A Tutorial of Viewing and Querying the Ontology of Soil Properties and Processes

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1 Introduction

The ontology of soil properties and processes (OSP) mainly describes soil properties and processes, as well as how they affect each other. For example, the strength of soil is influenced by the water content of it. The OSP ontology reuses and specifies some high-level classes in the Semantic Web for Earth and Environmental Terminology (the SWEET ontology) [7], which is developed by NASA and widely adopted and extended. The OSP ontology is developed using the NeOn methodology [10]. It is created manually and written in OWL 2 Web Ontology Language Manchester Syntax [5], which is based on description logic (DL) [3]. The DL expressivity of the ontology is $\mathcal{SRI}$, allowing transitive relations and inverse relations[1]. These relations are very useful when inferring new information from the ontology using reasoning in description logic. The OSP ontology contains 592 concepts and 2243 relation statements (logical axioms). The concepts and relation statements are created based on the knowledge of domain experts, the SWEET ontology [7] developed by NASA, English dictionaries [1, 2] and a textbook 'Principles of Soil Physics by Rattan Lal and Manoj K. Shukla, 2004' [6]. The soil properties and processes described in the ontology have agricultural, engineering and environmental applications, including asset maintenance.

The OSP ontology is publicly available under the Creative Commons Attribution 4.0 International (CC BY 4.0)[2]. This tutorial aims to help people to learn how to view and query the OSP ontology using an ontology editor Protégé [8].

2 Installing Protégé and its Plugins

Protégé is a free open-source ontology editor. It can be downloaded from: `http://protege.stanford.edu`. Protégé supports different platforms, including Windows, Mac OSX and Linux. The detailed installation instructions for installing the latest version of Protégé are available at: `http://protegewiki.stanford.edu/wiki/Install_Protege5`.

To query the OSP ontology, we need to install some reasoners within Protégé. After opening Protégé, please follow the instructions below:

[1] To avoid confusion, we call 'OWL object properties' relations.

[2] https://creativecommons.org/licenses/by/4.0/

1. Go to the 'File' menu on the top-left corner.
2. Select 'Check for plugins...', then a window as shown in Fig. 1 will appear.
3. Select the three reasoners selected in Fig. 1 and click 'Install'.
4. Wait about two or three seconds, then a message will pop up saying 'Updates will take effect when you next start Protege'.
5. Close and restart Protégé.

After installing the reasoner plugins, one should be able to see their names under the 'Reasoner' menu.

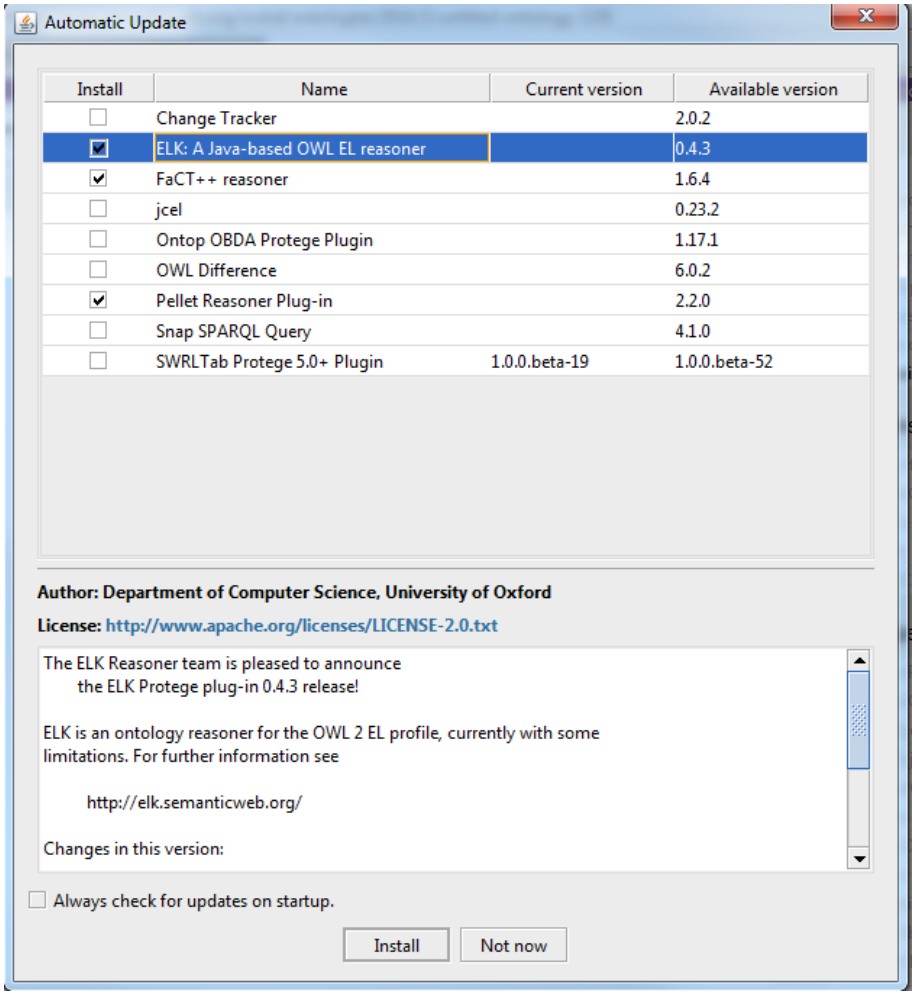

Fig. 1. Installing Protégé reasoner plugins

3 Viewing and Querying the OSP ontology using Protégé

The OSP ontology is stored in the file Soil-Property-Process.owl. Open it using Protégé (go to the 'File' menu, click 'Open', locate and select Soil-Property-Process.owl), the window shown in Fig. 2 will appear. The window displays information about the scope, purpose and knowledge sources of the OSP ontology, as well as numbers of classes and axioms in it.

By using the 'Entity' tab, we can see the class hierarchy and relation hierarchy in the OSP ontology (Fig. 3). For a selected class, its usages and annotations are displayed on the right side of the window. For example, the usages of the class *SoilStrength* [3] are shown in Fig. 4 and Fig. 5, where *SoilStrength* is classified as a *SoilPhysicalProperty* and its relationships with several other properties and processes are defined. Fig. 6 shows the annotations of the class *SoilStrength*. These annotations indicate the knowledge sources used for defining it. The page numbers, table names, figure names, chapter or section names in the annotations are provided to help users locate explanations or evidence in the textbook 'Principles of Soil Physics by Rattan Lal and Manoj K. Shukla, 2004' [6].

The DL Query tab (go to the 'Window' menu, go to the 'Tabs' list, tick 'DL Query') can be used to query the OSP ontology. Before executing a query, one should select and start a reasoner (e.g. go to the 'Reasoner' menu, select 'ELK 0.4.3', and click 'Start reasoner'[4]). Ticking the 'Subclasses' on the right and executing the query '*hasImpactOn* some *SoilStrength*', we will get a list of all the subclasses of the class expression '*hasImpactOn* some *SoilStrength*', as shown in Fig. 7. For each class C in the list, the relation statement 'C *hasImpactOn SoilStrength*' can be inferred from the OSP ontology using DL reasoning. The list in Fig. 7 consists of 173 classes, which fall into different categories, such as *Property*, *Process*, *Substance* and *HumanActivity*. To obtain a list of soil properties which *hasImpactOn SoilStrength*, we execute the query '(*hasImpactOn* some *SoilStrength*) and *SoilProperty*', as shown in Fig. 8. (Note that *owl* : *Nothing* is the default bottom class in OWL. It is interpreted as an empty set and it is a subclass of any class.) Each class in the list of query results has a 'question mark button' on the right, which is used to display explanations about why the class is in the list. Clicking the question mark button, one will see a message box as shown in Fig. 9. It tells how many explanations are found. When all the explanations are found, a window as shown in Fig. 10 will be displayed automatically. However, it is possible that a large number of explanations exist and it takes relatively long time to calculate all of them. In such cases, we may 'Stop searching', once enough explanations are found.

Fig. 10 displays explanations for '*SoilMoistureContent* is a kind of *SoilProperty*' and '*SoilMoistureContent hasImpactOn SoilStrength*'. In Explanation 1, State-

[3] The class *SoilStrength* can be found by using 'Search' on the top-right corner, or going down the class hierarchy from *Property*, to *SoilProperty*, to *SoilPhysicalProperty*, to *SoilStrength*.

[4] Some ELK warning messages will pop up to tell you the limitations of the ELK reasoner. Tick 'Do not show further messages of this kind in this session' or 'Do not show this message again in this session' and click 'OK'.

ments 1-3 justify '*SoilMoistureContent* is a kind of *SoilProperty*' and Statements 4 and 5 justify '*SoilMoistureContent hasImpactOn SoilStrength*'. In Explanation 2, Statements 1-4 justify '*SoilMoistureContent* is a kind of *SoilProperty*' and Statements 1 and 5 justify '*SoilMoistureContent hasImpactOn SoilStrength*'.

4 Summary and Recommended Tutorials

This tutorial explains how to install and use Protégé and its reasoner plugins to view and query the OSP ontology. Like other OWL ontologies, the OSP ontology can be edited or extended using Protégé or other editors. We recommend the following tutorials for people who would like to learn more about Protégé and OWL 2.

For Beginners: The Protégé OWL tutorial [4] provides a step-by-step guide to modelling in OWL using Protégé. It is available at: `http://owl.cs.manchester.ac.uk/publications/talks-and-tutorials/protg-owl-tutorial`.

For Advanced Users: The Manchester Family History Advanced OWL Tutorial [9] provides a comprehensive step-by-step guide to modelling family history using advanced OWL 2 features. It is available at: `http://owl.cs.manchester.ac.uk/publications/talks-and-tutorials/fhkbtutorial`.

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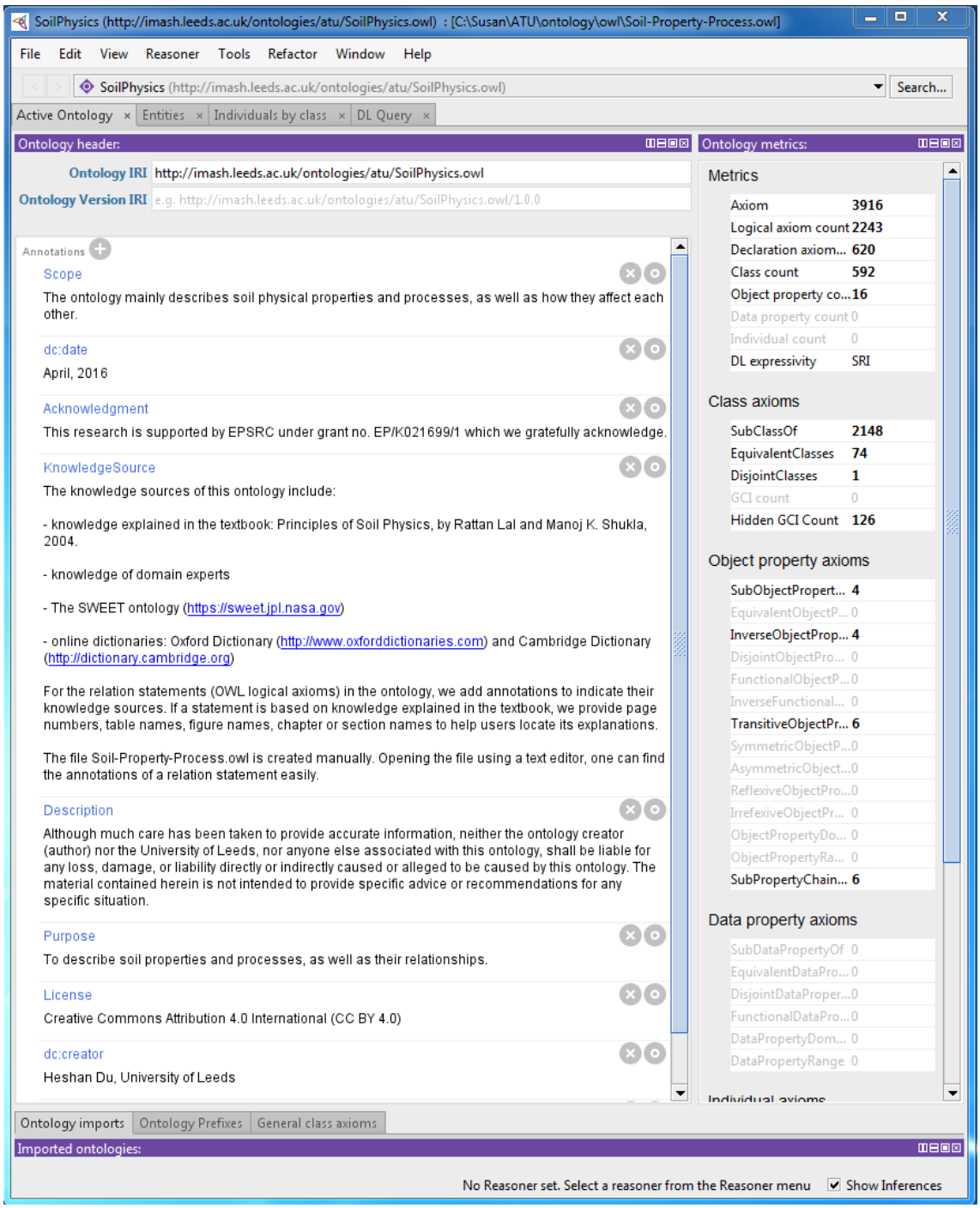

Fig. 2. Opening the OSP ontology using Protégé

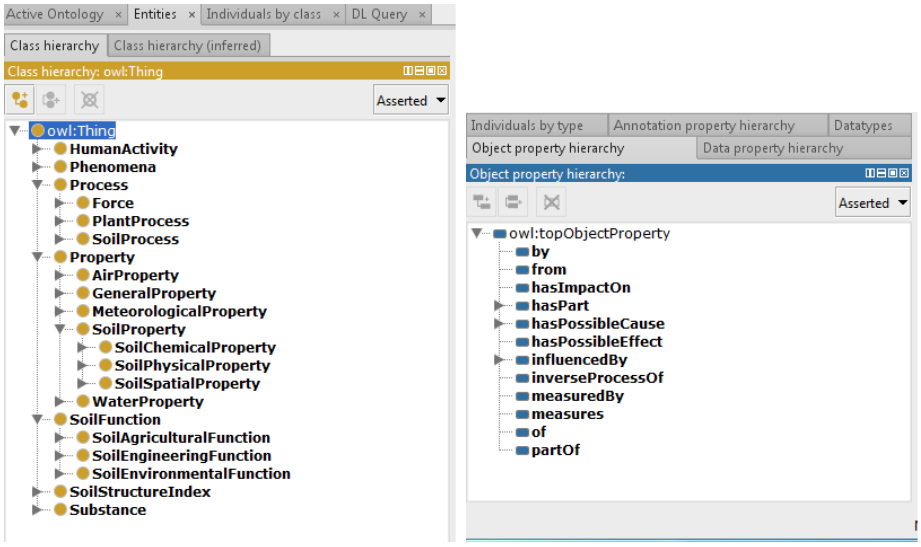

Fig. 3. Class hierarchy and relation hierarchy in the OSP ontology

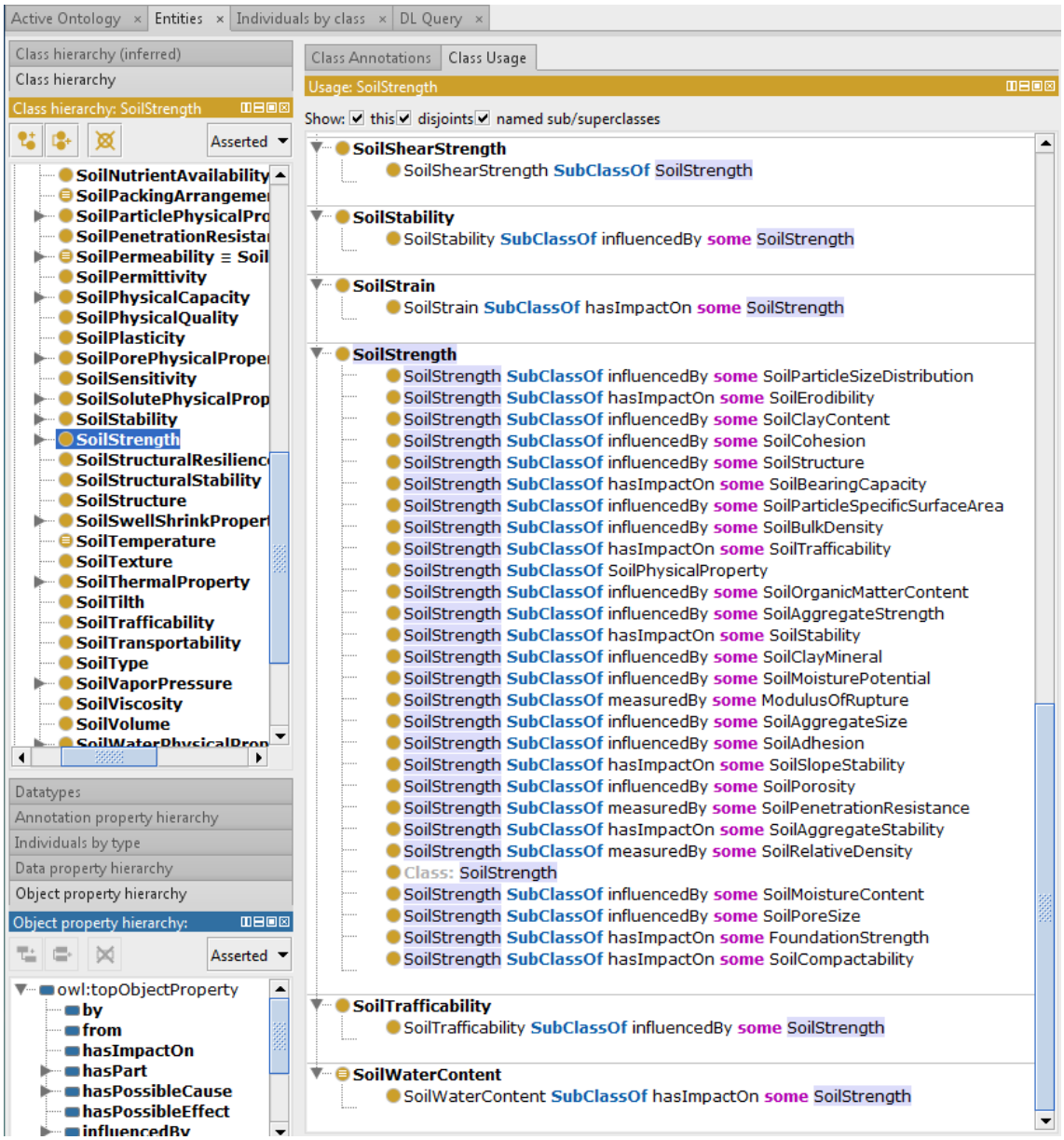

Fig. 4. Usages of *SoilStrength*: View 1

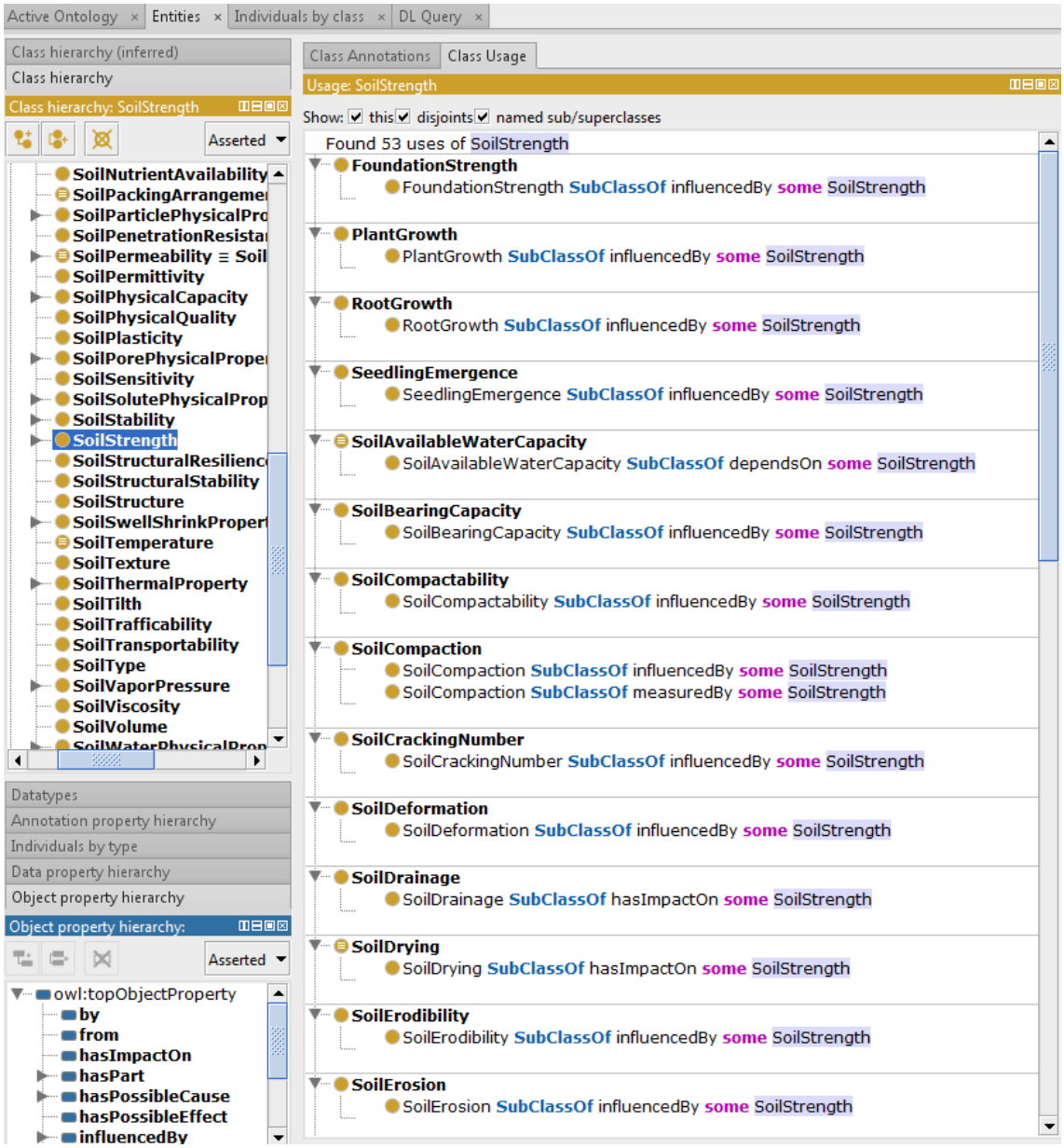

Fig. 5. Usages of *SoilStrength*: View 2

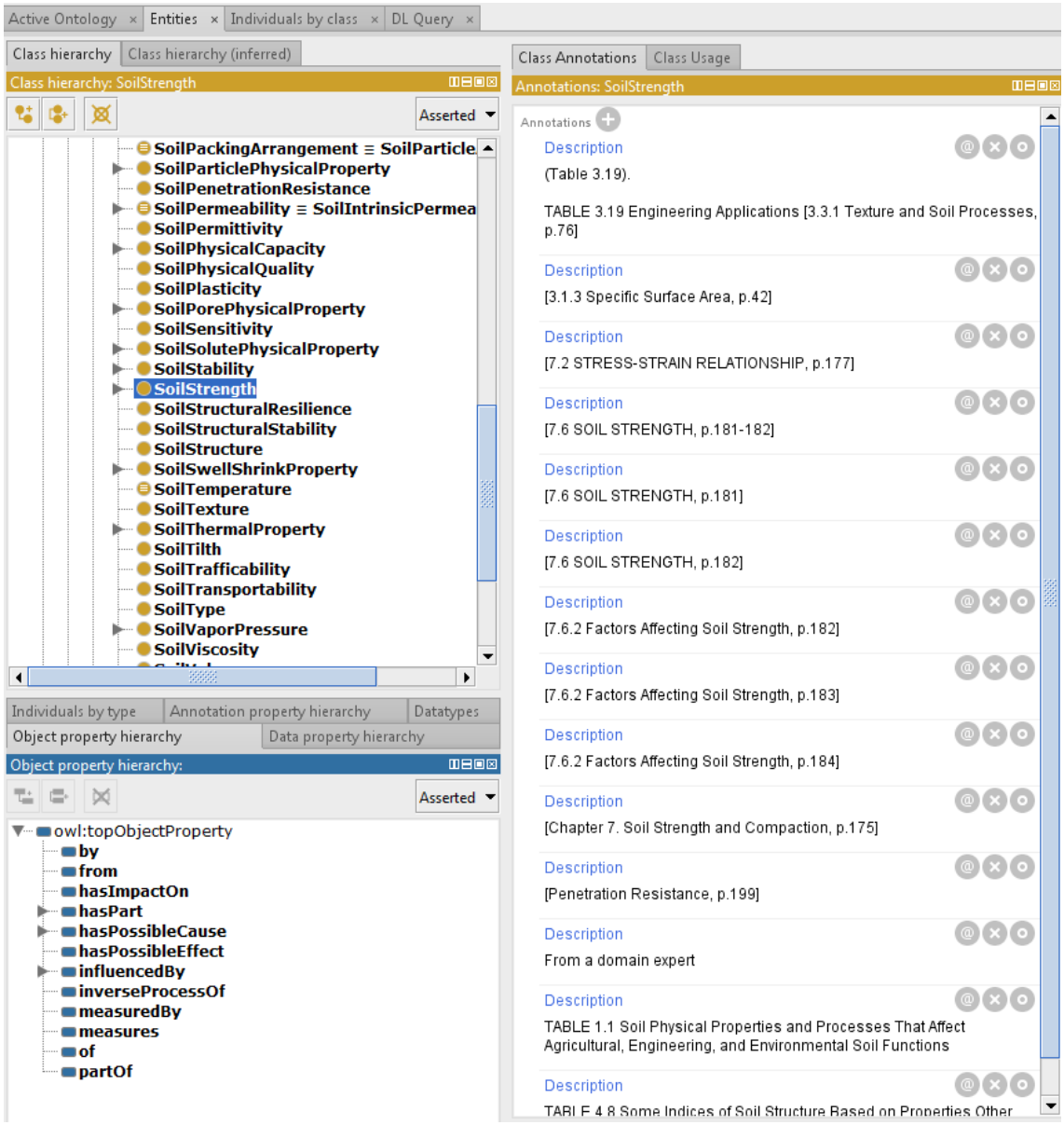

Fig. 6. Annotations of *SoilStrength*

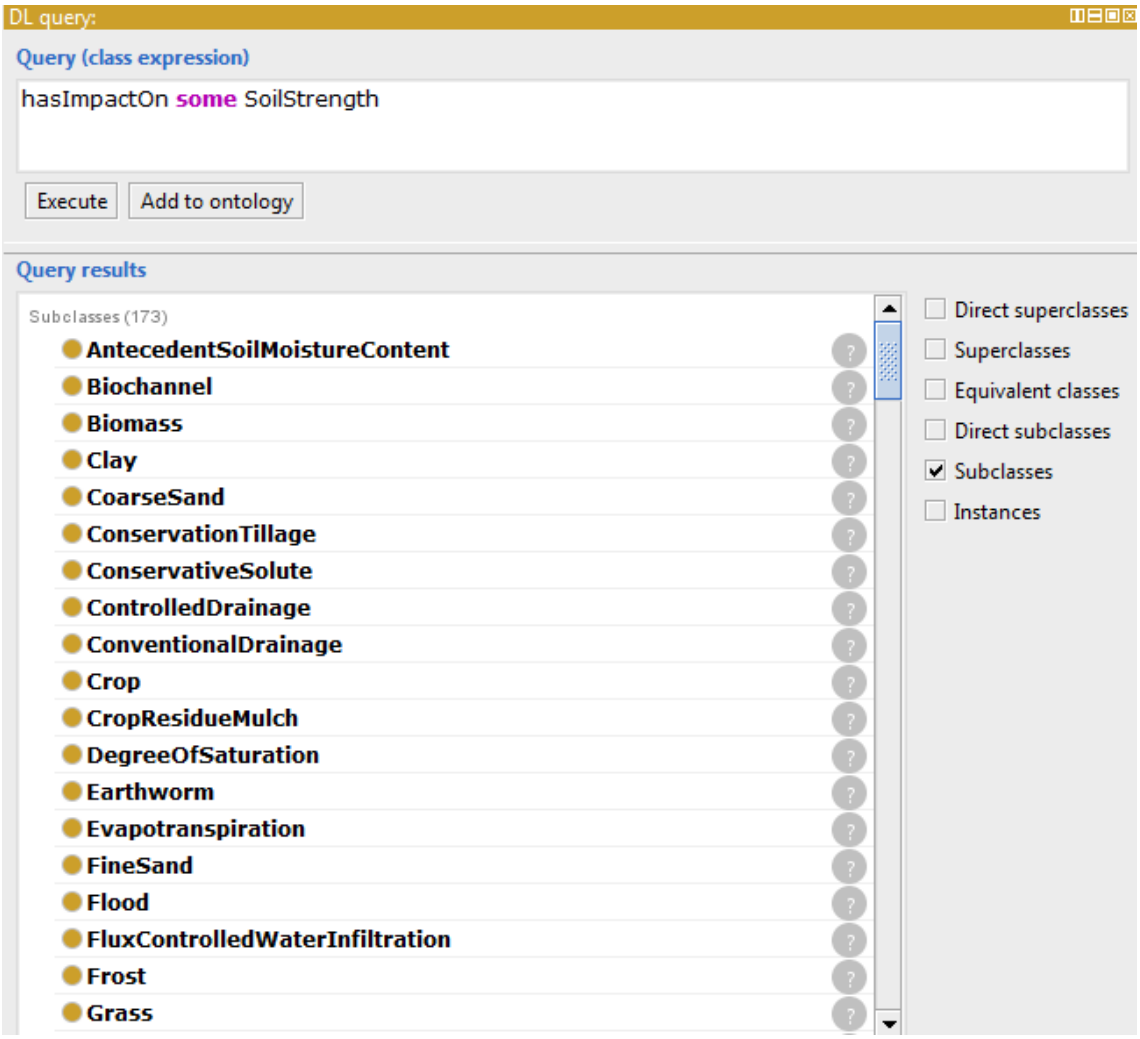

Fig. 7. DL Query: all subclass of the class expression '*hasImpactOn* some *SoilStrength*'

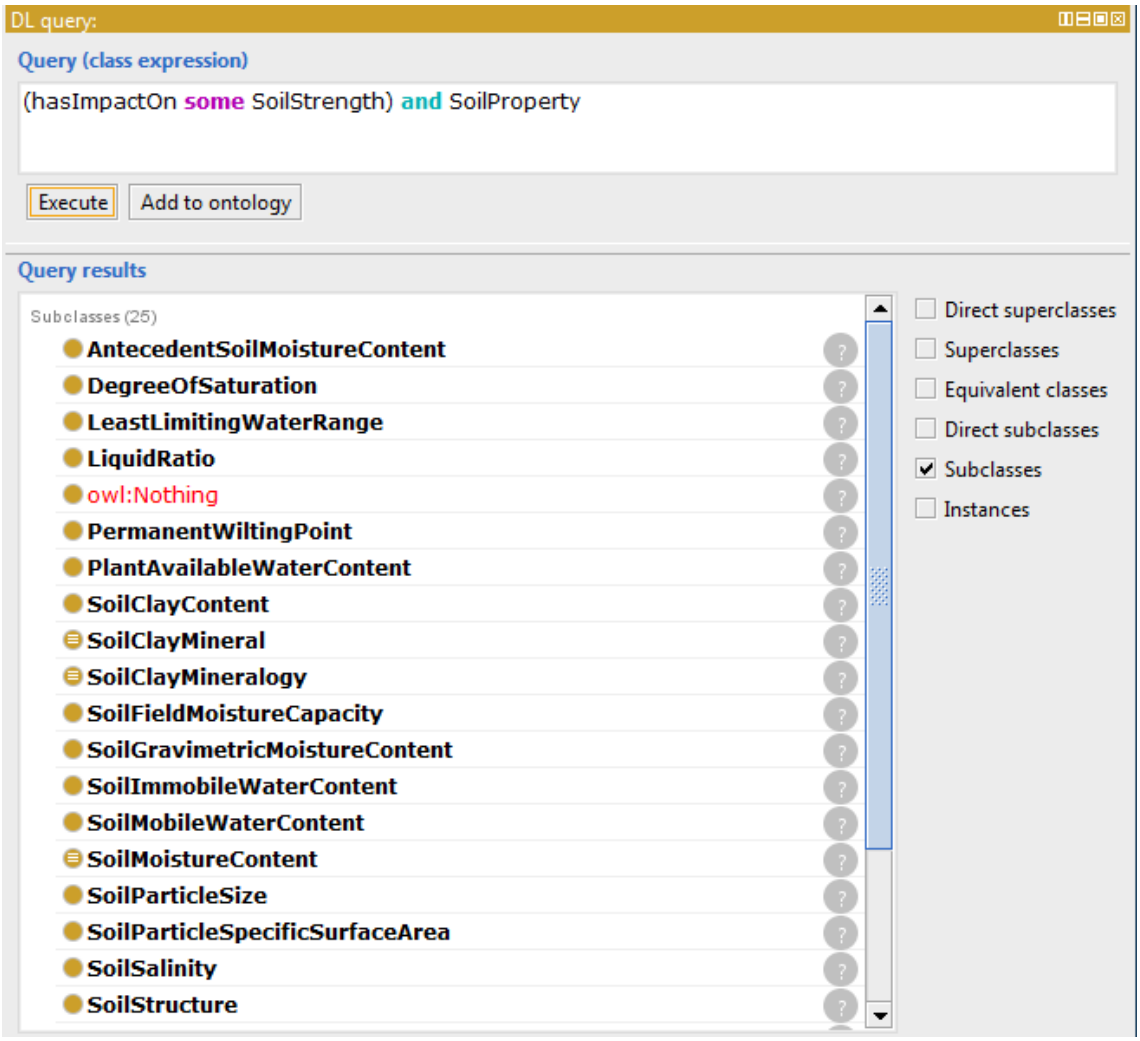

Fig. 8. DL Query: all subclass of the class expression '(*hasImpactOn* some *SoilStrength*) and *SoilProperty*'

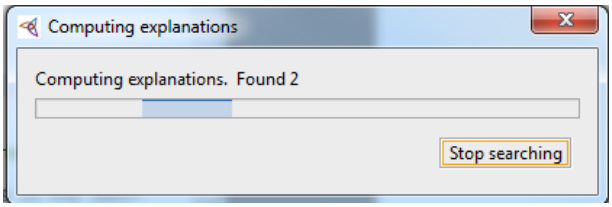

Fig. 9. Computing explanations

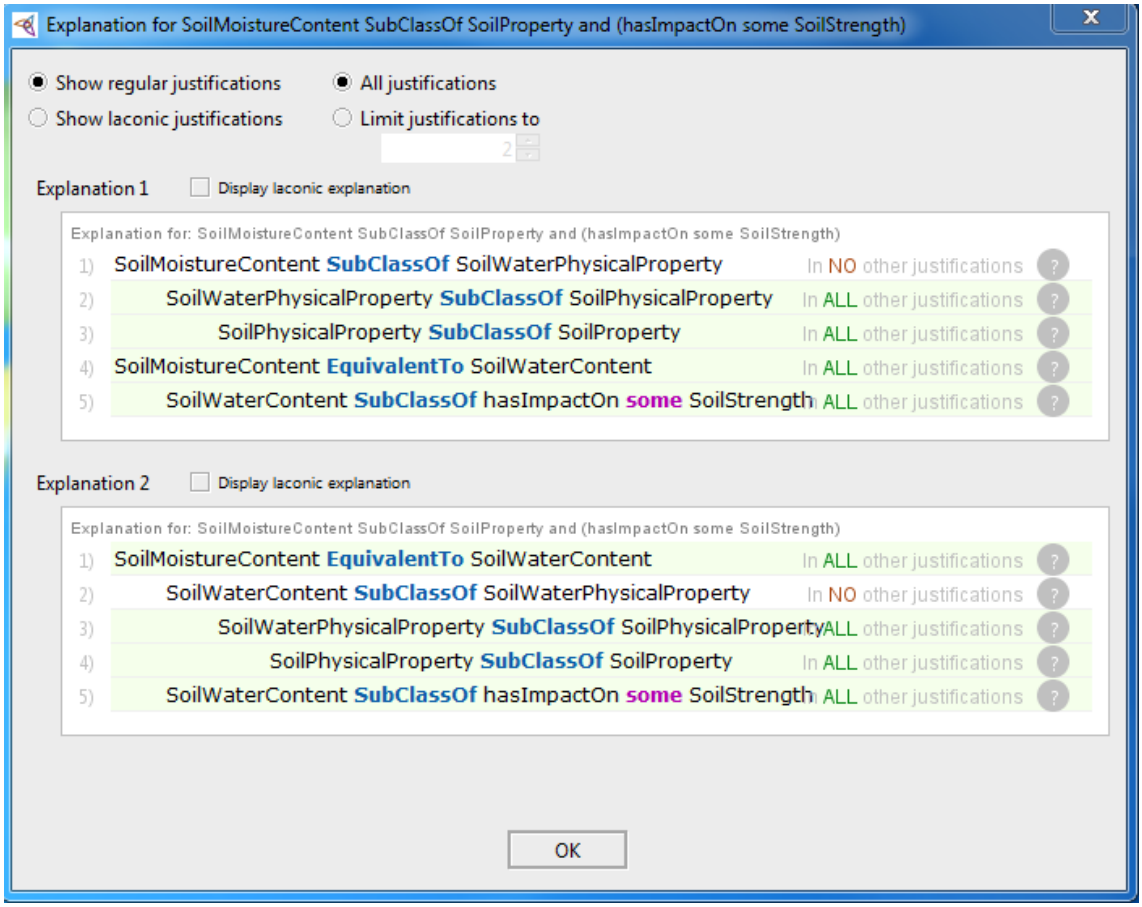

Fig. 10. Explanations for '*SoilMoistureContent* is a kind of *SoilProperty*' and '*SoilMoistureContent hasImpactOn SoilStrength*'.