How Nefertiti's Tomb Should Appear on Radar

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Between 2008 and 2011, in support of Dr. Zahi Hawass' expedition in the Valley of the Kings, my foundation performed ground penetrating radar (GPR) surveys in the Valley. By the end of that work we had recorded more than 10 kilometers of radar transects. Here, using the experience I gained during that work and employing a computerized technique known as "forward modeling" I will predict what Nefertiti's tomb should look like to GPR, should it exist in substantially the form Nicholas Reeves theorizes.

Reeves postulates that two unrecorded spaces lie just beyond the painted and plastered walls of Tutankhamen's burial chamber (Figure 1). The first, a new annex (X in Figure 1), may be accessed through a sealed door cut into the burial chamber's west wall. The second space (Y), might consist of a corridor attached to the north wall of the burial chamber. Figure 2 shows Reeves' postulated elements (in red) added to Howard Carter's plan of the tomb.

The best targets for the radar survey are not the new annex or the corridor per se, but the sealed doorways leading to them. Carter discusses the makeup of a sealed doorway in his description the moments leading up to the time when the burial chamber first came into public view (Carter 1963, 179-180):

"There before us lay the sealed door [between the antechamber and the burial chamber], and with its opening we were to blot out the centuries and stand in the presence of a king who reigned three thousand years ago. My own feelings as I mounted the platform were a strange mixture, and it was with a trembling hand that I struck the first blow.

"My first care was to locate the wooden lintel above the door: then very carefully I chipped away the plaster and picked out the small stones which formed the uppermost layer of the filling. The temptation to stop and peer inside at every moment was irresistible, and when, after ten minutes' work, I had made a hole large enough to enable me to do so, I inserted an electric torch. An astonishing sight its light revealed, for there, within a yard of the doorway, stretching as far as one could see and blocking the entrance to the chamber, stood what to all appearance was a solid wall of gold. For the moment there was no clue as to its meaning, so as quickly as I dared I set to work to widen the hole. This had now become an operation of considerable difficulty, for the stones of the masonry were not accurately shaped blocks built regularly upon one another, but rough slabs of varying size, some so heavy that it took all of one's strength to lift them: many of them, too, as the weight above was removed, were left so precariously balanced that the least false movement would have sent them sliding inwards to

crash upon the contents of the chamber below. We were also endeavoring to preserve the seal-impressions upon the thick mortar of the outer face, and this added considerably to the difficulty of handling the stones."

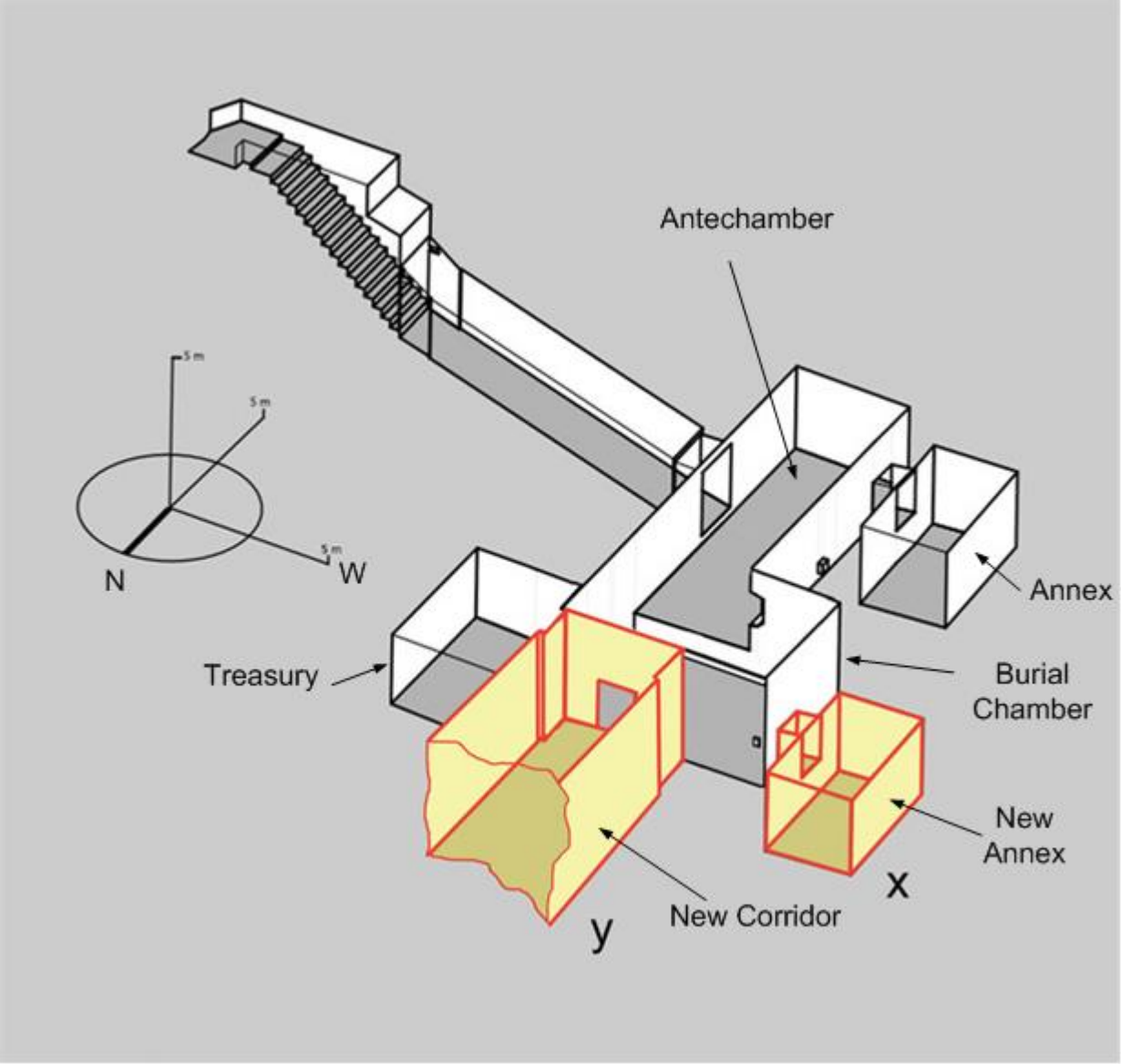

Figure 1: Nicholas Reeves' suggested "new annex" and "new corridor" attach to the Tutankhamen burial chamber. (Reeves 2015, frontpiece, with additions)

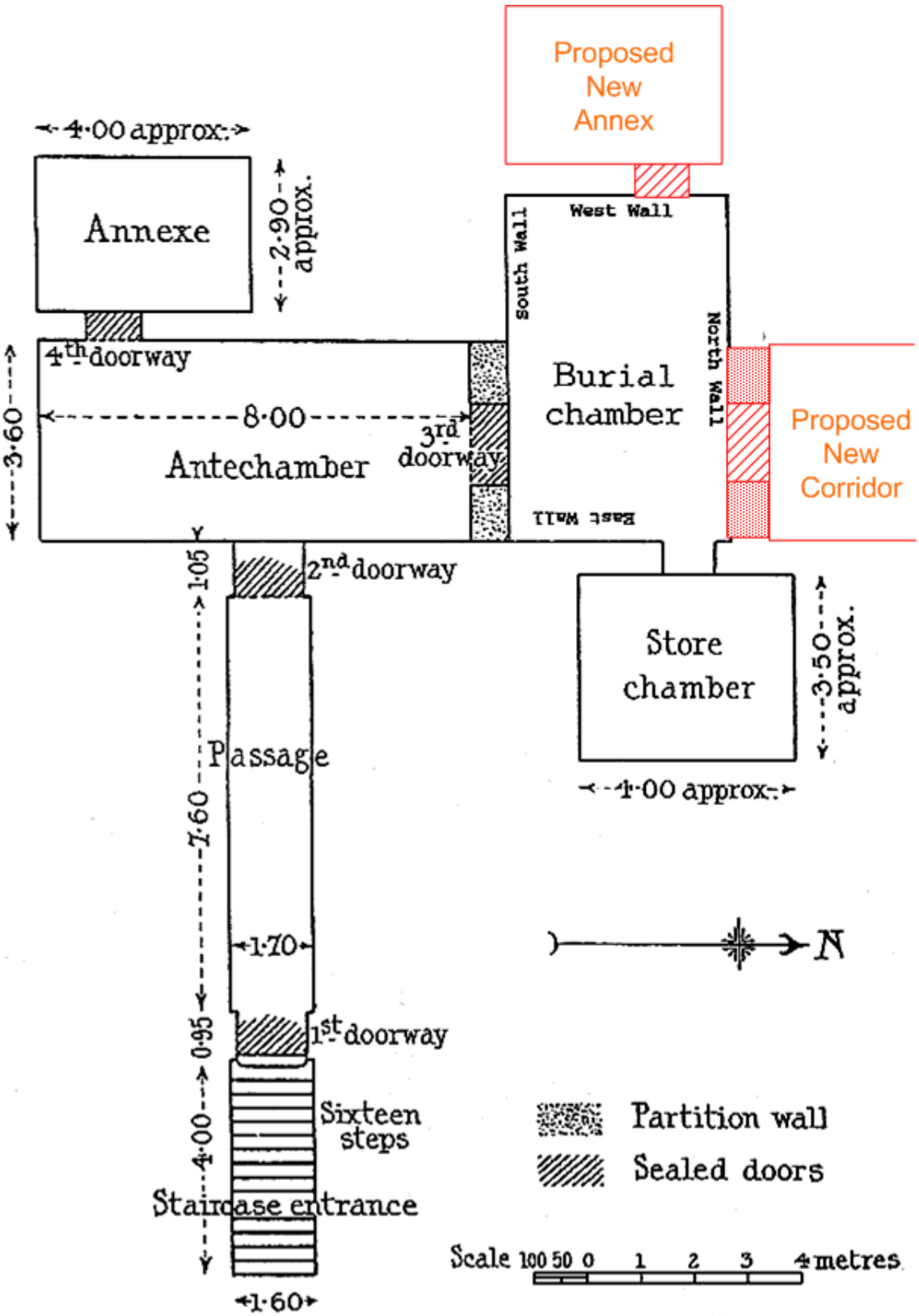

Figure 2: Carter's plan of the tomb of Tutankhamen with the proposed new annex and new corridor added. (Carter and Mace 1963, 223, with additions)

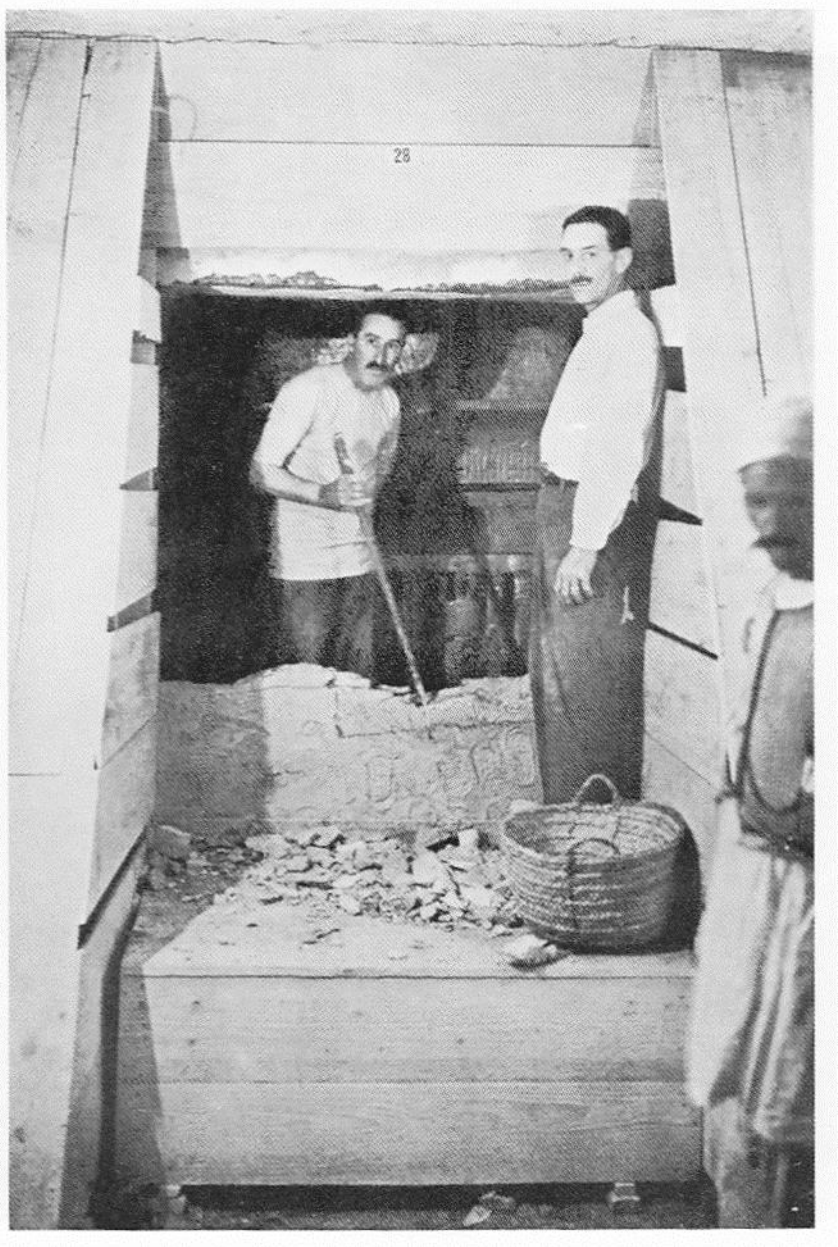

Figure 3: Carter and Mace opening the sealed doorway to the burial chamber. (Carter and Mace 1963, Plate XLIV, with additions)

Figure 3 shows Carter disassembling the sealed doorway.

Using Carter's description, we can construct models of the entries to the hidden spaces and run simulations to see what they should look like on radar. At the bottom of Figure 4, I repeat the plan of Figure 2 and indicate in red the first area I want to model and simulate. This is the area immediately around the wall separating the proposed new annex and the burial chamber. At the upper left in Figure 4, I have added a detailed illustration of that area, including a "sectional" drawing of the wall based the on what we know about the construction of the known tomb annex attached to the antechamber (Figures 1 and 2) and Carter's description of what a sealed doorway in Tutankhamen's tomb looks like. (A sectional drawing is a cut away view of the wall, viewed as if we cut through the wall horizontally.)

In my simulation, the radar operator scans by moving the radar horizontally across the face of the wall from left to right. The radar operator will have to keep the radar away from the wall to avoid damaging it, so in my model have included a 5 cm air space between radar and the wall. The wall plaster in my model consists of a 5 cm layer of gypsum mortar, typical of the plaster we find in the Valley.

The colored drawing at the upper right in Figure 4 is the product of the "GPRSIM" simulation.[2] The output is known as a "radargram." The thick red band at the bottom of the radargram is the burial chamber wall. The radar's transmitted pulse is 4.4 nanoseconds in width which accounts for the thickness of the band (the time scale is shown to the right and the equivalent depth scale at the left.) The black band above that red band is the interior of the bedrock wall. It is uniform, so there are no reflections. The red band above that black band is caused by the radar's signal reflecting off the back of the wall, the east wall of the new annex.

The sealed doorway produces a different sort of image. Here we see a multitude of reflections. We cannot pick out individual stones, but we can tell there are a lot of them. We also see on the radargram a distinctive signature formed by the rear door corners. Right angles carved in stone, such as those making up the door corners, are strong radar reflectors and produce this characteristic signature.

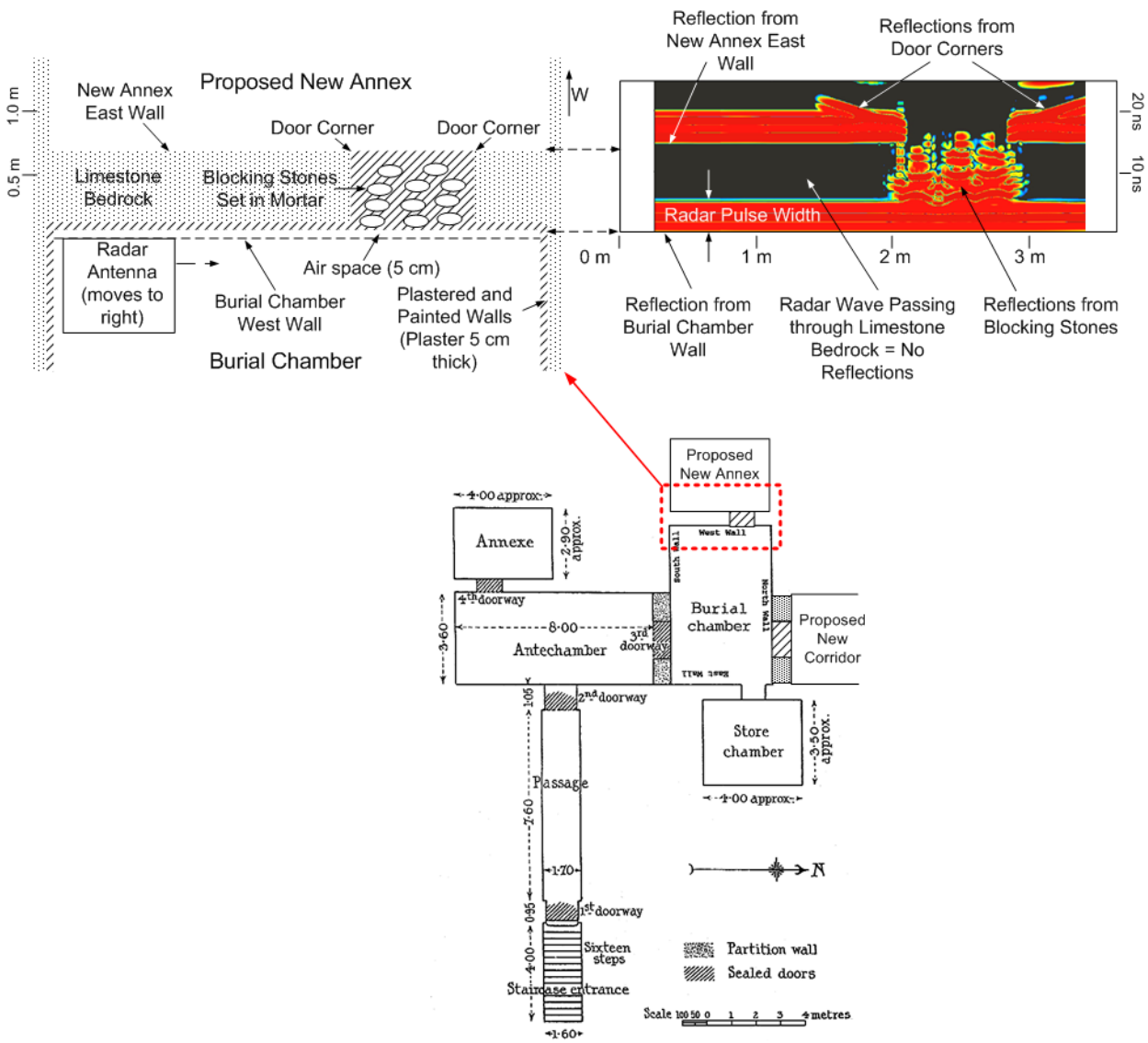

Figure 4: At the upper left is a "sectional" drawing of the wall (that is, a cut away view of the wall) that Reeves suggests stands between the burial chamber and the proposed new annex. At the upper right, a simulated radar image of the same section.

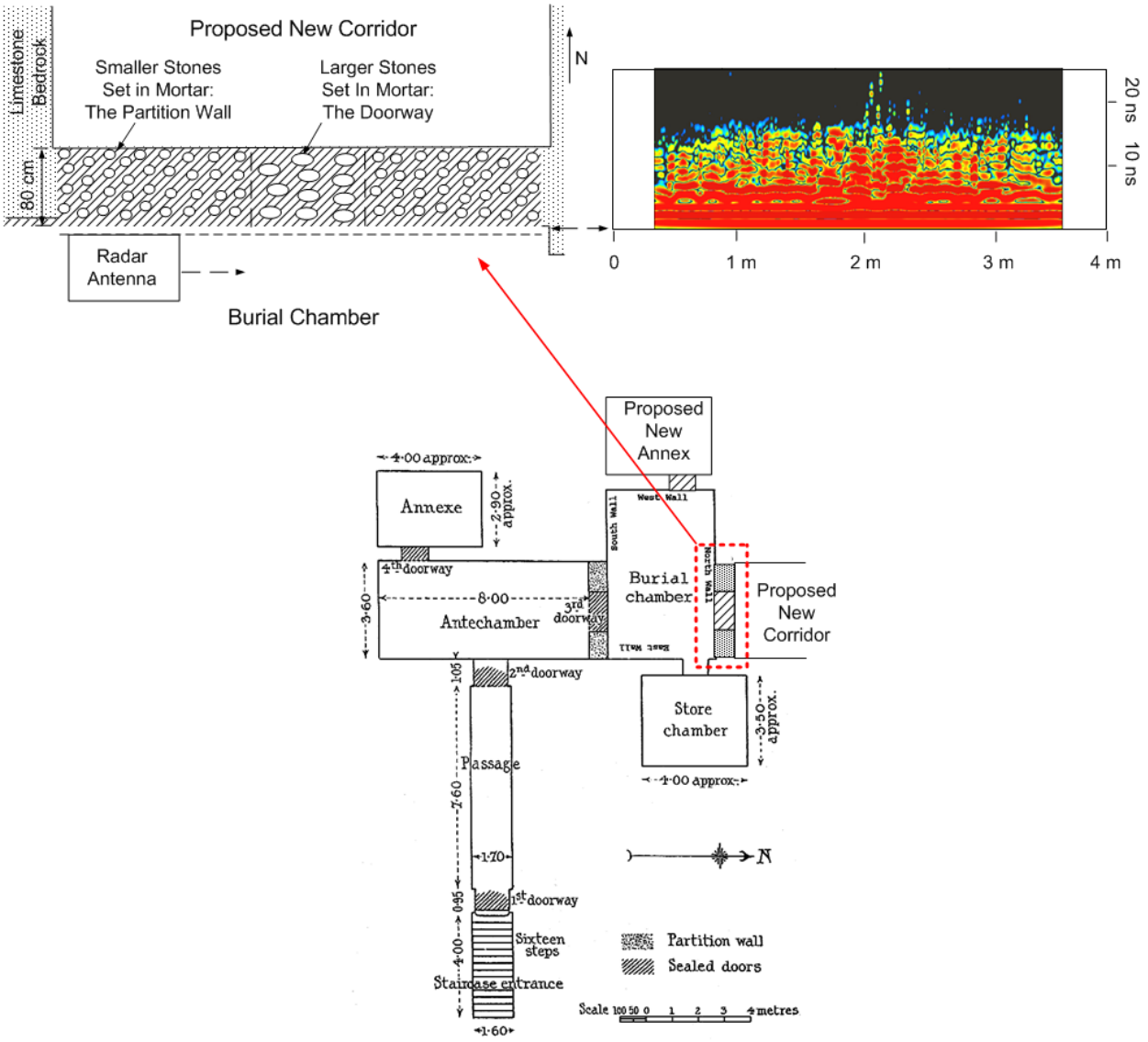

Figure 5: At the upper left is a sectional drawing of the wall Reeves suggests may separate the burial chamber from a hidden corridor. At the upper right is its simulated radar image.

Figure 5 shows the results we can expect when the doorway between the burial chamber and the new corridor is examined. The passageway between the two, if it matches Carter's description, should consist of a sealed doorway between two partition walls. While Carter describes the sealed passageway in detail, he does not provide us with a description of the partition walls. For the purpose of this test, I have modeled the partition walls as consisting of 10 cm rounded stones set in mortar.

To the radar, the partition walls and the sealed doorway do not appear much different. However, one can readily see that the wall separating the burial chamber and the new corridor is made up of a multitude of objects and not merely bedrock.

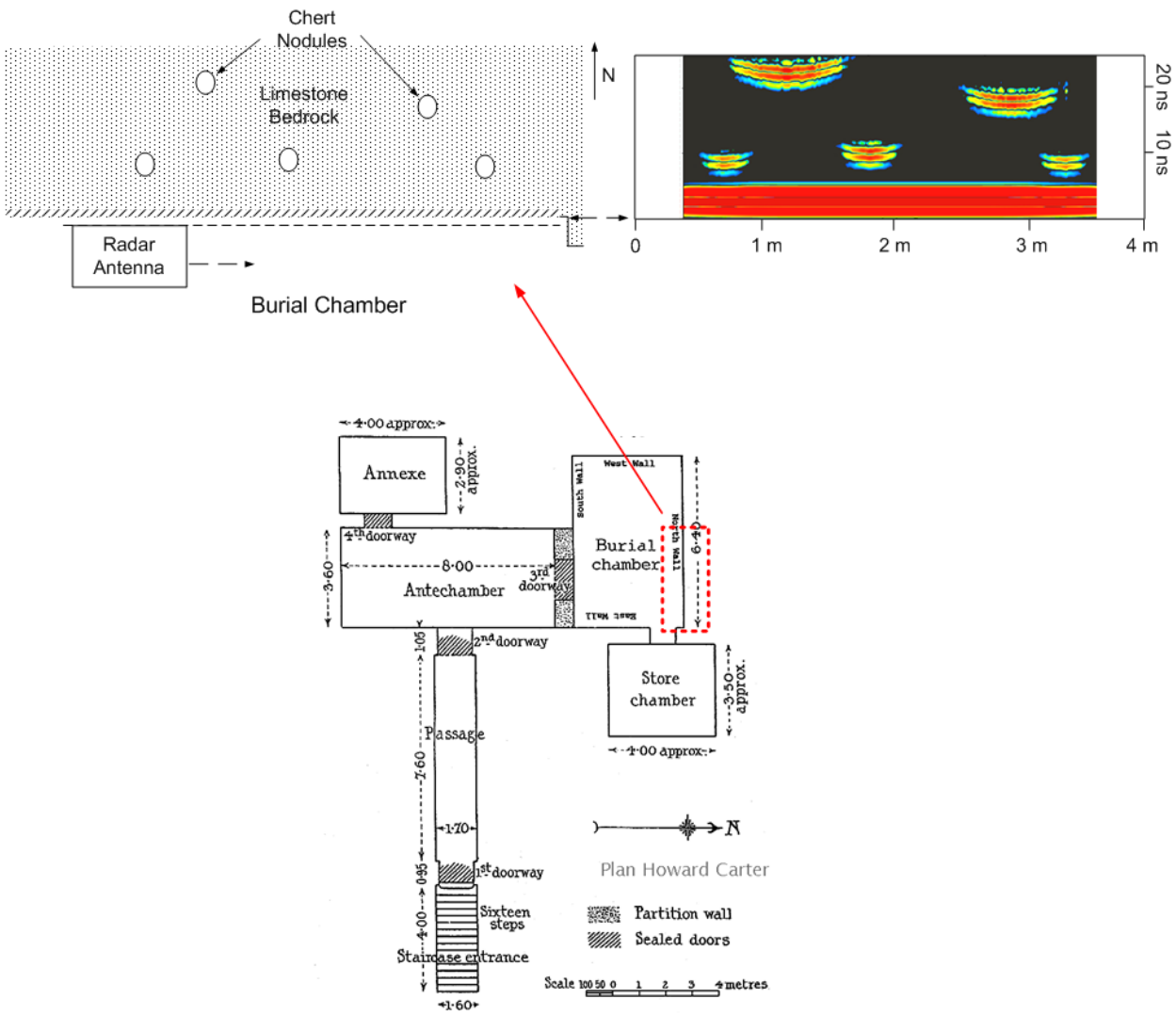

Figure 6: A simulation of a bedrock wall with chert nodule inclusions.

In contrast, if there is no new corridor, then what lies behind the walls of the burial chamber is just bedrock, a situation I have modeled in Figure 6. I have set some chert (flint) nodules in the bedrock to make things a little more realistic. Such nodules are common in the Valley.

The radargram in Figure 6 looks quite different from those in Figures 4 and 5. In Figure 6 we see no reflections other than the face of the wall and the distinctive signatures created by the chert nodules.

There are a lot of things like chert nodules that populate the bedrock of the Valley. There are fissures, seams of chert and gypsum, and voids in the bedrock known as karsts. They are so common that there was really no place in the Valley that we did not encounter them. They will certainly show up on the radar scans the Egyptian authorities intend to have performed. The key to this examination, however, is to look for evidence of the sealed doorways. If they are there, there's probably something interesting behind them. If they are not, then Nerfertiti is almost certainly buried somewhere else.

References

Carter, Howard, and A. C. Mace. *The tomb of Tut-Ankh-Amen discovered by the late Earl of Carnarvon and Howard Carter,* Volume I, New York: Cooper Square Publishers, 1963.

Reeves, Nicholas, "The Burial of Nefertiti?" Amarna Royal Tombs Project, http://www.academia.edu/14406398/The_Burial_of_Nefertiti_2015_, Accessed October 22, 2015.

[1] Glen R. Dash Charitable Foundation d/b/a The Glen Dash Foundation for Archaeological Research

[2] GPRSIM is a product of the Geophysical Archaeometry Laboratory, Woodland Hills, California. Version 3.0 was used here. In constructing the model, I assigned limestone a relative permittivity of 9 and a conductivity of .005 mhos per meter. Mortar was assigned a relative permittivity of 2.5 and chert, a relative permittivity of 3.0. The conductivity of mortar was set at .001 mhos per meter and chert, 0 mhos per meter.