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CONNECTIONS BETWEEN THE GEOLOGICAL SCIENCES AND VISUAL ART: HISTORICAL PERSPECTIVES AND PERSONAL EXPRESSION IN ARTWORK

Othmar T. Tobisch*

Abstract — *Visual art and the geological sciences share common threads that are worthy of exploration. In the first part of this article, I give a brief and selective historical perspective of interaction between these two disciplines, beginning with the cave paintings of Lascaux some 15,000 years ago, in aspects of Chinese art, in Leonardo da Vinci's work, in nineteenth-century landscape painting, and in various features of twentieth-century art.*

In the second part, I briefly consider how aesthetics entered into my scientific work and give examples of my current photography, painting, and constructivist sculpture. Most of these works contain conceptual or physical components of rock at some level. I discuss the potential for using geological concepts and materials as metaphors of the human condition, the human transformation, and inner exploration directed toward self-knowledge.

I. INTRODUCTION

Such seemingly disparate disciplines as visual art and the geological sciences may appear unlikely mates. Yet in my experience, there are some common threads between these areas of activity which are worthy of bringing into one's awareness. Indeed, my own involvement in visual art and geological science is resulting in a symbiotic and creative interchange between the two. The geological sciences consist of a spectrum of subdisciplines [1]. These subdisciplines all deal with the nature, composition, and genesis of rocks.

Prior to about the fifteenth century, the role of rock in visual art was expressed in several obvious contexts, for example as artistic and architectural medium, in the derivation of pigment from the weathering product of rock, and in the portrayal of distinctive rock forms in Chinese landscape paintings. From the fifteenth century onward, perhaps starting with Leonardo da Vinci's artistic and scientific investigations in geology, artists have shown an increasing awareness of the geological characteristics of rocks and the processes which form them. This awareness was considerably expanded in the nineteenth century, when the geological sciences were developing as independent disciplines. In the twentieth century, a wide variety of artistic work displays an interface with the geological sciences on levels ranging from simple use of rock as medium to sophisticated use of geological metaphor.

II. HISTORICAL PERSPECTIVES

The connections between visual art and rock can be traced back to the very inception of art in the caves of Lascaux and Alta Mira some 15,000 years ago [2]. On the rock walls at these sites primitive people first inscribed their simple yet elegant figures with pigments taken from weathered rock (hydrated and nonhydrated iron oxides). While it is likely that these artistic acts were done in the context of ritual rather than for the sake of art as we know it, they nevertheless represent some of the first attempts at abstraction and representation, processes basic to art [2]. Some examples of this early art show how natural rock forms influenced these 'proto-artists', for example, certain rock forms suggested specific anatomical parts of animals (see [2] Figs. 1–4,) and were utilized as such in the rock painting.

Man has long utilized rock as a medium in his ritualistic and (later) artistic activities. Throughout much of antiquity, rock was regarded as unchanging, solid, indestructable, and hence symbolic of the eternal or divine, qualities men wanted their gods to maintain through time [3].

In Egypt and Greece, the limestone, marble, and sandstone quarried there have been immensely important in the development of sculpture and architecture since long before the time of Christ. The marbles of Italy played a similar role in later centuries. Artisans working with these materials must have known something about the quarrying characteristics of the rock, as well as its ability to resist weathering, the ease with which it can be cut, its ability to retain detail of form, and so forth. Their initial understanding of the physical properties of the rock, albeit primitive, was perhaps a first step towards man's more sophisticated knowledge of the earth's crust. As Cyril Smith pointed out "...the man who moulded clay into a fertility figurine was simultaneously an artist, a scientist learning to understand the properties of matter, and a technologist using these properties to achieve a definite purpose" [4]. What the early artisans learned concerning the suitability of materials for artistic or architectural purposes probably reflected certain geological or geochemical characteristics of the rock, some of which are used by scientists today to help establish sites of origin in archeological or art history studies [5].

In the Far East, the distribution and nature of the geological landscape strongly influenced the development of various arts in China. For example, the presence of certain rock types bearing tin and copper in the T'ung Shan mountains of eastern China provided the necessary raw materials for developing bronze in the An-Yang area (directly west of T'ung Shan), the center of bronze casting during the Shang dynasty (*ca.* 1523–1028 B.C.) [6]. The ceramics of China, begun as early or earlier than the bronzes, developed relatively quickly in that country. One reason for this is probably that two huge rivers (the Yellow and the Yangtze, which drain the majority of the landmass of China) provided large deposits of high-quality clay. In addition, significant parts of these deposits were high kaolin clay, a clay type essential for the high temperature firing necessary to produce translucent, very hard ceramic and high quality, impervious glazes [7]. The erosion of a landmass of highly diversified geological formations like China [8] may also have

*Artist, geologist and teacher, Earth Science Board, Applied Science Building, University of California, Santa Cruz, CA 95064, U.S.A.
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provided a wider range of material from which artists could develop pigments to incorporate into their glazes.

Jade, so prized in China and an important medium in Chinese art, is a rare raw commodity in that country. In fact, the only jade available for several millenia was of the nephrite variety [9], which had to be transported by ox cart, boat and foot from the Yarkand-Khotan area of far western China to the more populated eastern areas, a distance of over 3000 km [10]. It was not until the eighteenth century that other jade deposits were found, notably in Burma and in southern China. This jade was formed by the mineral jadeite [9]. The scarcity of jadeite is due to China's geology. Jadeite is a mineral formed at very high pressures, most commonly in areas of the earth's crust known as subduction zones [11]. There is little evidence for ancient subduction zones over large parts of the Chinese continent, although recent research shows the presence of these zones in southern China [12]. Since jade was such a rarity, its value was analogous to that of gold in the western world. It became an indication of wealth and status, in addition to its important role in Chinese art from Shang times onward [6, 10].

Perhaps the most prominent influence of geological phenomena on Chinese art is in landscape painting, which began during the T'ang dynasty (*ca.* 618–907 A.D.), reached its peak in the Sung dynasty (*ca.* 960–1280 A.D.) and continues to the present day [13]. Much of the southern part of China is underlain by limestone deposits which rapidly dissolve in its humid, semi-tropical climate. The dissolved rock forms sink-holes, underground caverns, and, if it progresses to 'mature' or 'old' stages, produces towers which rise above the surrounding terrain. These landforms are commonly referred to as karst topography [14]. In the southern Chinese provinces of Yunnan, Kweichow, and Kwangsi, karst towers are developed on a spectacular scale, some reaching heights of up 600 feet (200 meters), a most striking sight to behold (Fig. 1). These towers are common features in much Chinese landscape painting, often surrounded by wispy clouds formed during a recent shower. What many western observers of Chinese art may have thought was a peculiar fantasy landscape is indeed based on the occurrence of this karst topography.

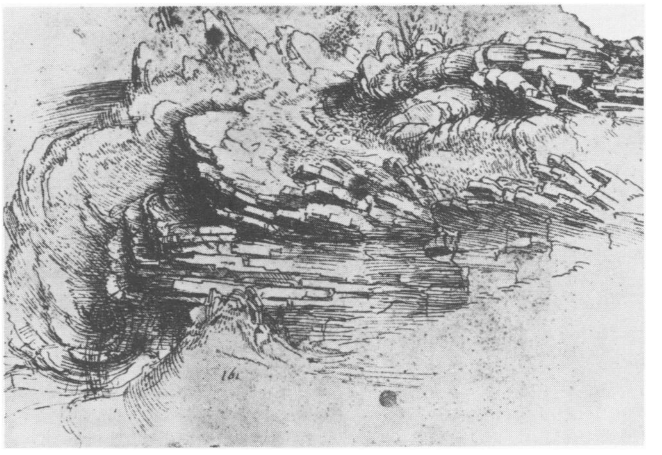

Fig. 2. Leonardo da Vinci, 'Study of Rock Formations', pen and ink over black chalk, 18.5× 26.8 cm, 1510–1513 Windsor, Royal Library, No. 12,394. Reproduced by gracious permission of Her Majesty Queen Elizabeth II.

While some Chinese artists rendered accurate portrayals of biological life during the early part of this millenium, the rock formations in their landscape painting were often idealized or generalized, and in fact painters were known to follow certain rules regarding such matters as what to include in the scene [13, 15].

Perhaps the first artist to study rocks and accurately draw their characteristics was the namesake of this journal, Leonardo da Vinci. Leonardo carried out extensive investigations of geological phenomena and the processes which brought them about [16–19]. In most instances, he used sketching and drawing to study the rock, and some of his drawing clearly shows that he perceived the stratified nature of rock, and was aware of its folded nature in mountains (Fig. 2). His drawings of mountains were also accurate and his notebooks indicate an understanding

Fig. 1. Karst towers along the Li River south of Kwei-ling, Kwangsi Province, southern China. Towers probably exceed 150 meters in height. Photograph by R. S. Coe.

of their formation that was way ahead of Leonardo's time [17]. It has been pointed out, however, that in his paintings, Leonardo's renderings of mountains are not realistic and show distortions in stratigraphy and in geomorphic features [18]. His notebooks indicate that his interest in geology stemmed from his dislike of mountains (common among Renaissance intellectuals) and an obsessive fear of floods generated by swollen streams [18]. As Popham noted, there is a "...difficulty in drawing a line between the strictly (scientific) and the purely artistic" in a number of Leonardo's works [19]. It has been suggested that Leonardo's considerable knowledge of geological strata and landscape configuration, as shown in his drawings, was not ignored in his painting, but was "used in the service of his imagination" [20].

In the approaches of both Leonardo and nineteenth-century landscape artists in America, there was a desire to study and understand nature's workings through the process of art. However, the American artists were strongly influenced by the religious idealism of the period. Nineteenth-century attitudes towards landscape painting in America had a firm foundation in the "unity of faith, art, and science" [21]. Many American landscape artists of the nineteenth century were acquainted with the emerging science of geology, and the prevailing world view fostered an atmosphere for artists to seek new concepts and awareness concerning evolution of the geological landscape and to reflect these in their paintings. Thomas Cole, the father of the Hudson River School of painting, for example, possessed books on geology. He showed his interests in keeping up with recent scientific advances by visiting and corresponding with Benjamin Silliman, professor of chemistry and natural history at Yale and first president of the Association of American Geologists [21]. The British scientist Charles Lyell, whose book *Principles of Geology* (1830) influenced Darwin's thought, was also well respected in American artist circles [21] and associated in various ways with American painters. In the leading art journal of that time (1859), *The Crayon,* an article appeared entitled "The Relation between Geology and Landscape Painting". The title indicates that the study of geology was in the artist's mind, not only as an influence in his art, but suggesting that "perhaps unintentionally, he (the artist) is a geologist" [21]. This likely holds true for many well known American landscape painters, such as Cole, Asher Durand, Albert Bierstadt, Thomas Moran,

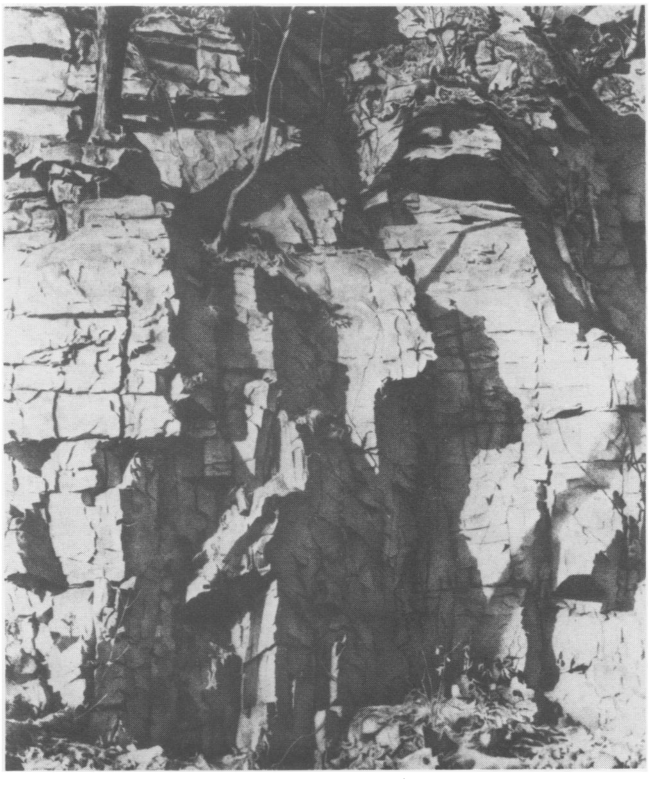

Fig. 3. Charles Sheeler, 'Rocks at Steichen's', conte crayon, 27× 22 cm., 1937. Reproduced with the permission of Alan Gussow, Friends of the Earth from A Sense of Place, The Artist and the American Land *(1972).* [24].

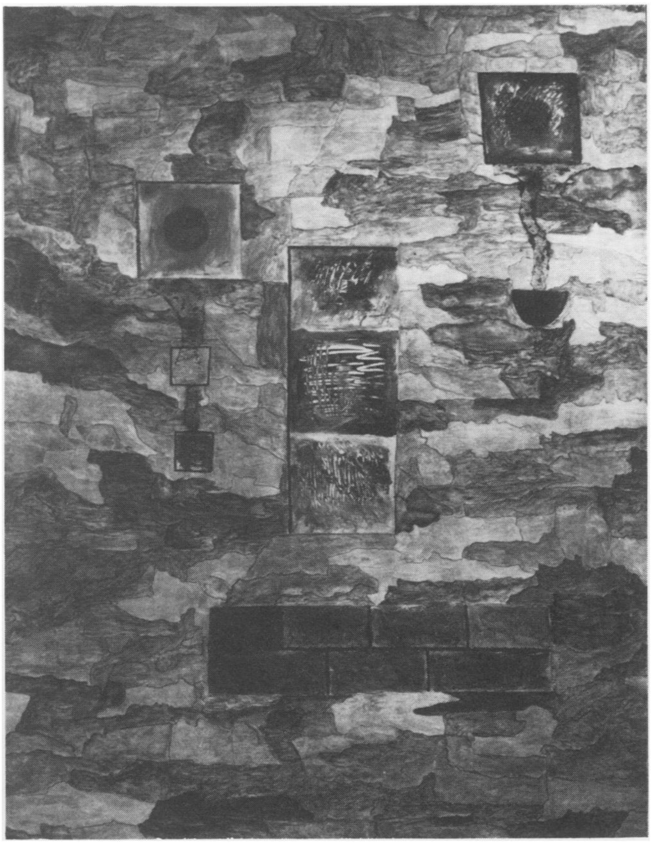

Fig. 4. 'Man Weeping', acrylic paint, watercolor, graphite stick, tissue paper, torch on paper, 112 × 91 cm, 1980–81.

and Frederic Church. Even lesser-known landscapists show this influence, such as Charles Dix in his painting 'Marblehead Rocks' (1868), which exhibits a clear awareness of structure and erosional characteristics developed in the rock faces [22].

While artists such as Durand and Dix accurately portrayed the rocks and landscapes, religious idealism had a strong effect on many others. Numerous works of nineteenth-century landscapists reflect a heroic attitude toward their landscapes, and distortions of scale and somewhat inaccurate renderings of geological phenomena are not uncommon. For example, Albert Bierstadt's painting 'Mt Whitney—Grandeur of the Rockies' (1875), shows what appears to be an exaggeration in vertical scale that looks unreal. Clarence King, noted nineteenth-century geologist with whom Bierstadt spent some time, reportedly commented that in some of Bierstadt's paintings "he substituted cream-puffery for geology" [23]. In a comparable manner, rock formations in Thomas Cole's allegorical work 'Expulsion from the Garden of Eden' (1827–28) exhibit strange erosional characteristics and appear fabricated to meet the artist's compositional demands for allegory.

Because advances in the geological sciences within this century have been widely disseminated throughout society, artists today show a heightened awareness of the evolving earth. Accurate renderings of rock formations, for example, minus the heroic qualities of last century's landscapists, are one direct expression of artists' continuing interest in rock forms. The American artist Charles Sheeler, perhaps best known for his urban landscapes, was also a keen observer of nature [24]. His crisp drawing 'Rocks At Steichen's' (1937), done nearly half a century ago, shows his acute perception of rock structures and the way that rocks weather with time (Fig. 3). The structural characteristics and weathering history of rock have also influenced sculptors such as Henry Moore and Max Ernst, whose tendency in some works was to let the rock "express itself" [25, 26]. Some of Joan Miro's pieces directly or indirectly reflect the shapes of stones picked up on the beach during his daily strolls [26]. Numerous other examples could be cited.

The Earthworks or Earth Art of the 1960s and 1970s shows one of the more provocative influences of the geological sciences on twentieth-century artists. With due recognition to artists such as Walter de Maria, Michael Heizer, Dennis Oppenheim, Robert Morris, Mark Boyle, and Christo who have contributed to that movement [27], Robert Smithson stands out as an Earthworks artist who dealt with the geological aspects of his art in a most profound manner. Smithson showed an interest in natural history from an early age and made frequent visits to the Museum of Natural History in New York City [28]. He possessed numerous geology books, which he consulted in developing his ideas and commonly employed in site descriptions [29]. On a deeper level, Smithson used geological concepts such as crystallography (crystal lattice), mineralogy, paleontology, and physical processes such as entropy, sedimentation, oxidation, hydration, and solution as metaphors in his visual art and his writings. Smithson frequently used geologic time as a base line to speak of the human condition in terms of a coextensive world stretching between prehistory and the modern world in which he lived [30]. Smithson's vision had an important impact on contemporary artists [28, 31]. This aspect of his work and the depth with which Smithson used geology in his art is beyond the scope of this paper. The reader is referred to recent publications concerning Smithson's work [28, 32].

III. EXPLORATIONS IN SCIENCE AND ART

My scientific work is principally in structural geology, the investigation of three-dimensional aspects of the earth's crust and the mechanisms which deform rocks [33]. This field has direct application to another of my research interests, how mountain belts of the world have evolved throughout geologic time. While these subjects are intellectually stimulating, geology is also visually stimulating. This is especially true of structural geology, which deals with wave forms (folds) in space, and textural aspects of rock. As I have already discussed this in a previous paper [34], I will only note here that the color, texture, and form of rock—aesthetic qualities that are obviously vital to visual art—initially seduced me into studying the earth as a

Fig. 5. Untitled, cibachrome print, 22 × 33 cm, from the series 'India: Doors, Walls and Windows', 1981.

scientist. These aesthetic qualities of rock continue to promote my scientific studies. In the words of Cyril Smith, "creative discovery in any field is a matter for the whole man not his intellect alone" [35].

For example, some years ago I carried out geological work in the Scottish Highlands. While writing up the material for publication, I decided that drawing the geological structures in three-dimensions would help the reader. The rock structures subsequently portrayed show a fluidity of form that reflects their mode of origin. Even today, nearly two decades later, observing them still evokes in me a sense of wonder akin to viewing an impressive sculptural piece for the first time. In addition, I am boosted by having access to an intellectual understanding of how the forms came about, which includes their documentation [36].

The function of intuition in scientific discovery is well known [37], and its role in my geological work has also contributed to the aesthetic satisfaction I derive from scientific work. Intuition played a particularly important role in one geologic mapping project I carried out in the southern Appalachians, where after a relatively short period of field work the larger geologic picture suddenly became apparent. This involved using my intuition to picture the three-dimensional configuration of structures in space, based on limited observations. The remainder of the field work, which lasted many months, involved documenting that intuited vision and supporting my field data with thorough laboratory investigation [38]. Such is the way of scientific inquiry. Yet here is an instance in which aesthetic insight laid the groundwork for more complete intellectual understanding of the problem at hand. That aesthetics play a precursory role to much scientific discovery has been well documented [4].

Working in the scientific mode regardless of the aesthetic components did not prove satisfying enough for me, and neither, one might speculate, was it for Leonardo. This genius used his art to study nature, and, as he insisted in his notebooks, his scientific studies were directed at improving his painting [39]. Yet his accurate sketches and drawings of mountains were not directly employed in painting his mountainous background landscapes. It has been suggested that Leonardo chose to distort mountains to express better his feelings about them [18]. This interesting suggestion raises an important distinction between the functions of science and art. Science helps me to understand my outer environment; whereas art allows me the freedom necessary to express my feelings and explore my inner environment. The minimalist sculptor Carl Andre addressed this duality when he said, "The ideal of science is to create at least theoretical models of things we hope have some correspondence with what exists; whereas with art, you try as a human being to create something that wouldn't exist unless you made it" [40].

Much of the art work I do is connected in some way with earth, so in a loose sense one might term it Earth Art. My first focused efforts came naturally out of my scientific work and involved exploring the visual qualities of rocks through photomicroscopy. While the geologist microscopically examines thin sections of rock to gain insight into the genesis of rock, my intent was to utilize the color, form, and texture of rock to make explicit visual statements of an emotional nature. Robert Smithson used metaphors of dinosaurs and the geologic record to create a continuum with prehistory, thereby expanding his connection with the earth through time. In similar manner, I used the natural qualities of rock as formal components to

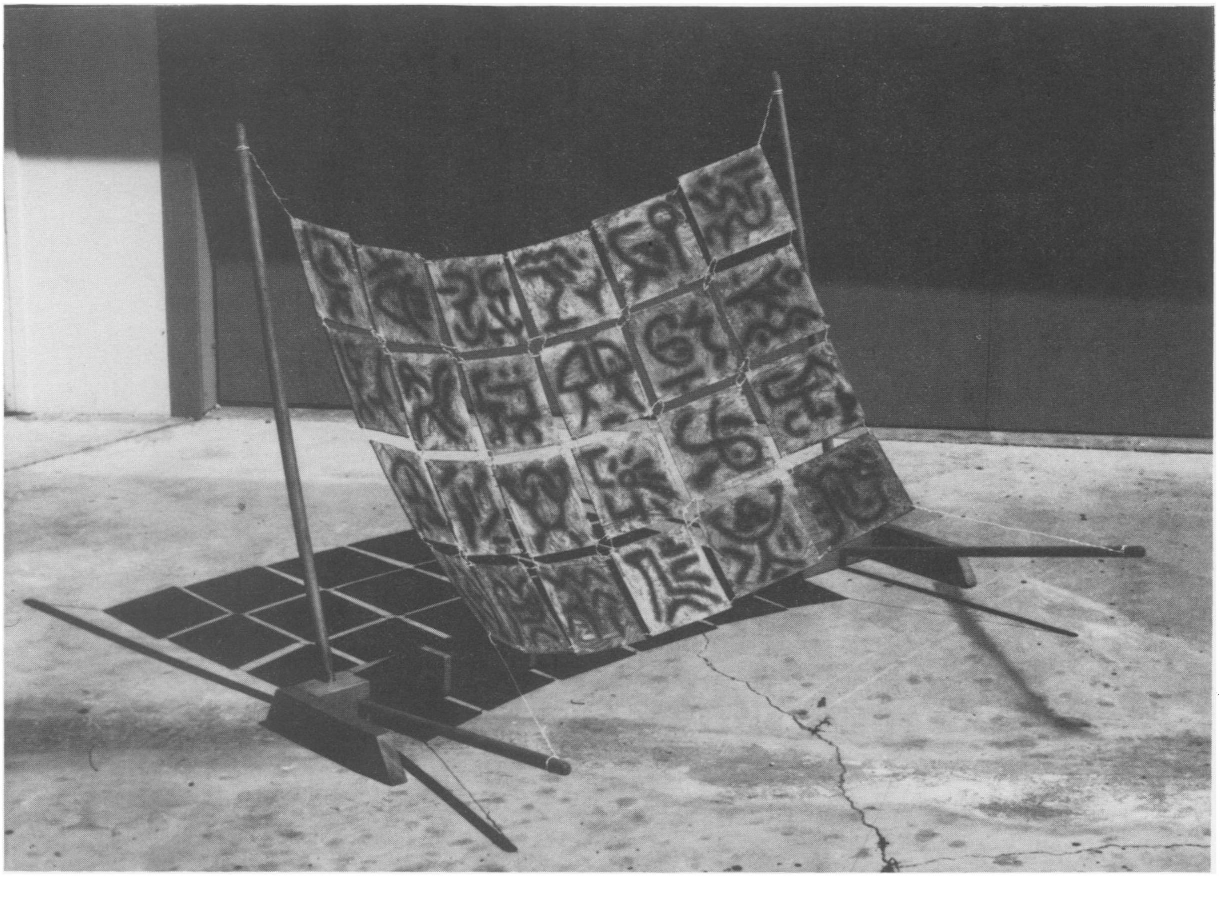

Fig. 6. 'Messages from the Sun', linoleum sheets, rhoplex, acrylic paint, torch, wood, wire, 46 × 122 × 168 cm, 1978.

explore my feelings and inner states of being, creating for myself a deep connection with the earth. The photomicrographic compositions were akin to seeing my own emotions reflected in a tiny piece of the earth's crust, the same ultimate source from which my bones had formed.

My scientific knowledge of rocks contributed to this work insofar as I soon recognized that certain types of rock provided images, colors, textures, etc. that were better than others for expressing a given feeling or portraying a given state of mind. For example, the colors shown in igneous rocks are incredibly beautiful (Color plate No. 2), but their textures tend to yield static compositions. Metamorphic rocks, which have often undergone internal movement, display textures that are more often likely to yield fluid or mobile compositions [34]. I also learned that certain colorless minerals such as quartz have more potential for showing a full spectrum of color under polarized light than do other minerals which may be naturally colored in sunlight.

While the optics of apparatus used in my early work was rather crude [41], a more sophisticated apparatus used later allowed me to attain high resolution images of great clarity, even at considerable enlargement (122 × 152 cm).

From the mid-1970s, following a period of art school, my work has included painting, drawing, some constructivist sculpture, and photography. My early paintings are highly textural, and I utilized natural rock materials such as sand and pumice, along with oil and acrylic paint, rhoplex, and other water-based adhesives. Regardless of materials, my work often maintains a textural emphasis.

At present, I am working with a variety of materials and concepts to investigate the human condition and man's connection to the earth and the cosmos. In the history of the earth, rock shows a record of countless cycles and transformations through geologic time. These changes in the earth, and the models man constructs to comprehend them, are potent metaphors for the continual change man experiences in his life, whether measured in seconds, decades, or centuries.

For example, it is known that in an active mountain belt like the Himalayas, the rocks at some depth are undergoing great stress, heat, and deformation, constantly changing their forms and contents over millions of years. The textural pattern or fabric found in such highly deformed metamorphic rock shows preferred dimensional orientation of minerals and creates a visual sense of coherency (i.e., unidirectional effort). There are many possibilities for using such a fabric as metaphor to describe man's mental and emotional states. Figure 4 illustrates my recent painting entitled 'Man Weeping' (1980–81), in which the ground pattern used has been abstracted from metamorphic rock textures.

In a similar spirit, my present photographic work concerns the use of natural material (principally rock) in man-made structures. Recently I initiated a scientific research project to study the collision between the Indian and Asian continents in the great Himalayan range. Contact with India's rich cultural heritage moved me to work on a photographic series I have entitled 'India: Doors, Walls, and Windows', in which I explore on several levels the fragile structures made by man. Some of the more tangible levels may be expressed in terms of tactile qualities (texture, form, color, shape, etc.) inherent in each piece of rock; structural qualities (the way natural properties of the rock influence the shape of structures man builds); psychological qualities (emotional implications of doors (entrance/exit), walls (confinement/protection), and windows (look in/out)); and the formal qualities of the image (line, ground, balance, etc.) common to nonfigurative art. While in each composition one of these four levels may predominate, I seek to bring all four into play, letting the predominant message emerge naturally as a result of the particular composition's characteristics (Fig. 5).

In Fig. 6, I show a constructivist sculpture entitled 'Messages from the Sun' (1978). This work features a grid form, which is prominent in a number of my pieces and has been commonly used in painting and drawing of various persuasions since the Renaissance [42]. For me, the grid is a crystalline form that gives any work a stability within which the artist can take many liberties. In addition, it can be taken as a simplified two-dimensional representation of atomic and crystal structure. In these works, I am exploring the link between organic and inorganic matter, or that connection between human consciousness and the material world. How conscious is a rock? a plant? lower animals? How is consciousness structured in man and in these lower forms? Perhaps in response to such questions, my grids often contain an additional component, a symbolic notation, sometimes expressed in a calligraphic form. In the piece shown in Fig. 6, the grid is hung in an arched form to represent a type of transmitter/receiver pointed at the sky, suggesting perhaps some exchange of vital information.

At present I am working on a piece that has elements of painting and constructive sculpture (Fig. 7), utilizing slabs of strongly lineated metamorphic rock [43] along with other materials. While this work in progress is still somewhat of a mystery to me, the elements of time and direction appear crucial. Consider the incredibly long time it would take a recently deposited sedimentary layer (e.g., clay or sand in a shallow bay) to be transformed into an intensely deformed (lineated) rock through the processes of heat and pressure during the mountain building process—millions of years, to be sure. In time scale, it would seem that earth's transformations

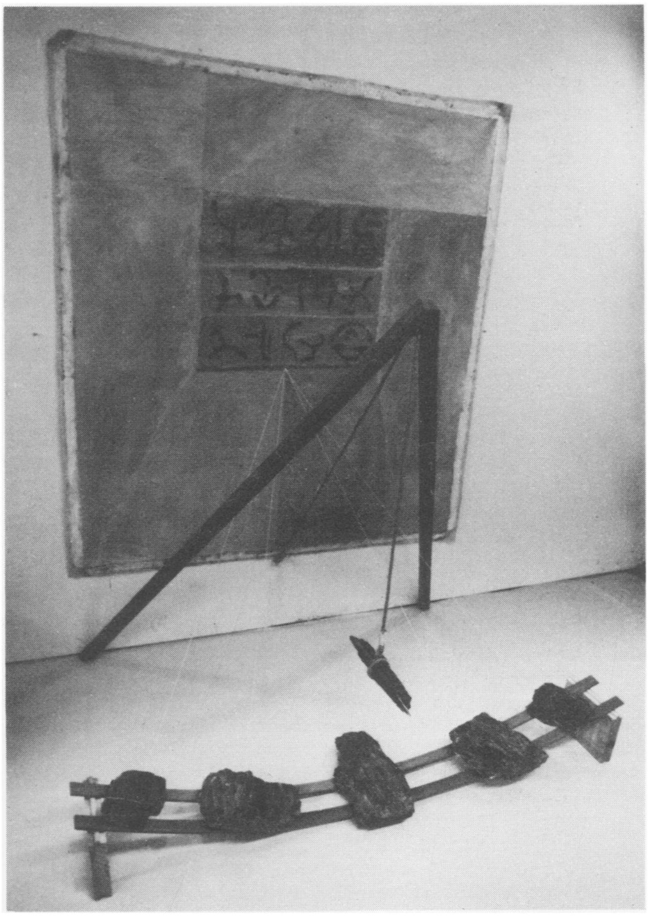

Fig. 7. Untitled, (work-in-progress), canvas, acrylic paint, rhoplex, wood, chromium shaft, string, rope, rock slabs, 200 × 160 × 110 cm, 1982–83.

and man's are eons apart. Yet throughout history, many eastern and western saints and great religious and secular thinkers have spoken of man's continual rebirth on earth until sufficient purification transforms him into higher states of awareness [44]. Was Smithson's striving to make a continuum with prehistory in his art some subtle, perhaps unconscious, inquiry in this direction? My present work is intended to address this kind of connection.

IV. CONCLUSION

There are some linkages between man and matter which I think are best explored with visual language. These are sometimes so subtle and delicate that trying to verbalize or analyze them using scientific method either changes or destroys their characteristics. Making such linkages is most effective for me through the traditions of visual art, yet they commonly involve concepts or images illuminated on the physical level by scientific investigations. Indeed, art and science are methods of exploring different levels of existence, and for me, both types of investigation are necessary in working toward deeper levels of self-knowledge.

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9. Nephrite and jadeite, the two minerals which can form jade, are relatively rare, even though they both belong to mineral groups (amphibole and pyroxene groups, respectively) that are fairly common in the earth's crust. For a general introduction to mineralogy, see C. S. Hurlburt, Jr, *Dana's Manual of Mineralogy* (New York: John Wiley, 1979). For more sophisticated information, such as crystal structure, etc., see W. S. Deer, R. A. Howie and J. Zussman, *An Introduction to the Rock-forming Minerals* (New York: John Wiley, 1966).
10. T. Froncek, *op. cit.,* p. 66; see also S. H. Hansford, *Chinese Jade Carving* (London: Lund Humphries, 1950).
11. The concept of plate tectonics and sea-floor spreading maintains that the earth's crust is divided into large plates that act as relatively rigid bodies and interact with each other along their boundaries. These boundaries take three forms: (a) *spreading ridges* like the mid-Atlantic ridge, where material is rising and then moving away from the ridge horizontally, (b) *subduction zones* shown as deep trenches such as the Tonga or Mindanao trenches in the Pacific, where oceanic crust is descending into the deeper parts of the earth, and (c) *transform faults,* where the plates slide by each other in a horizontal motion. The San Andreas fault in California or the Motagua fault in Guatemala are two examples of modern, active transform faults. *Scientific American* has a series of articles written for the layman on this subject (see J. Dewey, Plate Tectonics, *Scientific American* **226** (5), 5 (1972). For a more sophisticated treatment of the subject, see K. Condie, *Plate Tectonics and Crustal Evolution* (New York: Pergamon Press, 2nd Ed., 1982).
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27. No really comprehensive summary on earthworks exists at present. See however, S. Tillam, Earthworks and the New Picturesque, *Artforum* **7,** 43 (1968–69); G. Muller, *The New Avant Garde: Issues for the Art of the Seventies* (New York: Praeger, 1972); C. Tomkins, Maybe a Quantum Leap, in *The Scene: Reports on Post-Modern Art* (New York: Viking Press, 1976) p. 129; J. Beardsley, *Probing the Earth, Contemporary Land Projects,* Hirshorn Museum and Sculpture Garden (Washington: Smithsonian Institution Press, 1977); R. Krauss, Sculpture in the expanded field, *October* **8,** 31 (1979); J. L. Locher, *Mark Boyle's Journey to the Surface of the Earth* (Stuttgart: Edition Hansjörg Mayer, 1978); R. Morris, Notes on Art as/and Land Reclamation, *October* **10,** 87 (1980).
28. N. Holt (ed.), *The Writings of Robert Smithson, Essays with Illustrations* (New York: New York University Press, 1979) p. 5.
29. V. Tatransky, Themes With Meaning: the Writings of Robert Smithson, *Arts Magazine* **52** (9), 143 (1978).
30. T. A. Zaniello, "Our Future Tends to be Prehistoric": Science Fiction and Robert Smithson, *Arts Magazine* **52** (9), 116 (1978).
31. For example, Craig Owens, in his article Earthwords (*October* **10,** 87 (1979) states, "That Smithson thus transformed the visual field into a textual one represents one of the most significant aesthetic 'events' of our decade." See also [28] p. 5.
32. Further writings on Smithson's works appear in a special issue of *Arts Magazine* **52** (9) (1978); see also R. Hobbs, *Robert Smithson: Sculpture* (Ithaca, New York: Cornell University Press, 1981).
33. A relatively uncomplicated introduction to structural geology may be found in J. G. Dennis, *Structural Geology* (New York: Ronald Press, 1972); a more sophisticated version is found in B. E. Hobbs, W. D. Means, and P. F. Williams, *An Outline of Structural Geology* (New York: John Wiley, 1976).
34. O. T. Tobisch, Rock Forms and Art, *Leonardo* **4,** 141 (1971).

35. C. S. Smith, *op. cit.,* p. 494.
36. O. T. Tobisch, Large-scale Basin-and-Dome Pattern Resulting from the Interference of Major Folds, *Bulletin Geological Society of America* **77,** 383 (1966); see especially Fig. 11, p. 406.
37. A. Koestler, *The Act of Creation* (London: Hutchinson, 1964).
38. O. T. Tobisch and L. Glover, III, Nappe Formation in Part of the Southern Appalachian Piedmont, *Bulletin Geological Society of America* **82,** 2209 (1971).
39. H. de la Croix and R. G. Tanner, *op. cit.,* p. 526.
40. Lucy Lippard, *Six Years: The Dematerialization of the Art Object from 1966 to 1972* (New York, Praeger, 1973) p. 40.
41. See Figs 6, 8–9 in [34].
42. For two interesting viewpoints of the function and meaning of grids in visual art, see J. Elderfield, Grids, *Artforum* **10,** 52 (1972), and R. Krauss, Grids, *October* **9,** 51 (1979).
43. Lineated metamorphic rock has been strongly deformed in a manner which results in the rock being stretched into a pencil-like form, hence the term linear (line) indicating the character of the rock fabric.
44. J. Head and S. L. Cranston, eds., *Reincarnation, An East—West Dialogue on Death and Rebirth* (New York: Julian Press/Crown Publishers, 1977).

No. 1. Top left. *Morgan O'Hara. 'First Lunar Month of 1983', graphite, colored pencil, acrylic paint on bristol vellum, 100 cm × 113 cm, 1983.* (See page 266)

No. 2. Top right. *Othmar T. Tobisch. 'Oceanic Myths', ektacolor print mounted on canvas, 152 cm × 122 cm, 1973.* (See page 285)

No. 3. Bottom left. *Paul Pratchenko. 'Self Portrait at the Age of 37', acrylic on canvas, 77 × 97 cm, 1982. Collection of Mark Bernstein, M.D., San Francisco, California, U.S.A.* (See page 273)

No. 4. Bottom right. *Bella Tabak Feldman. 'Vanir', resined fiber-glass and rosecane, 168 × 300 × 122 cm, 1982.* (See page 264)