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V. *An Attempt to account for the formation of Spars and Crystals.* By Edward King, Esquire, of Lincoln's Inn, F. R. S.

Read Jan. 29, 1767. **I**N all our enquiries concerning the works of the Supreme Being, and in our endeavours to investigate the secondary causes by which the various phænomena of nature are effected, we certainly cannot be too cautious and circumspect. Our comprehension of things is at best very imperfect; and we may easily be led, by too hasty a view, to draw false conclusions. It therefore becomes us to be very modest, and to endeavour to go upon sure grounds, before we indulge any hypothesis whatever. But if we observe this rule, we cannot carry our searches or conjectures too far, since the result of them will often be the discovery of what may be useful to mankind, and will almost always increase our knowledge in some degree, and be a means of raising in our minds more noble and exalted ideas of the Almighty Creator of all things.

This consideration encourages me to fling together the following conjectures, with regard to the production of those beautiful and transparent substances, which go by the name of spars, crystals, and jewels; but I would not venture to consider them as amounting to any thing more than queries.

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I was first led to entertain these thoughts, by observing the nature of Bristol stones, and the various states in which they appear; and was encouraged to think they might have some little weight, by observing also the nature of spars, and of those stony concretions found in large caverns. I shall, therefore, first mention the observations I made, and then draw my conclusions.

1. And in the first place, it is known, that the Bristol stones grow within the hollow cavity of some other rough stone; and that the substance of the external stone is porous, and frequently so strongly impregnated with crystalline corpuscles, that they glitter amongst the earthy particles, when held up to the light.

2. In the next place, it is to be observed, that, wherever there is a hollow cavity in these kind of stones, the inside is almost always lined with such shining substances, either in a perfect or imperfect state.

3. We find the Bristol stones appear in several different states; for in some places of the cavity, where the crystallization is not completed, they are of a dusky red, without any transparency; in others they appear of a dirty yellow; and in others white; and at last transparent.

4. As to the spars and crystals formed even in flints, and other hard bodies; I think they are generally observed in such as have evidently been at one time or other in a soft state, and lay in or near moist places strongly impregnated with saline particles of some kind or other; or else they are found in bodies wherein some saline and moist substances have for-

merly been inclosed, and prevented from evaporating; of which kind are the spars found in fossil shells, wherein the bodies of the shell fish have perhaps lain and perished.

5. We observe, not only in the small cavities of stones, but also in large caverns, such as those in the Peak in Derbyshire, Okeyhole in Somersetshire, and the famous grotto in the Greek island of Antiparos, and in short wherever moisture descends through the earth to a void space, and stops upon the inward surface, that it there forms crystals, or spars, or stony concretions of some sort or other; of which some are so very imperfect, as to have only the appearance of rude heaps of petrified matter, without any regular form, which chiefly happens where there is much moisture, and where it descends, or soaks through pores so large as to carry many earthy particles with it.

6. To all which I must add, that Sir Isaac Newton has made it appear, that the transparency of bodies is occasioned by the minuteness of their pores, and the opacity of them by the largeness of the pores, in which the rays of light being reflected from side to side are lost, and prevented from passing through; whence it is, that paper becomes transparent by being oiled, and the oculus mundi stone by being soaked in water.

These are the principal observations on which I found my conjectures; and from hence I am induced to conclude, that all these above-mentioned substances, are formed by means of those crystalline (perhaps saline) corpuscles with which the surrounding earth or porous stones abound, and which probably are
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diffused throughout the whole globe, and mixed in some degree with most stratas. These small particles, I apprehend, are carried along gradually, by the moisture, or vapors, which soak through the pores, till they come to some cavity, and there, being stopped by the discontinuance of the earthy or stony substance from proceeding any further, they collect together in drops, and as they dry and harden, do of course, by their mutual attraction, form themselves into crystalline figures; and as the pores are more and more filled up, by the accession of more corpuscles, or by their mutual attraction which draws them closer together, they become more and more transparent. Some, however, of the bodies thus formed never have any transparency at all, being mixed with too many earthy or stony particles, or other heterogeneous matter, and have sometimes so much of that as not to be able to put on any regular form, but only to petrify in a confused heap; the earthy or stony particles preventing the crystalline or saline particles from forming themselves, by their mutual attraction, into regular figures; and there being perhaps but few of the true crystalline corpuscles mixed with them. This seems to be the case with many of the stony concretions in large caverns: and perhaps, from a small mixture of these same heterogeneous particles it is, that spars are inferior to crystals, and also differ from one another. Mr. Platt, in the Philosophical Transactions, Vol. LIV. p. 41. has observed, that spar seems to be nothing but crystal debased by a calcareous earth.

I cannot help suspecting, that what I have called crystalline corpuscles are in reality a kind of salts; I will beg leave, therefore, to call them hereafter by

that name ; and will just endeavour to illustrate what I have said more particularly by the instance of Bristol stones. In their first state, these are of a dirty red, or some other dusky color ; but afterwards, as more salts, or crystalline corpuscles, are added, by the descent of moisture, or the passage of more vapor, they begin to be more compact ; and then, the pores becoming smaller, they approach nearer to transparency, and put on a yellow or whitish color ; and at last, receiving a further addition of salts, and having the component particles drawn still closer together by their mutual attraction, they become still harder and more transparent, till they acquire, by a length of years, their greatest degree of perfection.

As to the Bristol stones being found of such different sizes ; I am induced to think they grow larger or continue small, only by the accident of the moisture bringing salts to them faster or slower ; for had they any other regular method of growing, I think they ought never to be found in their most perfect state, till they had first acquired their full bulk ; whereas, on the contrary, they are found in their greatest degree of perfection of all sizes.

I therefore imagine, that, till the outside surface is hardened, whatever addition of salts is made will increase the bulk of the stone ; but that, after the outward surface is once hardened, the addition of salts then only helps to bring it to its most perfect transparent state ; and therefore, that when the flow of moisture or vapor, and consequently the addition of salts, is very quick, there (the outward surfaces not having time to harden till a considerable quantity of salts are accumulated together) the stone, will grow
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large; but where the flow of moisture is slow, there (the outside surfaces, and indeed the whole mass, becoming hard before a fresh supply of salts is added) the stones will be small. And again, where the moisture and salts pass through large pores, there the crystal, or spar, or other concretion, will be very imperfect, being mixed with much heterogeneous matter; but where the moisture, and crystallizing particles, or salts, descend through very minute pores, there the salts will be most unmixed and pure, and the crystal or stone will be of the most transparent kind. In short, I cannot but look upon the largest caverns in the earth, and the smallest cavities in stone, as producing similar effects, and therefore consider them in the same light.

In these conclusions I may perhaps be mistaken, but they are at least consistent with the observations we make: for wherever there are cavities in the earth, or in stones, into which moisture can any way descend, we almost always find these kind of crystallizations and concretions; and the more plentiful the moisture is, and the more porous the strata of earth or stones are through which it passes, the larger the concretions are, and the more remote from a transparent state; as appears in those great caverns in the Peak, and in Somersetshire, &c. Whereas, on the contrary, the harder and less porous the substance is through which the moisture passes, the more transparent are the stones formed by it, as in the case of Bristol stones, and of some of those beautiful spars adjoining to veins of ore.

Whether all kind of stones may not be formed in somewhat the same manner, by the water carrying the
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the stony particles to the same place, and their collecting there together, by their mutual attraction, I leave to others to determine; but I am much persuaded, that this may probably be the manner of the production of spars and crystals: and perhaps jewels, or precious stones, may grow just in the same way; and owe their perfection solely to their being composed of still more minute salts, and more slowly; whence we may conjecture, why it is so rare to find large diamonds. I have observed some of the Bristol stones to have a fine purple appearance, like an amethyst; and it is well known, that several sorts of spars are of various beautiful colors, by means of a mixture of mineral particles, in which they have a distant resemblance of jewels; and indeed they seem to be very analogous to them in many respects.

After all, however, I am sensible that what I have advanced deserves not to be considered as any thing more than mere guesses. I know that a confirmation of the truth of these conjectures must depend upon experiments, which I have it not in my power to make: and I can only conclude with wishing, that some gentlemen, conversant in chemistry, may some time or other attempt to analyze these bodies, and to see whether they really are composed of what may properly be called salts, and of what kind.

It is much to be lamented, that, in enquiries into the nature of fossils, there have not been more chemical experiments made.