The application of multispectral imaging in the study of Caucasian palimpsests

Jost Gippert, Frankfurt

For the three ancient written languages of the Caucasus, Armenian, Georgian, and "Albanian", the first centuries of their literacy are still quite obscure as only very few manuscript remains from this period have come down to us. As a matter of fact, most of the manuscripts of the Vth–VIIIth cc. were not preserved in their primary state but as palimpsests, i.e., reused and overwritten after a more or less total erasure, and special techniques are required to uncover and restore their original content.

All this is true for the palimpsest codex Vind. 2 housed in the Austrian National Library in Vienna, which is an outstanding monument of Old Georgian indeed. Most of what has been known so far about the Vienna palimpsest[1] was worked out in the early 1970's by John Neville Birdsall who published the first editions of three of the underlying manuscripts, one containing fragments of the Gospels, one, fragments of the (apocryphal) Old Testament book of Esdras Zorobabel, and one, a major part (eight chapters) of the Protevangelium of James, all of these texts pertaining to the "Khanmeti" period (Vth–VIIth cc.)[2]. As Birdsall observed, the palimpsest comprises several other original manuscripts, representing at least 12 different hands of different age; among them there are at least three further Khanmeti fragments and seven other manuscripts written in Old Georgian majuscules, the so-called *Asomtavruli* script[3]. Only two of these fragments have since been published; they contain parts of the treatise on Measures and Ponds by Epiphanius of Cyprus[4] and a Khanmeti version of the legend of St. Christina[5].

The plan to prepare a complete edition of the oldest layer of the Vienna palimpsest, i.e., the Khanmeti and Post-Khanmeti texts written in Asomtavruli script, was developed in 1997 when the late Zurab Sarǯvelaʒe sojourned as a visiting professor at the University of Frankfurt and proposed to compile, as an extension of the TITUS text data base[6], an electronic corpus of Khanmeti texts including the fragments contained in the Vienna palimpsest. To achieve this, a set of ultraviolet negatives of the corresponding pages was procured from the Austrian National Library[7], and on the basis of a digitization of these images, the three underlying manuscripts that had been dealt with by Birdsall were re-read in total, and one further manuscript (containing the legends of Cyprianus and Christina), about halfway through. As a

[1] The palimpsest originates from the Monastery of the Holy Cross in Jerusalem; for details cf. the forthcoming edition (cf. note 12).

[2] Cf. J.N. Birdsall, *A second Georgian recension of the Protoevangelium Jacobi*, Le Muséon 83, 1970, pp. 49–72; *Khanmeti Fragments of the Synoptic Gospels from Ms. Vind. Georg. 2*, Oriens Christianus 55, 1971, pp. 62–89; *Palimpsest fragments of a Khanmeti Georgian version of I. Esdras*, Le Muséon 85, 1972, pp. 97–105.

[3] Cf. J.N. Birdsall, *A Georgian Palimpsest in Vienna*, Oriens Christianus 53, 1969, 108-112; *MS Vindob. Georg. 2: a progress report*, Oriens Christianus 58, 1974, pp. 39–44; Jost Gippert, *Die georgische Palimpsesthandschrift Codex Vindobonensis georgicus 2*, Biblos. Beiträge zu Buch, Bibliothek und Schrift 1–2, 2003, 31–46.

[4] Cf. Michel Jean van Esbroeck (ed.), Les versions géorgiens d'Épiphane de Chypre, Traité des poids et des mesures, Lovanii 1984 [Édition / Traduction] (Corpus scriptorum christianorum orientalium, 460–461 / Scriptores iberici, 19–20), pp. 5–9 / 23–25.

[5] Cf. Lamara Kaǯaia, *Ċm. Kriṣṭinas ċamebis xanmeṭi ṭeksṭi*; Gelatis mecnierebata aḳademiis žurnali / Journal of Gelati Academy of Sciences 3/2006, pp. 34–59.

[6] The TITUS data base of electronic texts (University of Frankfurt) comprises a large collection of Old and Middle Georgian texts; cf. http://titus.uni-frankfurt.de/texte/texte2.htm#georgant.

[7] The same specimens of "excellent ultra-violet photography" were also used by John Neville Birdsall in his work on the Vienna palimpsest; cf. his articles *Ms. Vind. Georg. 2...* (cf. n. 3), p. 39 and, before, *A Georgian Palimpsest...* (cf. n. 3), p. 108.

result of the common work undertaken in 1997–8, a first digital edition comprising the fragments named above was published on the TITUS server in February, 1998[8].

Unfortunately, Zurab Sarǯvelaʒe did not live to participate in the continuation of this work, which was initiated shortly after his untimely death in December, 2002. In the course of a project devoted to the manuscript remains of the Caucasian "Albanians"[9], the idea was born to apply the newly developed technology of multispectral imaging in the analysis of palimpsests of Caucasian provenance. This idea has been realised since 2004 when, thanks to a generous grant by the Volkswagen Foundation, a "MuSIS" camera system[10] could first be used to cope with the bad readability of the Vienna codex and the "Albanian" palimpsests of Mt. Sinai[11]. As the application of this system meant a big step forward in the study of these manuscripts, it may be appropriate to shortly describe its function here. The results of the investigations facilitated by the new technique will be published in the editions of the palimpsests which are to appear in 2007[12].

The main principle of multispectral imaging consists in the fact that the resonance of any object differs with respect to different wavelengths of light, depending on the consistence of its colour; this is true both for the visible and the invisible (ultraviolet and infrared) parts of the spectrum. By applying a photographing method that is restricted to a certain range of the spectrum, a specific resonance may be retained or suppressed. This principle can easily be demonstrated using a bicoloured manuscript such as the Church Slavonic menaion manuscript displayed in Fig. 1[13]. Of the two colours represented in it, red and dark-brown, the first one will appear extremely bright when photographed within the red range of the spectrum, i.e., 620–750 nm, and it will be more and more dark the more we go down the spectral range; cp. Figs. 2–5 showing this effect.

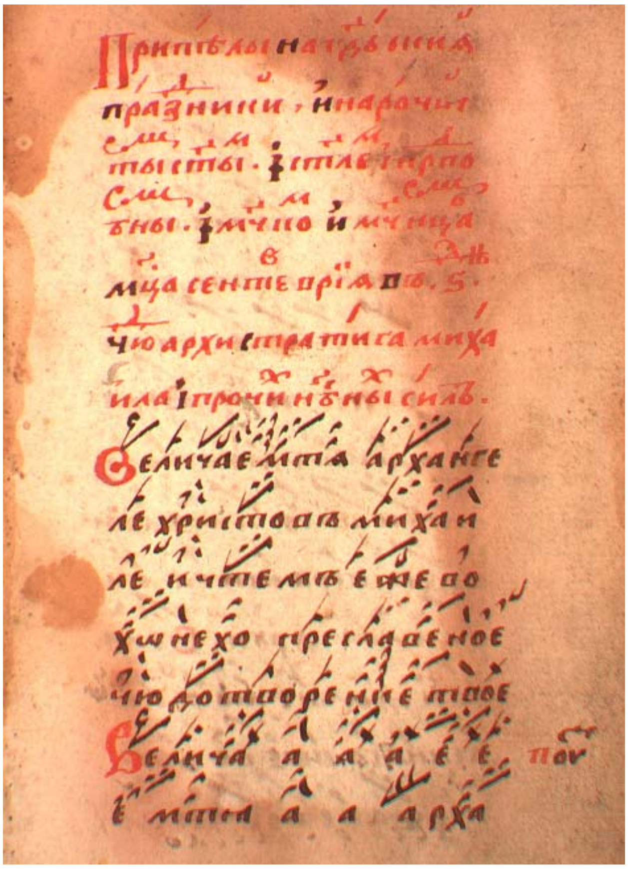

Fig. 1: Church Slavonic menaion (bicoloured)

[8] Cf. http://titus.fkidg1.uni-frankfurt.de/texte/etcc/cauc/ageo/xanmeti/vienna/vienn.htm; the edition has steadily been improved and extended since.

[9] Cf. http://armazi.uni-frankfurt.de/armaz3.htm (part of the project "ARMAZI: Fundamentals of an Electronic Documentation of Caucasian Languages and Cultures").

[10] The "MultiSpectral Imaging System" is a product of Forth Photonics, Greece; cf. http://musis.forth-photonics.gr.

[11] The project "Neue Wege zur wissenschaftlichen Bearbeitung von Palimpsesthandschriften kaukasischer Provenienz" has been funded by the Volkswagen Foundation since 12.12.2003; it is jointly run by Zaza Aleksiʒe, Jost Gippert, Jean-Pierre Mahé, Wolfgang Schulze, and Manana Tandaschwili.

[12] The editions will be published in the series Monumenta Palaeographica Medii Aevi, Series Iberica et Caucasica, as volumes I and II; vol. I containing the edition of the Vienna codex is currently in the press.

[13] The manuscript (allegedly of the early XVIIth century) was donated to the University of Frankfurt in 2003 so that it could be used for testing the application of the multispectral imaging system.

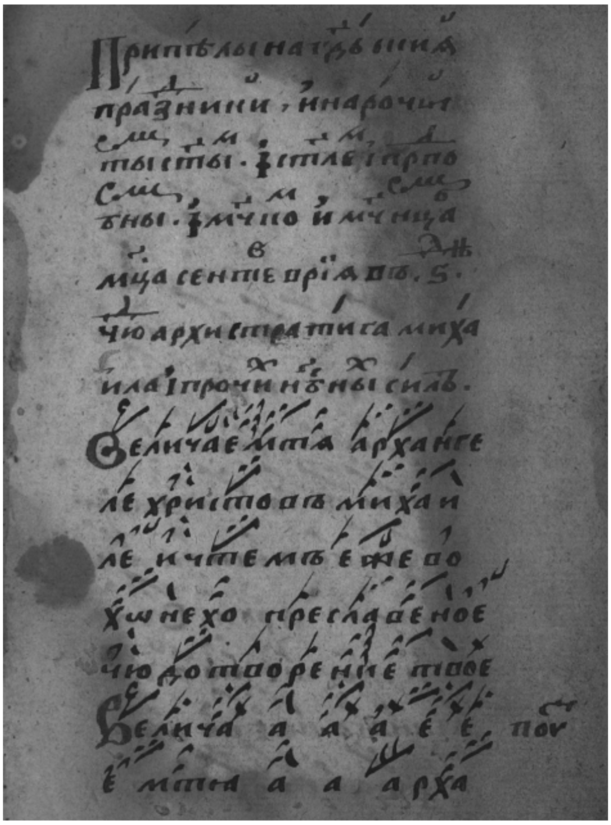

Fig. 2: Same, at 440 nm (violet)

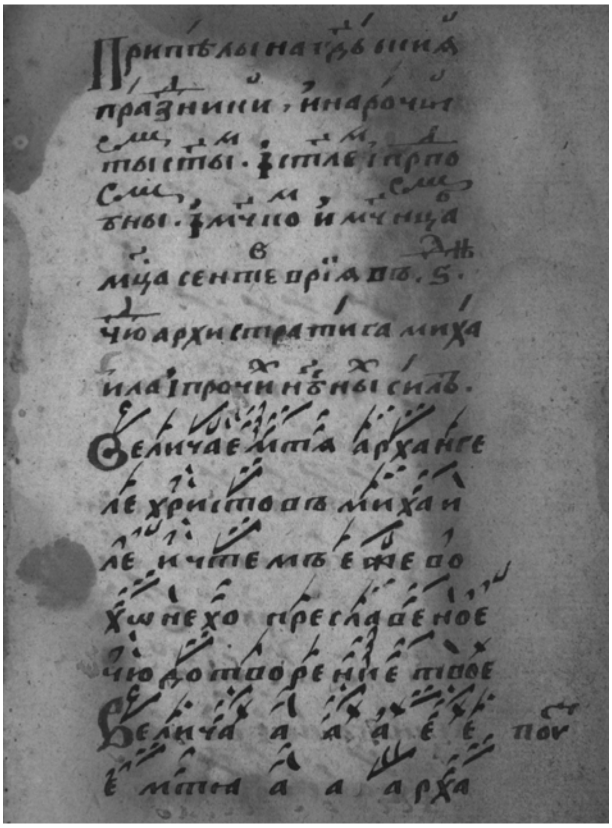

Fig. 3: Same, at 540 nm (green)

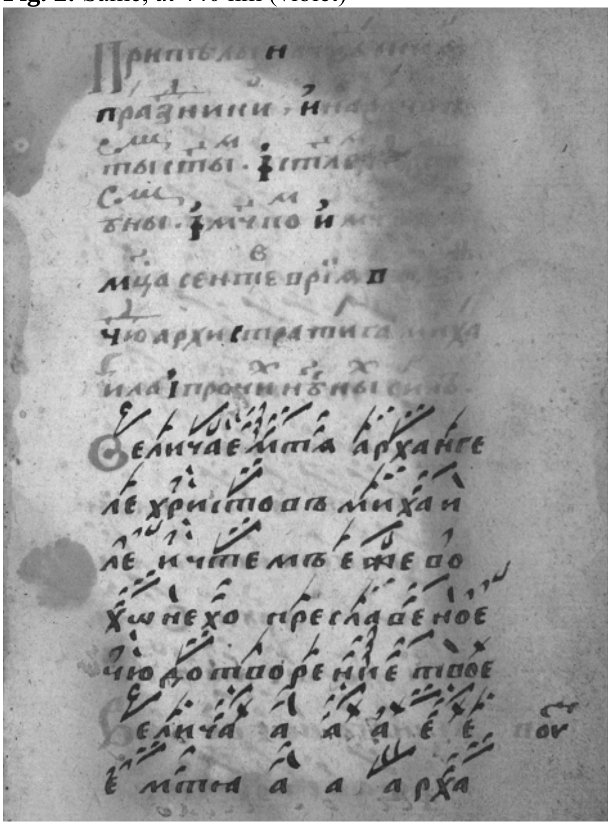

Fig. 4: Same, at 620 nm (orange)

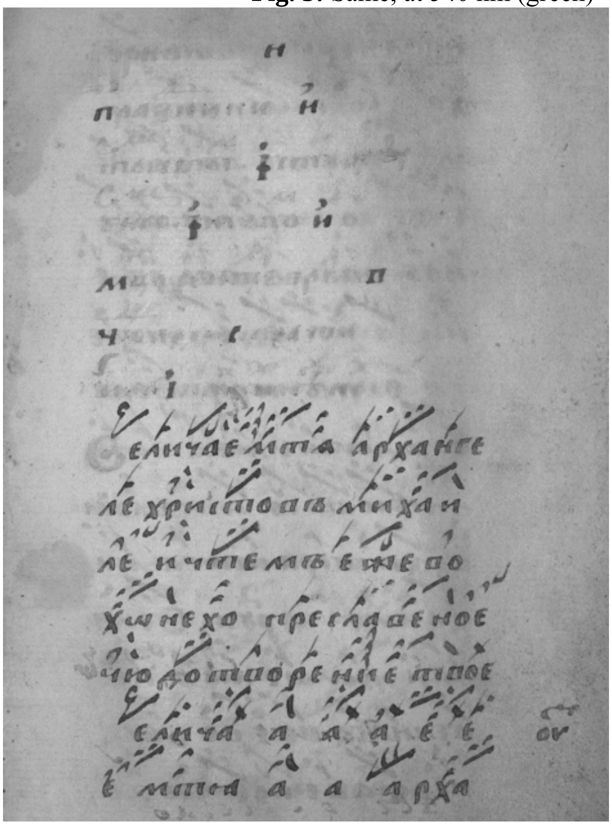

Fig. 5: Same, at 680 nm (red)

In the case of palimpsest manuscripts, the effect that can be gained from this predisposition depends on three factors: The colour resonance of the upper script, that of the lower script, and that of the background, i.e., the parchment itself. One might expect that the the first two are the most decisive factors in this constellation, as in many cases, it might be desirable to “enhance” the lower script in contrast with the upper script covering it. This, however, is not always possible in parchment palimpsests of Caucasian (or, rather, Near Eastern) provenance as both the lower and the upper scripts were usually written with the same type of inks, which results in similar resonances. Thus the application of multispectral imaging must concentrate upon two aims:

a) increasing the contrast between the (erased) lower script and the background. This aim is quite the same as that of applying ultraviolet photographing to the palimpsests as it is mostly in the violet and ultraviolet range (370–440 nm) that the contrast between a washed or wiped out ink and a parchment skin bearing it can be reinforced. The reason is that the inks used in the Near Eastern Middle Ages had but very few “blueish” portions and appear darker in that range while the parchment appears rather bright, at least if it has not been discoloured or stained in the course of history. In many cases, the results to be achieved applying a diversified spectral imaging will be better than those to be gained by mere ultraviolet photography as the range of optimal contrast may vary from leaf to leaf, often extending into the blue range (450–495 nm); cp. Figs. 6 and 7 which contrast an ultraviolet photograph and an image taken at 460 nm of fol. 10r of the Vienna palimpsest, and Fig. 8 showing a well readable extract of the latter. The method of preparing a large set of digital images covering the spectrum from the ultraviolet range upto the red range to be analysed on the computer screen has been applied extensively in the present project, and in the case of the Vienna palimpsest, it has led to an increase of the reading rates upto about 95% (while ca. 80% are achievable using ultraviolet photographs). It goes without saying that this method always remains experimental and its results depend to a high degree on the light source used and other conditions;

b) exploiting the difference of several images showing the same object to reduce the preponderance of the upper script. This aim is mostly connected with the task of reproducing the contents of the palimpsest in printed form, and it is the method of recalculating the brightness information of two different spectral images that can be applied here. To give an example, Figs. 9 to 16 below show another page of the Vienna palimpsest (fol. 28v, containing Mk. 10,29–30) in eight different appearances: first in a plain colour image and an ultraviolet photograph, then in two spectral images (at 440 and 580 nm), and lastly in four different “recalculations” of the latter pair of images[14]. It is clear from these specimens that neither the addition nor the multiplication of the data of two spectral images yield noteworthy results with respect to a better distinction of the upper and lower scripts. In contrast to this, a subtraction of the brightness data of the two images brings about a clear improvement as it effects the inversion of the lower script. The best results by far are achieved applying a division of the data as in Fig. 16. Here, the upper script is nearly levelled to the grey value of the (parchment) background, and the lower script alone stands out. The reason for this can be seen in the fact that the ink used in the upper script is near to black, which means that it has quite the same (low) level of brightness throughout the visible spectrum; the same holds true for the parchment background if it is whitish and not stained or discoloured in a peculiar way, as in the given example. Different from this, the lower script, which appears yellow or brownish to the human eye, will have extremely divergent brightness values in the blue and yellow range, resulting in a high quotient when divided. It must be admitted that this method, too, has narrow limits. Its efficiency depends not only on the grade of visibility of the lower script but also on the state and tinct of the parchment, and many of the pages of the Vienna palimpsest illustrate the problems resulting from this. Fol. 28 (and some other pages of the underlying Gospel ms.) are rather exceptional in the quality of the reproductions that can be achieved using the “recalculation” method.

[14] The recalculation procedures here discribed are integrated in the software provided with the MuSIS system.

Fig. 6: fol. 10r (ultraviolet photograph)

Fig. 7: fol. 10r (spectral image at 460 nm)

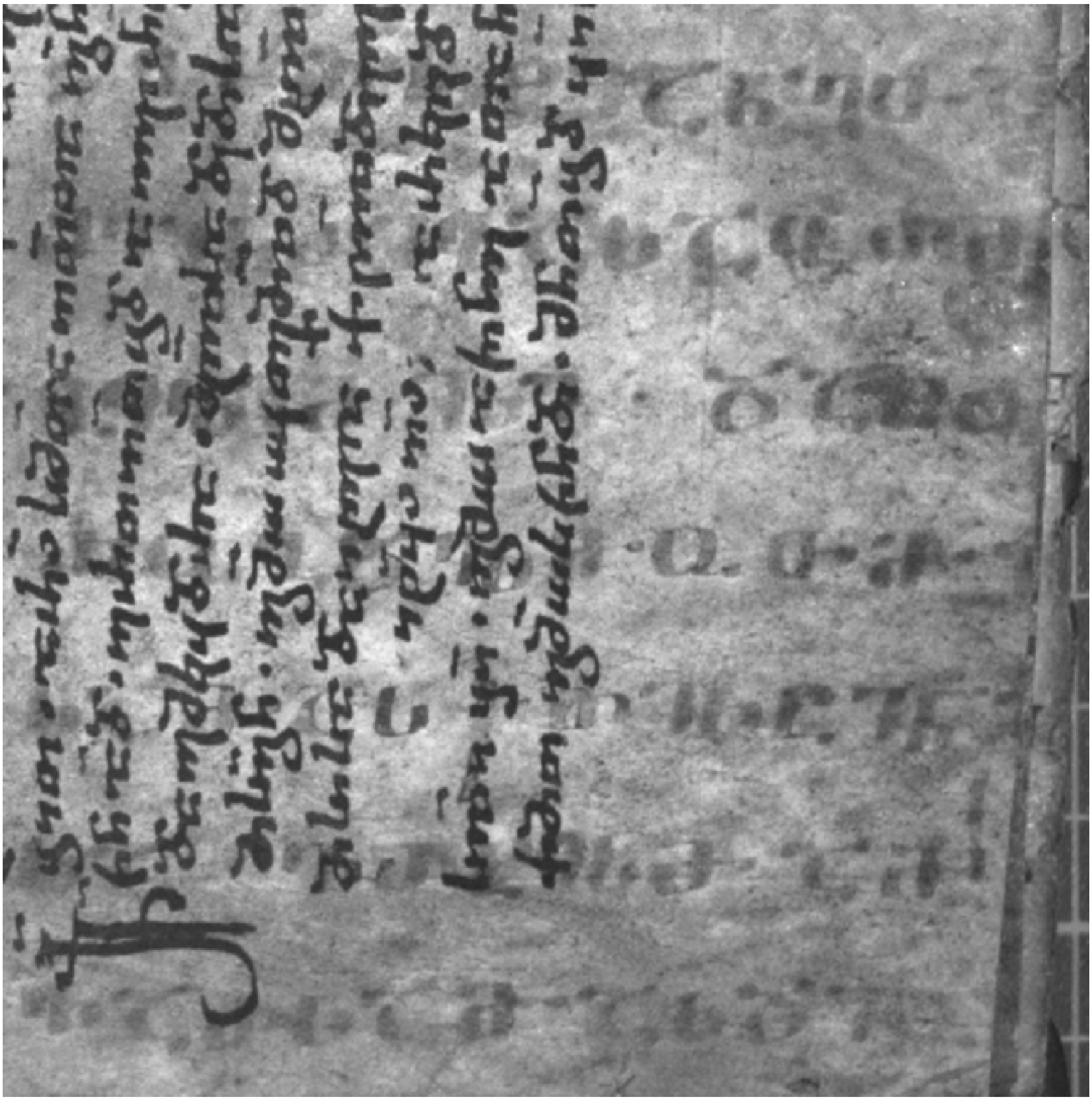

Fig. 8: same, extract (enlarged)

It should be added here that for those parts of the Vienna palimpsest the lower text of which is written in small Nuskhuri characters[15], none of the methods described above can be applied successfully. Whenever the lower script is covered by the upper text in its entirety, optical means will not be apt to make it reappear. For the lower texts in Asomtavruli script, the application of multispectral imaging has generally yielded good results, however.

In the case of the "Albanian" palimpsests from Mt. Sinai[16], the successful application of the multispectral imaging method was further limited by two special conditions. Firstly, very many leaves of the manuscripts were badly defaced by fire[17], which resulted in a dark stain especially of the margins; cf. Figs. 17–20 showing a specimen of this type. Secondly, one of

[15] These are fols. 106–128, 132, and 133 (Birdsall's "Hand 14").

[16] Cf. Zaza Aleksidze Mzekala Shanidze, Lily Khevsuriani, Michael Kavtaria, Καταλογος γεωργιανων χειρογραφων ευρεθεντων κατα το 1975 εις την ιεραν μονην του θεοβαδιστου ορους Σινα Αγιας Αικατερινης, Αθηνα 2005, pp. 257-9 (Sin.Geo.N.13) and 288 (Sin.Geo.N.55) for a description of the two manuscripts.

[17] Cf. the catalogue Τα νεα ευρηματα του Σινα, Αθηναι 1998, pp. 3–137 where the circumstances of the discovery of the "Albanian" and other manuscripts in St. Catherine's Monastery in 1975 are neatly discribed.

the original manuscripts (containing parts of St. John's Gospels) had been erased in such a drastic way that on many pages, hardly any remains of it have survived. This is why the reading rate is much lower than with the Vienna palimpsest, ending up with less than 50% for the latter original.

To be sure, the results of the present project have not been achieved by applying multispectral imaging alone. The "normal" ultraviolet photographs that had been prepared both for the Vienna codex[18] and for the "Albanian" palimpsests before[19] have been used throughout the editorial work to verify suggestions and support the readings. In some cases, even high resolution colour photographs[20] have turned out to be indispensable for the decipherment. For the study of palimpsests, it is therefore highly advisable to use all three kinds of images side by side.

Fig. 9: fol. 28v (colour image)

[18] Cf. Birdsall, A Georgian Palimpsest in Vienna (cf. n. 3), p. 108 according to whom the photographs were made by a certain Mr Janderka.

[19] The ultraviolet photographs were taken *in situ* in the course of the ARMAZI project (cf. n. 9) and have been published in digital form on the project server in http://armazi.uni-frankfurt.de/armaz3.htm since 2002.

[20] A complete set of digital colour images was prepared for both the Vienna codex and the Albanian palimpsests in the course of the present project.

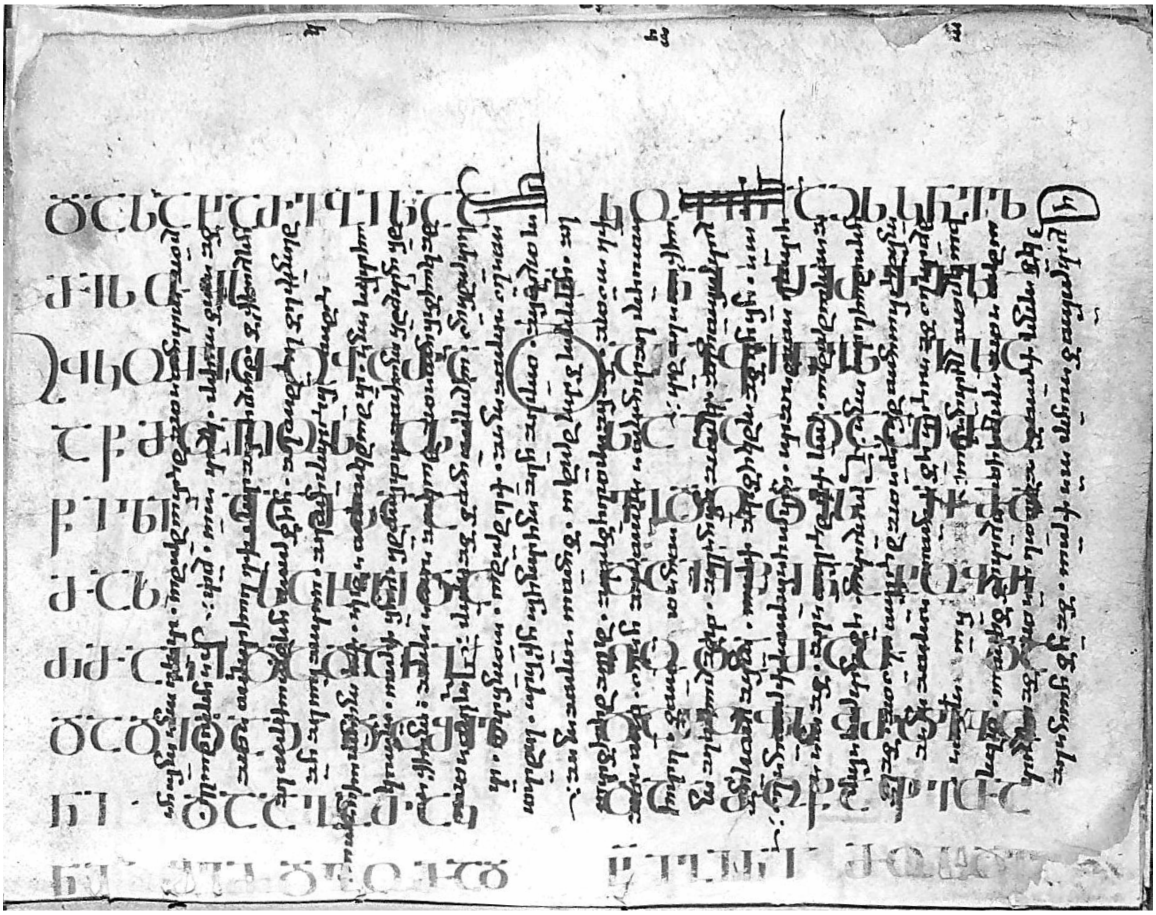

Fig. 10: same (ultraviolet photograph)

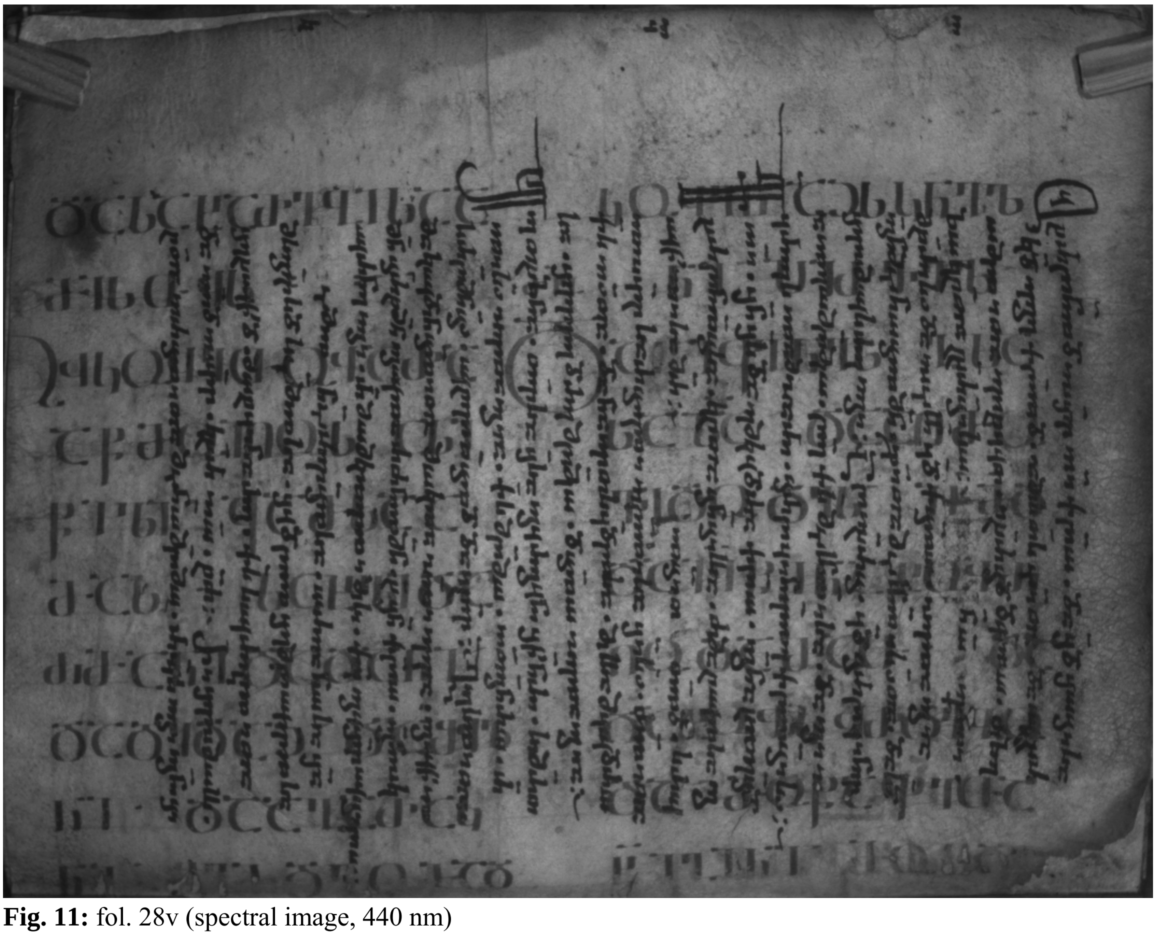

Fig. 11: fol. 28v (spectral image, 440 nm)

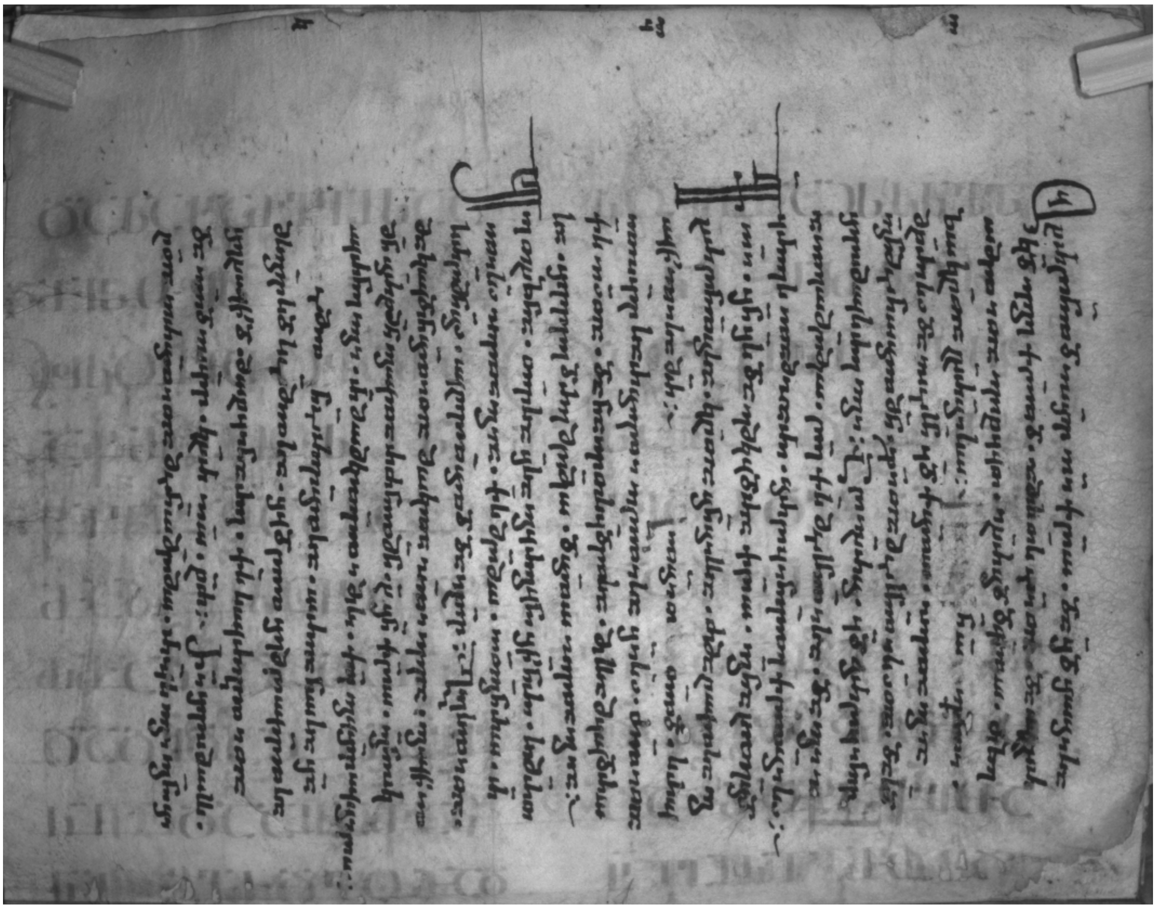

Fig. 12: same (spectral image, 580 nm)

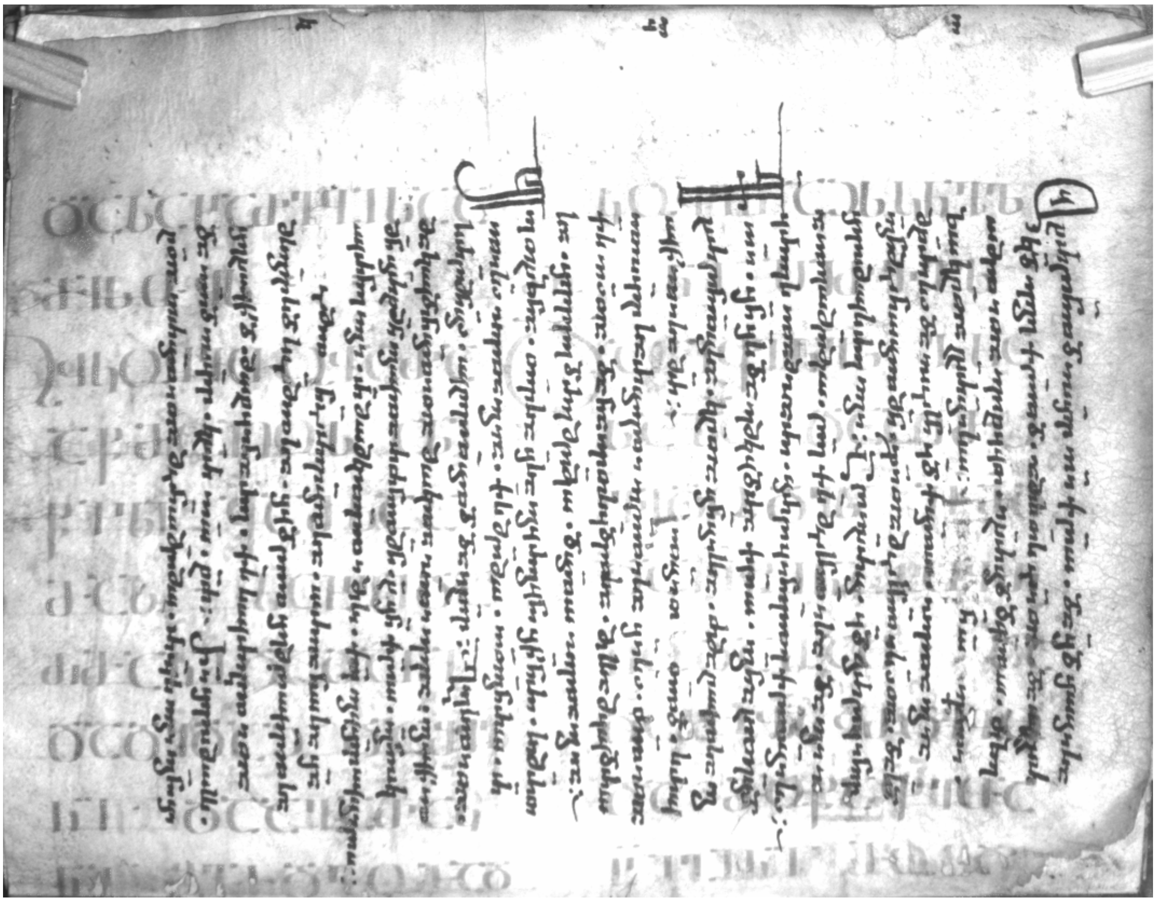

Fig. 13: same (values of Figs. 11 and 12 “added”)

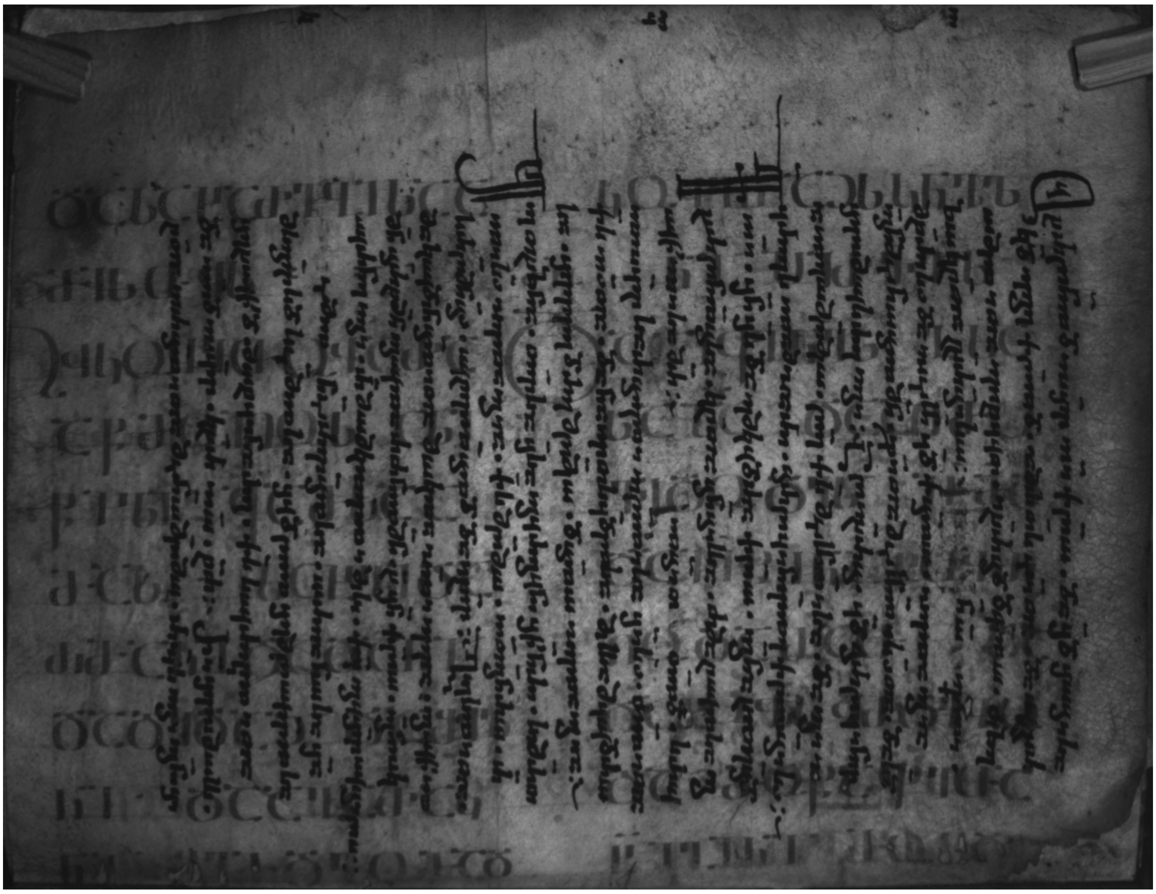

Fig. 14: same (values of Figs. 11 and 12 "multiplied")

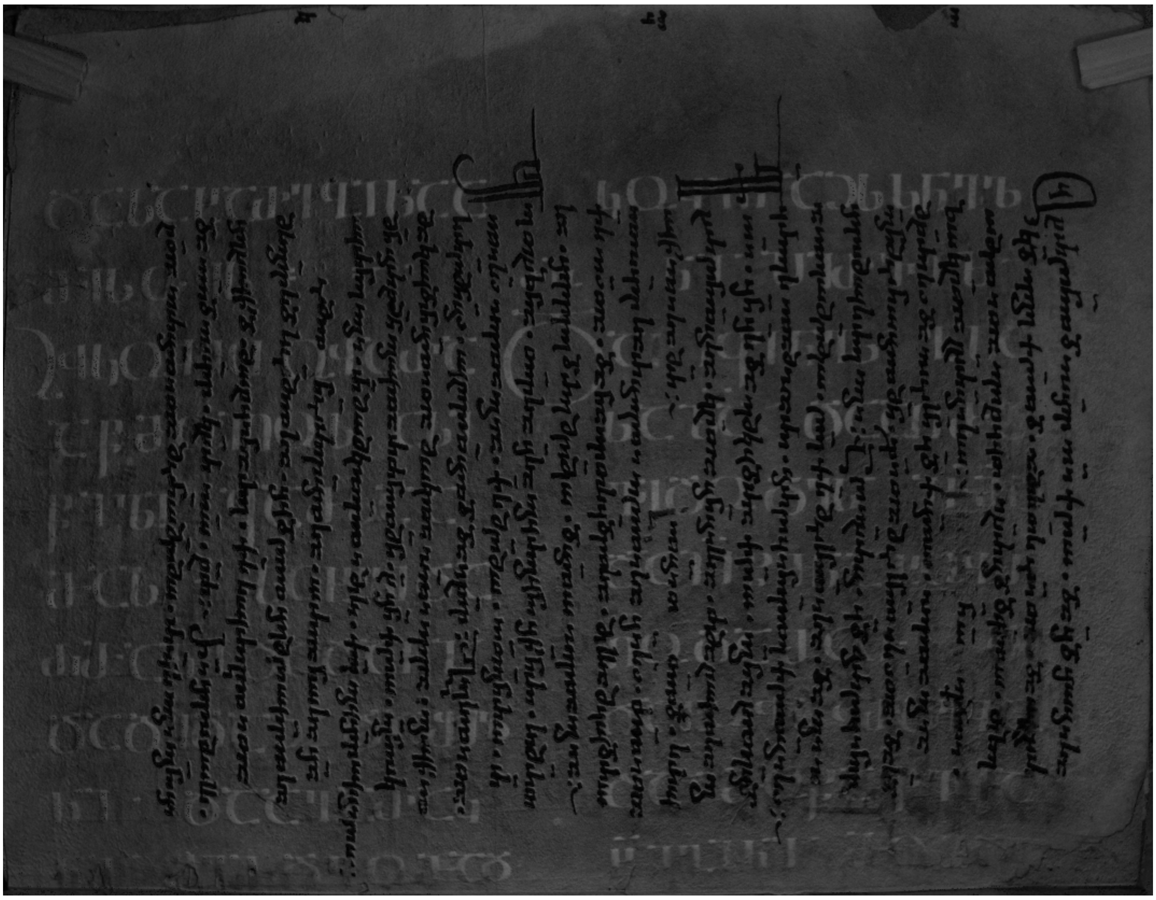

Fig. 15: same (values of Figs. 11 and 12 "subtracted")

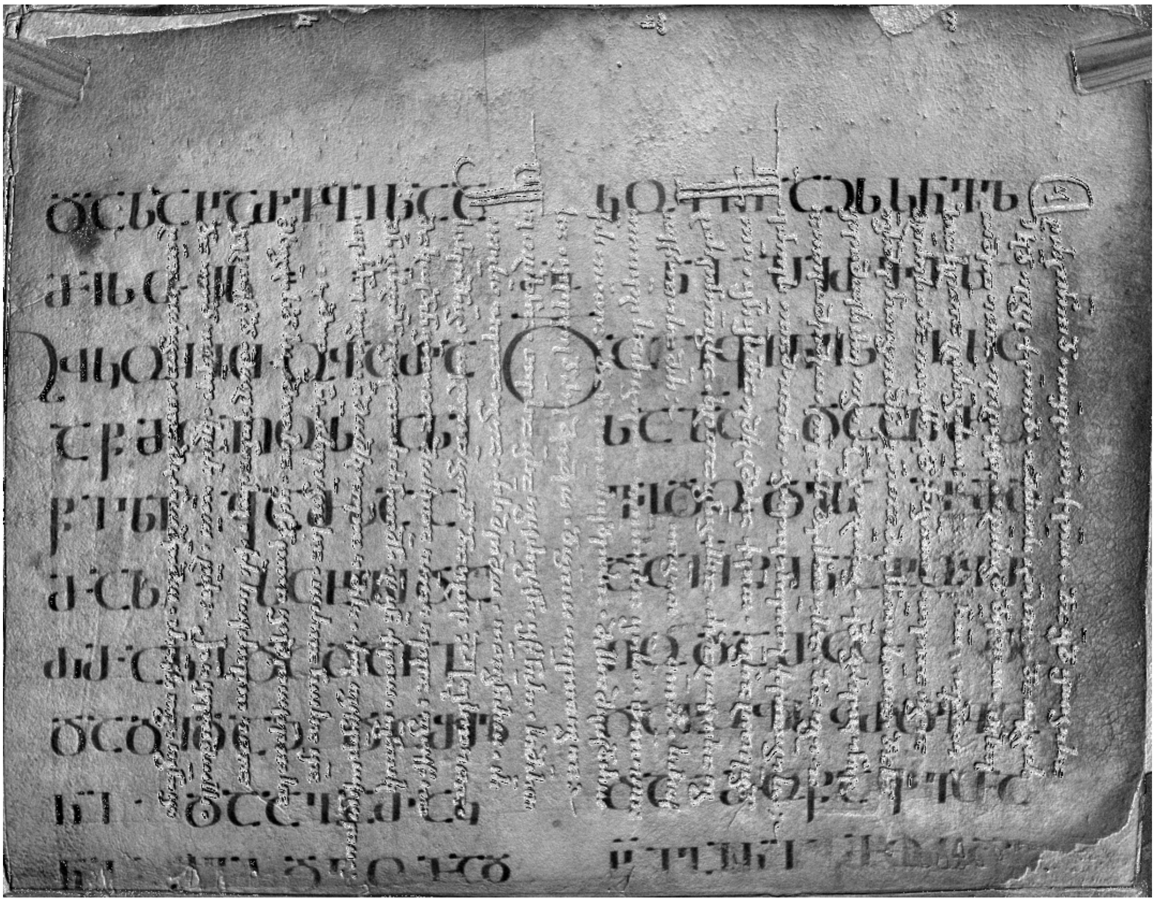
Fig. 16: same (values of Figs. 36 and 37 “divided”)


Fig. 17: 8r of the Albanian palimpsest M55 (colour)

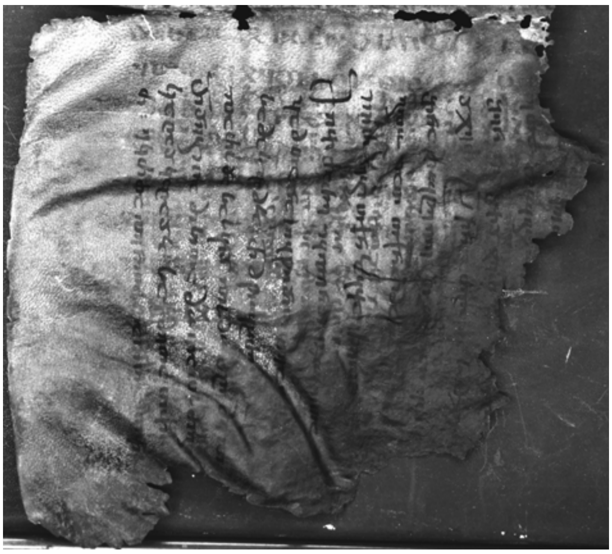
Fig. 18: same (ultraviolet photograph)

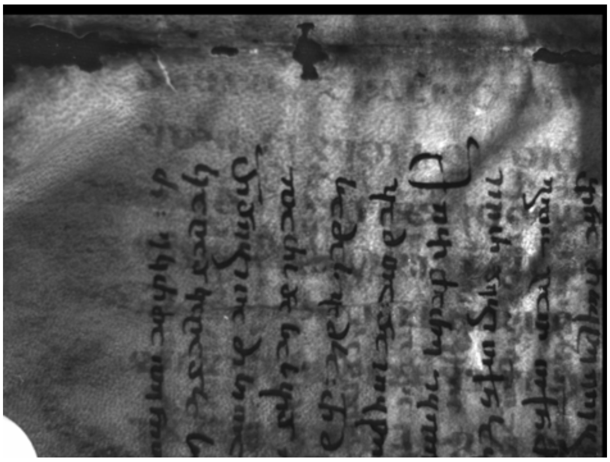

Fig. 19: same, extract (at 440 nm)

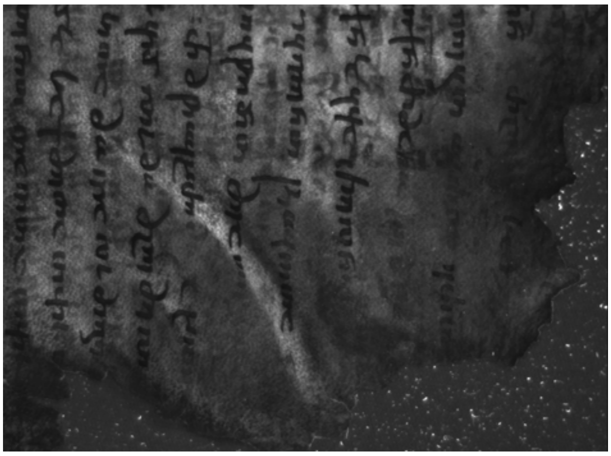

Fig. 20: same, extract (at 440 nm)