence sources.

Because of this battle environment and approach to fighting modern wars with a bottom-up flow of intelligence provided by field operators, COIN requires that regular soldiers have the following skills (among others)<sup>13</sup>: 1) have a comprehensive knowledge of the operational environment, 2) an adaptable and flexible mindset, and 3) be able to constantly learn and adapt. Combined, these feed the bottom-up flow of geospatial intelligence, which is the foundation of COIN operations.

### **Current Training Strategy**

Although the U.S. military has formally recognized the connection between critical thinking and the modern operating environment, they are, understandably, struggling to implement these skills in their training programs.<sup>14,15</sup> The current strategy is to “train the trainer,” by providing critical-thinking-skills training, for example, to instructors of the U.S. Army Medical Department Center and School (AMEDDC&C) and the Command and General Staff Officer Course (CGSOC).<sup>16</sup> Unfortunately, these trained trainers are only being prepared for a few field-grade officer schools, thus leaving over 95 percent of the U.S. Army without explicit training in how to reason and think. With these officers learning to manage troops in this new battle space, the Army is neglecting the bottom-up flow of intelligence/observations/syntheses required by COIN of the tactician.

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<sup>12</sup> Ibid.

<sup>13</sup> Ibid.

<sup>14</sup> Charles D. Allen and Stephen J. Gerras, “Developing creative and critical thinkers,” *Military Review* (November-December, 2009): pp. 77-83.

<sup>15</sup> Walter R. Schumm, Farrell J. Webb, David E. Turek, Kenneth D. Jones and Glenn E. Ballard, “A comparison of methods for teaching critical thinking skills for U.S. army officers,” *The American Journal of Distance Education* 20 (2006): pp. 39-50.

<sup>16</sup> Susan C. Fischer, V. Alan Spiker and Sharon L. Riedel. *Research Report 1881: Critical thinking for army officers, volume one: overview of research program* (U.S. Army Research Institute for the Behavioral and Social Sciences, 2008).

*The Fix–geological reasoning, what is unique about it?*

Geological reasoning is a deductive process based on a synthesis of the other physical sciences.<sup>17</sup> The uniqueness of geoscience training, however, lies in its interpretive and historical approaches<sup>18,19</sup> and has been recognized as the “the most useful of all the sciences to a soldier” since at least the middle of the 19<sup>th</sup> century.<sup>20</sup> This training is probably best specified in a paper by Kastens et al. where they suggest geosciences are unique in that their training is founded in four areas: 1) chronological thinking at the geological scale, 2) understanding the Earth as a complex system, 3) using the field environment as a learning tool and 4) the requirement of spatial thinking.

This educational mix of approaches allows geoscientists to “stack observations” by assigning different values to various observations, judge their worth, re-evaluate and hone in on a plausible explanation proportional only to the evidence. These observations and evaluations are placed in a chronological and spatial framework where particular events occur in a particular four-dimensional space. As a result of this flexible approach to problem solving, geoscientists typically approach problems using *bricolage*, an intellectual toolbox that contains a variety of tools selected as appropriate to the job at hand.<sup>21</sup> This multivariate approach to problem solving is paramount in an ever-changing world where data and observations are limited to time, space and support. Real-world problems rarely have a “correct” answer<sup>22</sup>, so assessment of ideas based on probability is reasonable, pragmatic and the specialty of the geoscientist.

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<sup>17</sup> W.H. Bradley, “Geologic laws,” In *The Fabric of Geology*, ed., Claude C. Albritton (Boston: Addison Wesley Publishing Company, 1963), pp. 12-23.

<sup>18</sup> Robert Frodeman, “Geological reasoning as an interpretive and historical science,” *Geological Society of America Bulletin* 107 (1995): pp. 960-968.

<sup>19</sup> Robert H. Dott, “What is unique about geological reasoning?” *GSA Today* 10 (1998): pp. 15-18.

<sup>20</sup> F.W. Hutton, “The importance of a knowledge of geology to military men,” *Journal of the Royal United Service Institution* 6 (1863): pp. 342-360.

<sup>21</sup> Robert Frodeman, “Geological reasoning as an interpretive and historical science,” *Geological Society of America Bulletin* 107 (1995): pp. 960-968.

<sup>22</sup> Wayne Powell and David Leveson, “The unique role of introductory geology courses,” *Journal of Geoscience Education* 52 (2004): pp. 301-305.

## Examples of Success

There has been a long-standing connection between the military and the geosciences. These connections have been thriving since WWII when the US Geological Survey supported the war effort with the first “Military Geology Unit,” a civilian “unit” of over 100 geoscientists who supported the war effort and proved the relevance of geoscience to the battlefield. Other connections are best highlighted in *Military Geology in War and Peace*<sup>23</sup>, which reveals how geoscience has shaped warfare for centuries.

The best evidence of successful implementation and use of geological-reasoning training by a government for its “soldiers” was completed as preparation for NASA Apollo astronauts during the 1960’s.<sup>24</sup> Before Apollo crews were selected from military personnel in the late 1960’s, many astronauts to that point had completed an intensive classroom and field-course curriculum in geology training. This curriculum comprised over 130 hours of lecture instruction, plus more than 15 field trips to support field observations, verbal description and sampling skills.<sup>25</sup> These skills built upon the basic observational skills of once-test pilots allowing them to determine what was important on the Moon and how to deal with it. Currently, NASA is developing new geological curriculum to train astronauts in the tools and techniques of geoscience exploration.<sup>26</sup> The focus of this training program is lecture and field oriented with geoscience problem recognition and solution as critical capabilities. Astronauts are no longer just engineers and pilots, but observational scientists with a focus on geoscience skills who will work the most important missions ever devised.<sup>27</sup>

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<sup>23</sup> James R. Underwood and Peter L. Guth *Military Geology in War and Peace, Reviews in Engineering Geology XIII* (Boulder, CO: Geological Society of America, Inc., 1998).

<sup>24</sup> David S. McKay, “Geology training of astronauts prior to Apollo crew selection,” (Paper presented at the annual meeting for the Geological Society of America, Houston, Texas, October 5-9, 2008).

<sup>25</sup> Ibid.

<sup>26</sup> M. A. Helper, H. H. Schmitt, W. R. Muehlberger and A. W. Snoke, “Astronaut geological training for lunar exploration.” (Paper presented at the NASA Advisory Council Workshop on Science Associated with the Lunar Exploration Architecture, Houston, Texas, February 27-March 2, 2007).

<sup>27</sup> Dean B. Eppler, Andrew Feustel, J. Mark Erickson, Kip Hodges, Laszlo P. Keszthelyi, Mark Helper, William R. Muehlberger, William Phinney, Art Snoke and Barbara J. Tewksbury, “Apollo/Constellation geologic training workshop: reviewing Apollo’s accomplishments and preparing a new generation of

On the battlefield, the U.S. Army put geoscientists to the test. From 2008 to the end of the War in Afghanistan, the U.S. Army, in conjunction with the Army National Guard, developed and employed Agricultural Development Teams (ADT) to Afghanistan. These specialized U.S. Army teams comprised 12 hand-selected, civilian-soldier experts in the agribusiness field; supported by an organic security team and a headquarters element.<sup>28</sup> As an egalitarian team, these soldiers worked directly with both regional and local Afghanistan government officials and farmers to support their agricultural needs. ADTs provided agriculture-related education, training and sustainable projects, which were US funded and locally operated and maintained. As of the end of 2014, nine states have supported the ADT mission (e.g., Texas, Kentucky and Tennessee) providing a total, thus far, of 49 teams that operated in 15 provinces and contributed over 680 agriculture-related projects, which generated over \$42 million in economic impacts for the people of Afghanistan.<sup>29</sup>

Team soldier-experts, for example, worked, when not deployed, as professionals in the following fields (by team strength): geoscience (up to 25 percent of strength), agronomy, veterinary science, engineering, agricultural marketing, and pest management.<sup>30</sup> The civilian and military planners who implemented these teams in 2008 got it right—an emphasis on traditionally trained, quantitative describers of observations who are well-versed in critical thinking—the geoscientists. Due to the flexibility of the geoscientist’s mindset and training, they worked a variety of missions—way beyond their traditional expertise—and with astounding ease and success. Typical projects run by geoscientists ranged from delay-action dam emplacement planning to mineral-resource reconnaissance to environmental protection projects and general

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geologic explorers for Lunar field geology,” (Paper presented at the annual meeting for the Geological Society of America, Houston, Texas, October 5-9, 2008).

<sup>28</sup> Center for Army Lessons Learned, *Afghanistan Agribusiness Development Teams*, Handbook 10-10 (Washington, D.C., 2009).

<sup>29</sup> National Guard Bureau, “National Guard Bureau Posture Statement: Sustaining an Operational Force,” 2014. Accessed January 15.

<http://www.arng.army.mil/News/publications/ApostureStatements/2014/Posture%20Statement%20FINAL%20hires.pdf>

<sup>30</sup> Alexander K. Stewart, “U.S. Army Agriculture Development Teams: A Grassroots Effort in Afghanistan Supporting Development and Tackling Insurgency,” *Science & Diplomacy* 3 (2014): pp. 70-87.



agricultural projects such as animal husbandry, irrigation and infrastructure support.<sup>31</sup> Geoscientists thrive in this type of environment—one requiring critical thinking and the use of *bricolage*.

### *Quo Vadis*

As a result of changes in the military mindset from conventional to expeditionary<sup>32</sup>, geoscience training during high school and/or college can be crucial in preparing enlistees to be ready-made critical thinkers. Unfortunately, high schools are not preparing students (i.e., future enlisted troops) in the geosciences the way they would physics, chemistry and/or biology, thus, reducing the attraction to major in geoscience if/when they go to college (enlisted/officers).<sup>33,34</sup>

With the U.S. Army working to develop critical thinking in their field-grade officers who will command soldiers in bottom-up COIN environments, something is amiss. Although troop management and mission management is crucial to winning the battle, so, too, is the movement of real-time information up the chain of command, which directs this management. With much reliance on high-school training to develop these sought-after critical-thinking skills, it would be beneficial for both high schools and colleges to increase their efforts to provide geoscience courses (geological-reasoning training) at the appropriate level(s). As of 2009, geoscience makes up only ~0.185 percent of baccalaureate graduates, 0.563 percent for Science, Technology, Engineering and Mathematics (STEM) or ~12.6 percent of physical science graduates.<sup>35,36</sup> High schools are no better, for they typically provide geoscience classes to the “weaker”

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<sup>31</sup> Richard Stone, “Soldier-scientists join counterinsurgency in Afghanistan,” *Science* 342 (2013): p. 682.

<sup>32</sup> Patricia M. Shields, “An American perspective on 21st century expeditionary mindset and core values: A review of the literature,” In *Core values and the expeditionary mindset: Armed forces in metamorphosis*, ed., Henrik Fürst and Gerhard Kümmel (Berlin: Nomos Publishers, 2011), pp. 17-34.

<sup>33</sup> Wendy van Norder, “Problems in geology education: our high schools are the weakest link,” *Palaios* 1 (2002): pp. 1-2.

<sup>34</sup> Julie Thomas, Toni Ivey and Jim Puckette, “Where is earth science? Mining for opportunities in chemistry, physics and biology,” *Journal of Geoscience Education* 61 (2013): pp. 113-119.

<sup>35</sup> United States Census Bureau, “Statistical abstract of the United States: section 4, Education,” 2012. Accessed January 15. <http://www.census.gov/prod/2011pubs/12statab/educ.pdf>

<sup>36</sup> American Geosciences Institute, “US degrees granted in the geosciences 1973-2009,” 2009. Accessed January 15. <http://www.agiweb.org/workforce/Currents/Currents-023-Enrollments2009.pdf>



students for half the time (i.e., 0.5 credits versus 1.0 for physics, chemistry and/or biology) and too early in their education (i.e., 9<sup>th</sup> grade, if taken). An increase in exposure at the high school level may result in an increase in the pursuit of a geoscience discipline during college. With geoscience at the fore in the modern, environment-conscious world, preparation of geoscience minds will greatly benefit the world and the military by helping prepare critically thinking minds, which can think and adapt to new situations without problem-specific training.

It would be optimal if soldiers were introduced to and began developing critical-thinking skills in their non-military schooling (e.g., high school and college); no discipline better covers these aspects than the geosciences. The geoscientist is a traditionally trained, quantitative describer of observations who is well versed in critical-thinking skills. Based on current research, the best way to develop critical-thinking skills is by: a) using a multidisciplinary approach, b) applied in a contextual environment and c) using encouragement and motivation. No other academic discipline is more multidisciplinary than the geosciences—covering all the natural sciences from physics, chemistry and biology. Regarding contextual environment, mental development of geoscientists is founded on context. Geoscience is spatially oriented and requires the mental flexibility to predict, postdict and interpret in four dimensions using field- and lab-based observations. Geoscientists are the best prepared to tackle operational changes that are greater and more rapid than training opportunities. Their ability to think quantitatively, objectively and descriptively has been shown to be a winner for the military as highlighted by the recent Agriculture Development Teams in Afghanistan.

## **Summary**

The problem of no critical-thinking skills being trained in army service schools is left to pre-entry education. Currently, the U.S. Military Academy at West Point graduates approximately 35 (3 percent total graduating body) environmental science/engineering students per year with an additional 150 (14 percent) who have also

had a three-course primer on geoscience thinking.<sup>37</sup> These are good starting figures for pre-developing these critical-thinking skills before soldiers enter the battle space. Unfortunately, however, these students invariably ask the question, “how can I use this major [or these skills] in the military.” The lesson they will learn on or off the battlefield is that, it’s not their academic major that matters, it’s the observational, quantitative, descriptive and contextual training used to develop their major. Overall, soldiers are getting smarter with an ~3 percent increase in recruits with some college education and a full 98 percent having completed high school (cf. 75 percent of non recruits)<sup>38</sup>; now, lets help them think critically in a flexible and adaptable way.

What these soldiers need to do once they have these skills is to convince their commander(s) of their abilities and to flex their mental muscles wherever they are—on or off the battlefield.

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<sup>37</sup> Marie Johnson, E-mail message to author, October 11, 2011.

<sup>38</sup> Tim Kane, “Who bears the burden? Demographic characteristics of U.S. military recruits before and after 9/11,” 2005. Accessed January 15. [http://s3.amazonaws.com/thf\\_media/2005/pdf/cda05-08.pdf](http://s3.amazonaws.com/thf_media/2005/pdf/cda05-08.pdf)